



Enabling Health Care Decisionmaking Through Clinical Decision Support and Knowledge Management



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**Evidence-Based
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**Health Information
Technology**

Enabling Health Care Decisionmaking Through Clinical Decision Support and Knowledge Management

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Prepared by:

Duke Evidence-based Practice Center
Durham, NC

Investigators:

David Lobach, M.D., Ph.D., Principal Investigator
Gillian D. Sanders, Ph.D., EPC Director
Tiffani J. Bright, Ph.D., Lead Investigator
Anthony Wong, M. Tech., Clinical Investigator
Ravi Dhurjati, Ph.D., EPC Investigator
Erin Bristow, B.A., Clinical Investigator
Lori Bastian, M.D., M.S., Clinical Investigator
Remy Coeytaux, M.D., Ph.D., EPC Investigator
Gregory Samsa, Ph.D., Statistician/EPC Investigator
Vic Hasselblad, Ph.D., Statistician
John W. Williams, M.D., M.H.S., EPC Investigator
Liz Wing, M.A., EPC Editor
Michael Musty, B.A., EPC Project Coordinator
Amy S. Kendrick, R.N., M.S.N., EPC Project Manager

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The information in this report is intended to help health care decisionmakers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of health care services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions, and new health care technologies and strategies.

The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments. To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review and public comment prior to their release as a final report.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

We welcome comments on this evidence report. Comments may be sent by mail to the Task Order Officer named in this report to: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.hhs.gov.

Carolyn M. Clancy, M.D.
Director, Agency for Healthcare Research
and Quality

Jean Slutsky, P.A., M.S.P.H.
Director, Center for Outcomes and Evidence
Agency for Healthcare Research and Quality

Stephanie Chang M.D., M.P.H.
Director, EPC Program
Center for Outcomes and Evidence
Agency for Healthcare Research and Quality

Jon White, M.D.
Task Order Officer
Center for Primary Care, Prevention, and
Clinical Partnerships
Agency for Healthcare Research and Quality

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Technical Expert Panel

Joan Ash, Ph.D., M.L.S., M.S., M.B.A.
Oregon Health & Science University
Portland, OR

David W. Bates, M.D., M.Sc.
Partners Healthcare System, Inc.
Harvard Medical School
Boston, MA

Eta S. Berner, Ed.D.
University of Alabama
Birmingham, AL

R. Brian Haynes, M.D., M.Sc., Ph.D.
McMaster University
Hamilton, Ontario, Canada

Blackford Middleton, M.D., M.P.H., M.Sc.
Partners Healthcare System, Inc.
Wellesley, MA

Ida Sim, M.D., Ph.D.
University of California
San Francisco, CA

Dean F. Sittig, Ph.D.
University of Texas
School of Health Information Sciences
Houston, TX

Paul C. Tang, M.D., M.S.
Palo Alto Medical Foundation
Los Altos, CA

Peer Reviewers

Robert Greenes, M.D., Ph.D.
Department of Biomedical Informatics
Arizona State University
Phoenix, AZ

Gil Kuperman, M.D., Ph.D.
Director, Interoperability Informatics
New York-Presbyterian Hospital
New York, NY

Jerome A. Osherooff, M.D.
Clinical Informatics
Thomson Reuters

David M. Rind, M.D.
Division of General Medicine
Beth Israel Deaconess Medical Center
Boston, MA

Enabling Health Care Decisionmaking Through Clinical Decision Support and Knowledge Management

Structured Abstract

Objectives: To catalogue study designs used to assess the clinical effectiveness of clinical decision support systems (CDSSs) and knowledge management systems (KMSs), to identify features that impact the success of CDSSs/KMSs, to document the impact of CDSSs/KMSs on outcomes, and to identify knowledge types that can be integrated into CDSSs/KMSs.

Data Sources: MEDLINE[®], CINAHL[®], PsycINFO[®], and Web of Science[®].

Review Methods: We included studies published in English from January 1976 through December 2010. After screening titles and abstracts, full-text versions of articles were reviewed by two independent reviewers. Included articles were abstracted to evidence tables by two reviewers. Meta-analyses were performed for seven domains in which sufficient studies with common outcomes were included.

Results: We identified 15,176 articles, from which 323 articles describing 311 unique studies including 160 reports on 148 randomized control trials (RCTs) were selected for inclusion. RCTs comprised 47.5 percent of the comparative studies on CDSSs/KMSs. Both commercially and locally developed CDSSs effectively improved health care process measures related to performing preventive services (n = 25; OR 1.42, 95% confidence interval [CI] 1.27 to 1.58), ordering clinical studies (n = 20; OR 1.72, 95% CI 1.47 to 2.00), and prescribing therapies (n = 46; OR 1.57, 95% CI 1.35 to 1.82). Fourteen CDSS/KMS features were assessed for correlation with success of CDSSs/KMSs across all endpoints. Meta-analyses identified six new success features: integration with charting or order entry system, promotion of action rather than inaction, no need for additional clinician data entry, justification of decision support via research evidence, local user involvement, and provision of decision support results to patients as well as providers. Three previously identified success features were confirmed: automatic provision of decision support as part of clinician workflow, provision of decision support at time and location of decisionmaking, and provision of a recommendation, not just an assessment. Only 29 (19.6%) RCTs assessed the impact of CDSSs on clinical outcomes, 22 (14.9%) assessed costs, and 3 assessed KMSs on any outcomes. The primary source of knowledge used in CDSSs was derived from structured care protocols.

Conclusions: Strong evidence shows that CDSSs/KMSs are effective in improving health care process measures across diverse settings using both commercially and locally developed systems. Evidence for the effectiveness of CDSSs on clinical outcomes and costs and KMSs on any outcomes is minimal. Nine features of CDSSs/KMSs that correlate with a successful impact of clinical decision support have been newly identified or confirmed.

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Executive Summary

Background

Efforts to improve the quality and value of health care increasingly emphasize a critical role for the meaningful use of clinical decision support systems (CDSSs) and electronic knowledge management systems (KMSs). For the purpose of this review, a **clinical decision support system** is defined as “any electronic system designed to aid directly in clinical decisionmaking, in which characteristics of individual patients are used to generate patient-specific assessments or recommendations that are then presented to clinicians for consideration.” Examples of electronic CDSSs include alerts, reminders, order sets, drug-dosage calculations, and care-summary dashboards that provide performance feedback on quality indicators or benchmarks. In contrast, a **knowledge management system** is defined as a tool that selectively provides information relevant to the characteristics or circumstances of a clinical situation but which requires human interpretation for direct application to a specific patient. Examples of electronic KMSs include information retrieval tools and knowledge resources that consist of distilled primary literature on evidence-based practices. An **information retrieval tool** is defined as an electronic tool designed to aid clinicians in the search and retrieval of context-specific knowledge from information sources based on patient-specific information from a clinical information system to facilitate decisionmaking at the point of care or for a specific care situation. A **knowledge resource** is defined as an electronic resource comprising distilled primary literature that allows selection of content that is germane to a specific patient to facilitate decisionmaking at the point of care or for a specific care situation.

The objective of a CDSS is to apply clinical knowledge in the context of patient-specific information to aid clinicians in the process of making decisions. Electronic KMSs can further support decisionmaking in any care situation by providing a range of strategies and resources to create, represent, and distribute knowledge for application by a human in clinical practice. As a form of health information technology, CDSSs and KMSs can serve as information tools to align clinician decisionmaking with best practice guidelines and evidence-based medical knowledge at the point of care as well as assist with information management to support clinicians’ decisionmaking abilities. Ultimately, when used effectively, CDSSs can reduce workloads and improve both the quality of health care outcomes and the efficiency of care delivery. However, in order to improve the quality of health care, CDSSs and KMSs need to be effectively integrated into the process of routine care so that the right action to take becomes the easiest action to take—and the action best supported by clinical evidence.

Within electronic KMSs and CDSSs, there is a continuum of decision support interventions that have the goal of providing knowledge to inform a decision at the point of care or for a specific care situation. Table A shows three types of decision support interventions and how context-specific queries are processed by these interventions to submit patient-specific information and generate patient-specific recommendations. This report examines each type of decision support tool presented in the table.

Table A. Continuum of decision support

Types of Decision Support Interventions	Classic Clinical Decision Support	Information Retrieval Tool	Knowledge Resource
Example	Preventive care reminder	Infobutton	Epocrates
Process: Submit patient-specific information	Automated (computer)	Automated (computer)	Manual (human)
Process: Generate patient-specific recommendation	Automated (computer)	Manual (human)	Manual (human)

An example of a classic CDSS is a preventive care reminder to remind the clinician of a specific action. For this type of decision support, the processes to submit patient-specific information and generate patient-specific recommendations are automated and performed by a computer.

An example of an information retrieval tool is an infobutton embedded in a clinical information system, such as an electronic health record (EHR), that when selected provides context-specific links to various information sources. For this type of decision support, the process to submit patient-specific information is automated and performed by a computer, and the process to generate patient-specific recommendations is performed manually by a human.

Examples of knowledge resources include UpToDate, Epocrates[®], and MDConsult. For this type of decision support, the processes to submit patient-specific information and generate patient-specific recommendations are performed manually by a human.

In spite of the increasing emphasis on the role of CDSSs/KMSs in improving care and lowering costs, substantial evidence supporting the widespread general use of CDSSs is still lacking. Until recently, most of the studies of CDSSs/KMSs have arisen out of four benchmark settings (Brigham and Women's Hospital/Partners Health Care, Department of Veterans Affairs, LDS Hospital/ Intermountain Health Care, and Regenstrief Institute). Additionally, few studies report about the ways in which CDSSs/KMSs have been used optimally or about the features of CDSSs/KMSs that lead to effective, sustained impact across a variety of clinical settings. Accordingly, a systematic review of the best research literature pertaining to CDSSs/KMSs was warranted in order to determine what is known about CDSSs/KMSs and what is lacking in our current understanding.

Objectives

This evidence report is part of a three-report series focusing on the strategic goals of the Agency for Healthcare Research and Quality's (AHRQ's) health information technology portfolio. The first report addresses the use of health information technology to improve the quality and safety of medication management, and the second report investigates the use of health information technology to support patient-centered care, coordination of care, and electronic exchange of health information to improve quality of care. This third report specifically explores facilitating health care decisionmaking through health information technology. Supporting health care decisionmaking is a core element of the meaningful use criteria for EHRs. As the expected level of sophistication of EHRs increases in the evolving definitions of meaningful use, the need for more sophisticated CDSSs/KMSs is imperative, as is the need for better operational use of these systems. This increasing importance of CDSSs/KMSs acknowledges that EHRs alone are not an end but are instead a tool to augment the delivery of safe, evidence-based, high-quality health care through more consistent and sound decisionmaking.

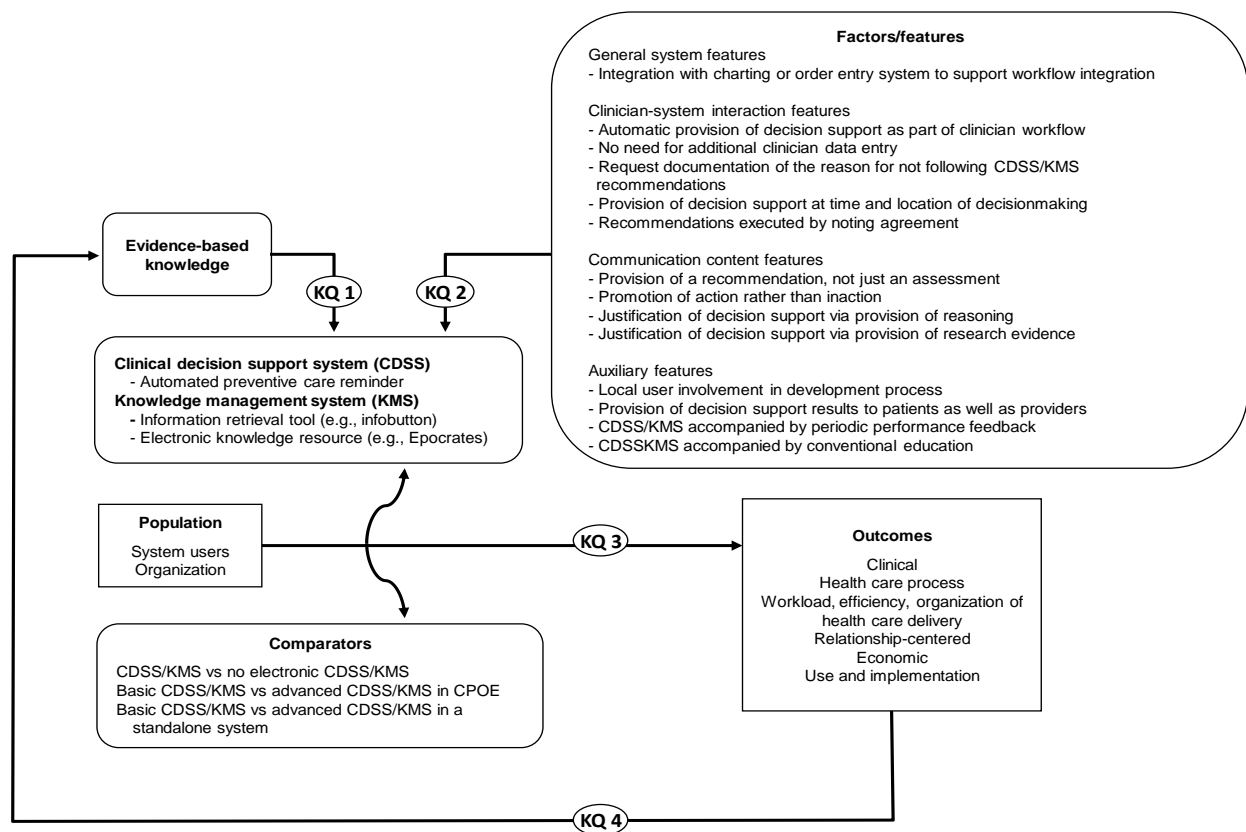
The goals of this report were to summarize the available evidence related to CDSSs and KMSs, highlight the limitations of the evidence, and identify areas for future research. The key questions (KQs) considered in this systematic review were:

- **KQ 1:** What evidence-based study designs have been used to determine the clinical effectiveness of electronic knowledge management and CDSSs?
- **KQ 2:** What contextual factors/features influence the effectiveness or success of electronic knowledge management and CDSSs?
- **KQ 3:** What is the impact of introducing electronic knowledge management and CDSSs?
 - 3a. Changes in the organization of health care delivery
 - 3b. Changes in the workload and efficiency for the user
 - 3c. Changes in health care process measures and clinical outcomes
- **KQ 4:** What generalizable knowledge can be integrated into electronic knowledge management and CDSSs to improve health care quality?
 - 4a. Knowledge from published evidence about electronic knowledge management and CDSSs to improve health care quality based on different types of measures (health care process, relationship-centered, clinical, economic)
 - 4b. How a clinician's expertise/proficiency/informatics competency using the electronic knowledge management and CDSS affects patient outcomes (one type of measure)

Analytic Framework

The analytic framework (Figure A) illustrates (1) how the effectiveness or success of CDSSs/KMSs is influenced by evidence-based knowledge and contextual factors/features and (2) how interactions with CDSSs/KMSs by system users and health care organizations may result in outcomes such as changes in the individual, changes in the organization, and changes in health care quality.

Figure A. Analytic framework



Abbreviations: CDSS = clinical decision support system, CPOE = computerized physician order entry, KMS = knowledge management system, KQ = key question

Methods

1. **Input from Stakeholders.** We identified experts in the fields of CDSS and KMS to serve as members of the project's Technical Expert Panel (TEP). We specifically selected individuals who had years of experience working with CDSSs/KMSs and who represented a broad range of perspectives including CDSS/KMS developers, implementers, evaluators, policymakers, catalogers, and standards makers. Panel members had experience in both academic and industry environments. TEP members contributed to AHRQ's broader goals of (1) creating and maintaining science partnerships and public-private partnerships and (2) meeting the needs of an array of potential customers and users of this report. To ensure accountability and scientifically relevant work, we asked TEP members for input at key stages of the project. More specifically, TEP members participated in conference calls and email exchanges to refine the analytic framework and key questions at the beginning of the project, refine the scope, discuss inclusion and exclusion criteria, and provide input on methodology. An additional group of peer reviewers was identified to provide comments on the report. Peer reviewers differed from TEP members in that they were not involved during the development phase of the project. The report was also posted for public comment. A summary of the comments and their disposition from peer and public reviewers has been prepared and submitted to AHRQ.
2. **Data Sources and Selection.** The comprehensive literature search included electronic searching of peer-reviewed literature databases. These databases included the Cumulative Index to Nursing and Allied Health Literature (CINAHL[®]), the Cochrane Database of Systematic Reviews, MEDLINE[®] accessed via PubMed[®], PsycINFO[®], and Web of Science[®]. Searches of these databases were supplemented with manual searching of reference lists contained in all included articles and in relevant review articles. Search strategies were specific to each database in order to retrieve the articles most relevant to the key questions. Our basic search strategy used the National Library of Medicine's Medical Subject Headings (MeSH) key word nomenclature developed for MEDLINE, limited to articles published in English, and a manual search of retrieved articles and published reviews. Search terms and strategies were developed in consultation with a medical librarian and included terms for evaluation and study types, clinical decision support systems, knowledge management systems, and computerized interaction.

Table B shows the inclusion and exclusion criteria for the key questions.

Table B. Inclusion and exclusion criteria

Category	Criteria
Study population	System user, defined as a health care provider who interacts with the KMS or CDSS. Includes nurses, nurse practitioners, care managers, physician assistants, training MDs (residents, fellows), attending physicians or general practitioners, pharmacists. Health care organization, defined as an organization that provides access to health care services delivered by medical and allied health professionals. Includes academic and community settings, clinics, practices, hospitals, long-term care facilities.
Study design	KQ 1: All study designs KQs 2–4: RCTs (parallel group, crossover, cluster)
Factors/interventions	Implemented electronic KMS and CDSS
Comparator	CDSSs/KMSs are compared with no electronic CDSS/KMS Basic CDSS is compared with advanced CDSS in computerized physician order entry (CPOE) or EHR Basic CDSS is compared with advanced CDSS in a standalone system
Study outcomes	Clinical outcomes (length of stay, morbidity, mortality, measure of health-related quality of life, adverse events) Health care process measures (recommended preventive care, clinical study, or treatment was ordered/completed and adhered to; user knowledge) Workload, efficiency, and organization of health care delivery (number of patients seen, clinician workload, efficiency) Relationship-centered outcomes (patient satisfaction) Economic outcomes (cost and cost-effectiveness) Health care provider use and implementation (acceptance, satisfaction, use, implementation)
Timing	No restrictions
Setting	No restrictions
Publication languages	English only

Table B. Inclusion and exclusion criteria (continued)

Category	Criteria
Admissible evidence (study design and other criteria)	Study must report one or more outcomes of interest (see above criteria) Study must report original data Study must report sufficient details for data extraction and analysis Intervention must be implemented in a real clinical setting Intervention must be aimed at health care providers Intervention must be used to aid decisionmaking at the point of care or for a specific care situation Study must evaluate the effectiveness of a KMS or CDSS
Exclusions	Title-and-abstract level (CDSS): Studies that describe nonelectronic CDSS interventions Studies where the CDSS intervention is not implemented in a real clinical setting (laboratory setting, use of simulated cases) Studies where the CDSS intervention is aimed at non–health care providers (patients, caretakers, administrators, etc.) Studies that do not report original research (editorials, commentaries, letters to the editor, etc.) Title-and-abstract level (KMS): Studies that describe nonelectronic KMS interventions Studies where the KMS intervention is not used to aid decisionmaking at the point of care or for a specific care situation Studies where the KMS intervention does not include an evaluation of clinician use at the point of care or for a specific care situation (survey, questionnaires, content analysis, interviews, etc.) Studies that do not include a comparator (descriptive study) Studies where the KMS intervention is not implemented in a real clinical setting (laboratory setting, use of simulated cases) Studies where the KMS intervention is used by nonclinicians (librarians, administrators, etc.) Studies that do not report original research (editorials, commentaries, letters to the editor, etc.) Full-text level: Studies with a sample size < 50 Studies of closed-loop systems that do not involve a provider Studies of systems that require mandatory compliance with the CDSS intervention, defined as when the clinician at the point of care is not given a choice about whether to follow the CDSS recommendations (compliance is mandated by the study protocol) Studies that evaluate only the performance of the system as opposed to the impact on clinical practice

Abbreviations: CDSS = clinical decision support system, CPOE = computerized physician order entry, EHR = electronic health record, KMS = knowledge management system, RCT = randomized controlled trial

Using the prespecified inclusion and exclusion criteria, titles and abstracts were examined independently by three reviewers for potential relevance to the key questions. Articles included by any reviewer underwent full-text screening. After the independent abstract screening stage by a single reviewer, 5 percent of the abstracts were randomly selected using a random number generator for a rescreen by a second reviewer. At the full-text screening stage, two independent reviewers read each article to determine if it met eligibility criteria. When the paired reviewers arrived at different decisions about whether to include or exclude an article, they reconciled the difference through a third-party arbitrator. Articles meeting our eligibility criteria were included for data abstraction.

3. **Data Extraction and Quality Assessment.** Data from published reports were abstracted into evidence tables by one reviewer and overread by a second reviewer. Data elements abstracted included descriptors to assess applicability, quality elements, intervention details, and outcomes. We examined 14 factors/features of a successful CDSS, identified a priori from a previous 2005 review, and specific characteristics of those interventions. Disagreements were resolved by consensus or by obtaining a third reviewer's opinion when consensus could not be reached. The final evidence tables are intended to provide sufficient information so that readers can understand the study and determine its quality.

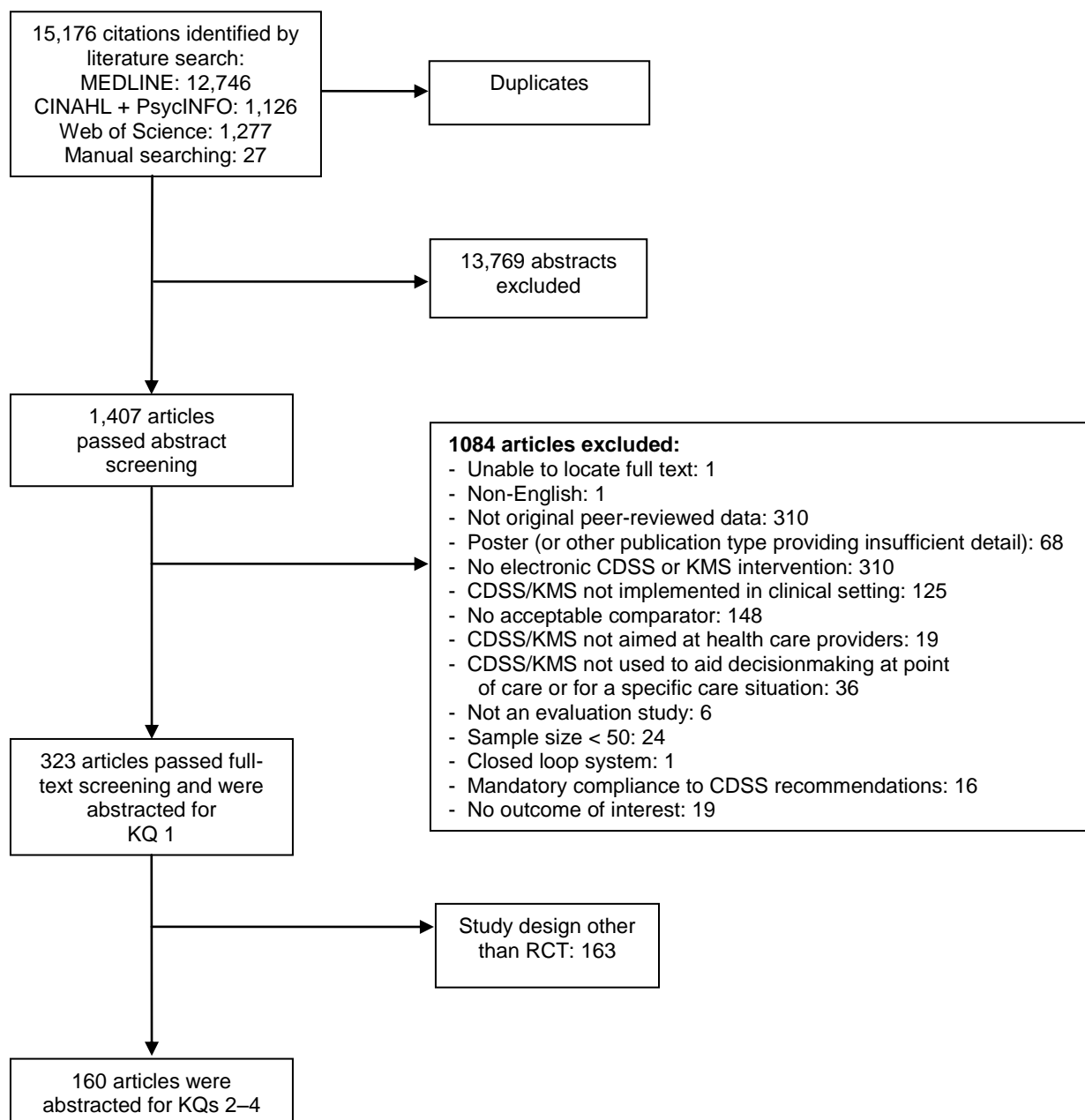
The included studies were assessed on the basis of the quality of their reporting of relevant data. We evaluated the quality of individual studies using the approach described in AHRQ's *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*. To assess methodological quality, we employed the strategy to (1) apply predefined criteria for quality and critical appraisal and (2) arrive at a summary judgment of the study's quality. To indicate the summary judgment of the quality of the individual studies, we used the summary ratings of Good, Fair, or Poor. To assess applicability, we identified specific issues that may limit the applicability of individual studies or a body of evidence. The strength of evidence for each key question was evaluated using the four required domains: risk of bias, consistency, directness, and precision. Additionally, when appropriate, the studies were evaluated for coherence, dose-response association, residual confounding, strength of association (magnitude of effect), publication bias, and applicability. The strength of evidence was assigned an overall grade of High, Moderate, Low, or Insufficient.

4. **Data Synthesis and Analysis.** Given that many studies did not have the statistical power to determine the benefit for the outcomes relevant to this review (which were often not the primary outcomes evaluated by study investigators), we considered synthesis (meta-analysis) in an attempt to overcome the type II error. We considered groups of studies to be suitable candidates for a quantitative synthesis when we were able to identify at least four studies that assessed the same outcome that could be expressed using a common endpoint. Estimates of parameters for the meta-analysis were calculated using the DerSimonian and Laird (1986) random effects model as implemented in Comprehensive Meta-Analysis (CMA) (Version 2.2.055). Most endpoints were combined using odds ratios, especially when event rates that approached 1.0 were involved. However, the clinical endpoints such as morbidity and length of stay were combined using relative risks because some of the results were given as events per time period instead of events per number of patients. For these endpoints, the event rates were low, and some of the studies reported risk ratios instead of relative risks.

Results

We identified 15,176 citations from all sources (after removing duplicates). After applying inclusion/exclusion criteria at the title-and-abstract level, 1,407 full-text articles were retrieved and screened. Of these, 1,084 articles were excluded at full-text review, with 323 articles remaining for data abstraction. Of these, 323 articles were abstracted for KQ 1 (representing 311 unique studies) and 160 articles (representing 148 unique studies) for KQs 2–4. The flow of articles through the literature search and screening process is depicted in Figure B.

Figure B. Literature search flow



Abbreviations: CDSS = clinical decision support system, KMS = knowledge management system, KQ = key question, RCT = randomized controlled trial

Table C provides an aggregated view of the strength of evidence and brief conclusions from this review.

Table C. Summary of findings

Key Question	Strength of Evidence	Conclusions
KQ 1: What evidence-based study designs have been used to determine the clinical effectiveness of electronic knowledge management and CDSSs?	Not applicable	<ul style="list-style-type: none"> • 311 studies were reviewed, including 148 RCTs (47.5%), 121 quasi-experimental (38.9%), and 42 observational studies (13.5%). • Clinical and health care process measures were frequently reported in all three study design types: <ul style="list-style-type: none"> ○ Clinical outcomes (19.6% of RCTs, 35.5% of quasi-experimental, 40.5% of observational studies) ○ Health care process measures (86.5.0% of RCTs, 75.2% of quasi-experimental, 69% of observational studies) • When RCT studies are impractical to conduct, well-designed quasi-experimental and observational studies have been used to evaluate the clinical effectiveness of CDSSs/KMSs.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
KQ 2: What contextual factors/features influence the effectiveness or success of electronic knowledge management and CDSSs?	Moderate	<ul style="list-style-type: none"> • Using meta-analysis on studies that evaluated adherence to preventive care (25 studies), clinical study (20 studies), and treatment as an outcome (46 studies), we confirmed 3 previously reported features associated with successful CDSS/KMS implementation and identified 6 additional features. • Our meta-analysis confirmed 3 previously reported factors/features were associated with successful CDSS/KMS implementation: <ul style="list-style-type: none"> ○ <i>Automatic provision of decision support as part of clinician workflow</i> (OR of 1.45, 95% CI of 1.28 to 1.64 for adherence to preventive care, n = 19; OR of 1.85, 95% CI of 1.52 to 2.25 for ordering of clinical studies, n = 15; OR of 1.59 95% CI of 1.33 to 1.90 for prescribing or ordering of therapy, n = 38). This set of studies included 44 good-quality, 26 fair-quality, and 4 poor-quality studies. ○ <i>Provision of decision support at time and location of decisionmaking</i> (OR of 1.35, 95% CI of 1.20 to 1.52 for adherence to preventive care, n = 22; OR of 1.78, 95% CI of 1.46 to 2.17 for ordering of clinical studies, n = 15; OR of 1.75, 95% CI of 1.47 to 2.08 for prescribing or ordering of therapy, n = 37). This set of studies included 41 good-quality, 28 fair-quality, and 6 poor-quality studies. ○ <i>Provision of a recommendation, not just an assessment</i> (OR of 1.50, 95% CI of 1.30 to 1.74 for adherence to preventive care, n = 18; OR of 2.01, 95% CI of 1.63 to 2.48 for ordering of clinical studies, n = 15; OR of 1.61, 95% CI of 1.34 to 1.93 for prescribing or ordering of therapy, n = 36). This set of studies included 43 good-quality, 22 fair-quality, and 5 poor-quality studies.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
KQ 2 (continued)		<ul style="list-style-type: none"> • The meta-analysis also identified 6 additional factors/features that were correlated with the success of CDSSs: <ul style="list-style-type: none"> ○ <i>Integration with charting or order entry system to support workflow integration</i> (OR of 1.47, 95% CI of 1.21 to 1.77 for adherence to preventive care, n = 13; OR of 1.56, 95% CI of 1.29 to 1.87 for ordering of clinical studies, n = 9; OR of 1.67, 95% CI of 1.39 to 2.00 for prescribing or ordering of therapy, n = 36). This set of studies included 39 good-quality, 19 fair-quality, and 3 poor-quality studies. ○ <i>No need for additional clinician data entry</i> (OR of 1.43, 95% CI of 1.22 to 1.69 for adherence to preventive care, n = 16; OR of 1.58, 95% CI of 1.31 to 1.89 for ordering of clinical studies, n = 11; OR of 1.78, 95% CI of 1.44 to 2.19 for prescribing or ordering of therapy, n = 30). This set of studies included 38 good-quality, 19 fair-quality, and 1 poor-quality studies. ○ <i>Promotion of action rather than inaction</i> (OR of 1.28, 95% CI of 1.09 to 1.50 for adherence to preventive care, n = 15; OR of 1.52, 95% CI of 1.23 to 1.87 for ordering of clinical studies, n = 9; OR of 1.71, 95% CI of 1.35 to 2.16 for prescribing or ordering of therapy, n = 22). This set of studies included 31 good-quality, 13 fair-quality, and 2 poor-quality studies. ○ <i>Justification of decision support via provision of research evidence</i> (OR of 1.60, 95% CI of 1.04 to 2.46 for adherence to preventive care, n = 5; OR of 2.93, 95% CI of 1.40 to 6.12 for ordering of clinical studies, n = 5; OR of 1.59, 95% CI of 1.13 to 2.24 for prescribing or ordering of therapy, n = 15). This set of studies included 17 good-quality, 4 fair-quality, and 2 poor-quality studies. ○ <i>Local user involvement in development process</i> (OR of 1.45, 95% CI of 1.23 to 1.73 for adherence to preventive care, n = 11; OR of 1.41, 95% CI of 1.18 to 1.70 for ordering of clinical studies, n = 10; OR of 1.90, 95% CI of 1.38 to 2.61 for prescribing or ordering of therapy, n = 20). This set of studies included 26 good-quality, 11 fair-quality, and 5 poor-quality studies. ○ <i>Provision of decision support results to patients as well as providers</i> (OR of 1.18, 95% CI of 1.02 to 1.37 for adherence to preventive care, n = 5; OR of 1.41, 95% CI of 1.26 to 1.58 for ordering of clinical studies, n = 5; OR of 1.97, 95% CI of 1.20 to 3.21 for prescribing or ordering of therapy, n = 5). This set of studies included 7 good-quality, 5 fair-quality, and 3 poor-quality studies.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
		<ul style="list-style-type: none"> Many studies included more than one feature/factor, and because the studies did not specifically evaluate whether the systems with and without an individual factor/feature differed in terms of their impact on the outcome of interest, it was difficult to determine the importance of individual factors/features.
KQ 3: What is the impact of introducing electronic knowledge management and CDSSs?		
3a. Changes in the organization of health care delivery	Insufficient	<ul style="list-style-type: none"> Of the eligible studies, none examined the impact of CDSSs/KMSs on changes in the organization of health care delivery.
3b. Changes in the workload and efficiency for the user		
Number of patients seen/unit time	Insufficient	<ul style="list-style-type: none"> Of the eligible studies, none examined the impact of CDSSs/KMSs on the number of patients seen/unit time.
Clinician workload	Insufficient	<ul style="list-style-type: none"> Of the eligible studies, none examined the impact of CDSSs/KMSs on clinician workload.
Efficiency	Low	<ul style="list-style-type: none"> 7 studies (4.7%) examined the impact of CDSSs/KMSs on efficiency (3 good-quality and 4 fair-quality studies). From these studies, there is limited evidence that CDSSs/KMSs demonstrated a trend toward improving efficiency.
3c. Changes in health care process measures and clinical outcomes		
<i>Health care process measures</i>		
Recommended preventive care service ordered/completed	High	<ul style="list-style-type: none"> 43 studies (29.1%) examined the impact of CDSSs/KMSs on ordering or completing recommended preventive care services. This set of studies included 20 good-quality, 16 fair-quality, and 7 poor-quality studies. A meta-analysis of 25 studies (58.1%) that provided sufficient data to calculate a common endpoint indicated that CDSSs increased preventive care service ordered/completed, with an odds ratio of 1.42 (95% CI 1.27 to 1.58). This set of studies included 13 good-quality, 10 fair-quality, and 2 poor-quality studies.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
		<ul style="list-style-type: none"> There is strong evidence from studies conducted in the academic, VA, and community inpatient and ambulatory settings that locally and commercially developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response were effective at improving the appropriate ordering of preventive care procedures.
Recommended clinical study ordered/completed	Moderate	<ul style="list-style-type: none"> 29 studies (19.6%) examined the impact of CDSSs/KMSs on the ordering and completion of recommended clinical studies. This set of studies included 16 good-quality, 9 fair-quality, and 4 poor-quality studies. A meta-analysis of 20 studies (69%) that provided sufficient data to calculate a common endpoint indicated that CDSSs increased appropriate clinical studies ordered/completed, with an odds ratio of 1.72 (95% CI 1.47 to 2.00). This set of studies included 11 good-quality, 5 fair-quality, and 4 poor-quality studies. There is modest evidence from studies conducted in the academic and community inpatient and ambulatory settings that CDSSs integrated in CPOE or EHR systems and locally and commercially developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response were effective at improving the appropriate ordering of clinical studies.
Recommended treatment ordered/prescribed	High	<ul style="list-style-type: none"> 67 studies (45.3%) examined the impact of CDSSs/KMSs on the ordering or prescribing of therapy. This set of studies included 35 good-quality, 24 fair-quality, and 8 poor-quality studies. A meta-analysis of the 46 studies (68.7%) that provided sufficient data to calculate a common endpoint indicated that CDSSs increased treatment ordered/prescribed, with an odds ratio of 1.57 (95% CI 1.35 to 1.82). This set of studies included 28 good-quality, 15 fair-quality, and 3 poor-quality studies. There is strong evidence from the academic, community, and VA inpatient and ambulatory settings that locally and commercially developed CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response were effective at improving appropriate treatment ordering/prescribing.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
Impact on user knowledge	Insufficient	<ul style="list-style-type: none"> 5 studies (3.4%) examined the impact of CDSSs/KMSs on user knowledge. This set of studies included 0 good-quality, 4 fair-quality, and 1 poor-quality studies.
<i>Clinical outcomes</i>		
Length of stay	Low	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on length of stay. All studies in this set were rated as good quality. A meta-analysis of 5 studies (83.3%) that provided sufficient data to calculate a common endpoint indicated a combined relative risk of 0.96 (95% CI 0.88 to 1.05). Although all of the studies were high-quality and 4 were evaluated with > 2000 patients, only 1 study was evaluated for ≥ 1 year. There is limited evidence that CDSSs that automatically delivered system-initiated (push) recommendations to providers were effective at reducing length of stay or demonstrated a trend toward reducing length of stay.
Morbidity	Moderate	<ul style="list-style-type: none"> 22 studies (14.9%) examined the impact of CDSSs/KMSs on morbidity. This set of studies included 13 good-quality, 7 fair-quality, and 2 poor-quality studies. A meta-analysis of 16 studies (72.7%) that provided sufficient data to calculate a common endpoint indicated a combined relative risk of 0.88 (95% CI 0.80 to 0.96). This set of studies included 11 good-quality, 3 fair-quality, and 2 poor-quality studies. There is modest evidence from the academic and community inpatient and ambulatory settings that locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care were effective or demonstrated a trend toward reducing patient morbidity.
Mortality	Low	<ul style="list-style-type: none"> 7 studies (4.7%) examined the impact of CDSSs/KMSs on mortality. This set of studies included 6 good quality and 1 fair-quality studies. A meta-analysis of 6 studies (85.7%) that provided sufficient data to calculate a common endpoint indicated a combined odds ratio of 0.79 (95% CI 0.54 to 1.15). This set of studies included all good-quality studies. Although the majority of the studies were high-quality, less than half of the studies were evaluated for ≥ 1 year or with > 2000 patients. There is limited evidence that CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers were effective at reducing patient mortality or demonstrated a trend toward reducing patient mortality.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
Health-related quality of life	Low	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on health-related quality of life. This set of studies included 3 good-quality, 2 fair-quality, and 1 poor-quality studies. The majority of these studies were evaluated for ≥ 1 year and included a sample size between 500 and 1000. There is limited evidence from the ambulatory setting that locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers demonstrated a trend toward higher quality-of-life scores.
Adverse events	Low	<ul style="list-style-type: none"> 5 studies (3.4%) examined the impact of CDSSs/KMSs on adverse events. This set of studies included 3 good-quality, 1 fair-quality, and 1 poor-quality studies. A meta-analysis of the 5 studies (100%) reported a combined relative risk of 1.01 (95% CI 0.90 to 1.14). Although the majority of the studies were high quality, most were evaluated for < 1 year and did not include a sample size > 2000 patients. There is limited evidence from the academic setting that CDSSs that delivered recommendations to providers synchronously at the point of care demonstrated an effect on reducing or preventing adverse events.
<i>Economic outcomes</i>		
Cost	Moderate	<ul style="list-style-type: none"> 22 studies (14.9%) examined the impact of CDSSs/KMSs on cost. This set of studies included 10 good-quality, 7 fair-quality, and 5 poor-quality studies. The majority of the studies that demonstrated a trend toward lower costs and greater cost savings were evaluated for < 1 year but were evaluated with ≥ 2000 patients. There is modest evidence from the academic and community inpatient and ambulatory settings that locally and commercially developed CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care demonstrated a trend toward lower treatment costs, total costs, and greater cost-savings than did the control groups and other non-CDSS intervention groups.

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
Cost-effectiveness	Insufficient	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on cost-effectiveness. This set of studies included 1 good-quality, 5 fair-quality, and 0 poor-quality studies. There is conflicting evidence from the ambulatory setting regarding the cost-effectiveness of CDSSs that delivered recommendations to providers synchronously at the point of care. Some studies demonstrated a trend toward cost-effectiveness; however, one of the included key articles reported a negative impact of CDSSs on cost-effectiveness, and therefore our confidence in the impact is additionally lessened.
<i>Use and implementation outcomes</i>		
Health care provider acceptance	Low	<ul style="list-style-type: none"> 24 studies (16.2%) examined the impact of CDSSs/KMSs on health care provider acceptance. This set of studies included 9 good-quality, 11 fair-quality, and 4 poor-quality studies. Studies that reported on health care provider acceptance suggested that high levels of acceptance (acceptance rate > 75%) of recommendations from CDSSs are the exception rather than the rule. Many successful CDSS studies did not report acceptance.
Health care provider satisfaction	Moderate	<ul style="list-style-type: none"> 19 studies (12.8%) examined the impact of CDSSs/KMSs on health care provider satisfaction. This set of studies included 9 good-quality, 7 fair-quality, and 3 poor-quality studies. The majority of these studies were evaluated for < 1 year and only 2 included a sample size > 2000 patients. CDSSs that fostered high satisfaction among providers were implemented within the academic, community, and VA ambulatory settings; integrated in CPOE or EHR systems; locally and commercially developed; and automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response.
Health care provider use	Low	<ul style="list-style-type: none"> 17 studies (11.5%) examined the impact of CDSSs/KMSs on health care provider use. This set of studies included 5 good-quality, 10 fair-quality, and 2 poor-quality studies. The majority of the included studies documented low usage (< 50% of time or patient visits), or less than half of clinicians used the CDSS or received alerts to guide therapeutic action; only one study documented usage over 80%. Among studies evaluating clinical or economic outcomes, none of these studies demonstrated provider use of CDSSs > 80%.
Implementation	Insufficient	<ul style="list-style-type: none"> 5 studies (3.4%) examined the impact of CDSSs/KMSs on implementation in practice. This set of studies included 0 good-quality, 3 fair-quality, and 2 poor-quality studies

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
Cost-effectiveness	Insufficient	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on cost-effectiveness. This set of studies included 1 good-quality, 5 fair-quality, and 0 poor-quality studies. There is conflicting evidence from the ambulatory setting regarding the cost-effectiveness of CDSSs that delivered recommendations to providers synchronously at the point of care. Some studies demonstrated a trend toward cost-effectiveness; however, one of the included key articles reported a negative impact of CDSSs on cost-effectiveness, and therefore our confidence in the impact is additionally lessened.
		<ul style="list-style-type: none"> There is insufficient evidence for how CDSSs/KMSs impacted implementation in practice, and no high-quality studies specifically examined this outcome.
<i>Relationship-centered outcomes</i>		
Patient satisfaction	Insufficient	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on patient satisfaction. This set of studies included 4 good-quality, 1 fair-quality, and 1 poor-quality studies. Although the majority of the studies were high quality and most reported that intervention patients were more satisfied with the care received or overall visit, it was difficult to assess the overall level of the evidence since each study used different metrics to evaluate patient satisfaction. There is limited evidence that clinician use of CDSSs had a positive effect on patient satisfaction.
KQ 4: What generalizable knowledge can be integrated into electronic knowledge management and CDSSs to improve health care quality?		
4a. Knowledge from published evidence about electronic knowledge management and CDSSs to improve health care quality based on different types of measures (health care process, relationship-centered, clinical, economic)	Not applicable	<ul style="list-style-type: none"> The most common source of knowledge incorporated into CDSSs/KMSs was derived from structured care protocols (61 studies, 41.2%) and clinical practice guidelines (42 studies, 28.4%) that focused on a single or limited set of medical conditions. <p>This set of studies included 56 good-quality, 33 fair-quality, and 15 poor-quality studies.</p>
4b. How a clinician's expertise/proficiency/informatics competency using the electronic knowledge management and	Not applicable	<ul style="list-style-type: none"> 53 studies (35.8%) reported data on clinician expertise in using CDSSs/KMSs although the definition and reporting of this expertise was variable and the relationship between this expertise and patient outcomes was sparse. Clinician expertise was not reported in 59 of the included studies (39.9%).

Table C. Summary of findings (continued)

Key Question	Strength of Evidence	Conclusions
Cost-effectiveness	Insufficient	<ul style="list-style-type: none">• 6 studies (4.1%) examined the impact of CDSSs/KMSs on cost-effectiveness. This set of studies included 1 good-quality, 5 fair-quality, and 0 poor-quality studies.• There is conflicting evidence from the ambulatory setting regarding the cost-effectiveness of CDSSs that delivered recommendations to providers synchronously at the point of care. Some studies demonstrated a trend toward cost-effectiveness; however, one of the included key articles reported a negative impact of CDSSs on cost-effectiveness, and therefore our confidence in the impact is additionally lessened.
CDSS affects patient outcomes (one type of measure)		<ul style="list-style-type: none">• In 36 studies (24.3%), CDSS/KMS recommendations were delivered using a paper-based format, so clinician expertise in using the CDSS/KMS was not relevant.

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, CPOE = computerized physician order entry, EHR = electronic health record, KMS = knowledge management system, OR = odds ratio

Discussion

We conducted a systematic review of the indexed medical literature to (1) determine what study designs have been used to evaluate the effectiveness of CDSSs/KMSs, (2) assess factors/features of CDSSs/KMSs that predict a successful clinical impact, (3) identify the best evidence concerning the impact of CDSSs/KMSs on a broad set of outcomes, and (4) identify the types of knowledge that can be integrated into CDSSs/KMSs. We also sought to identify gaps in the available evidence about the effectiveness of CDSSs/KMSs. We screened 15,176 abstracts and manuscripts dating back to 1976, from which we identified 311 comparative studies—of which 148 were RCTs. Studies with similar outcomes and common endpoints were combined to conduct meta-analyses. This review investigated the continuum of information support for clinical care, including classic CDSSs as well as information retrieval systems and knowledge resources developed for access at the point of care.

Of the 311 evaluative studies assessing CDSSs/KMSs, 47.5 percent were RCTs (148 studies), 38.9 percent were quasi-experimental studies (121 studies), and 13.5 percent were observational studies (42 studies). Using meta-analysis on studies that evaluated adherence to preventive care, ordering a clinical study, and prescribing a treatment as an outcome, we confirmed three previously reported factors/features associated with successful CDSS/KMS implementations and identified six additional factors/features. These nine factors/features included general system features, clinician-system interaction features, communication content features, and auxiliary features. These factors/features were present across the breadth of CDSS/KMS implementations in diverse venues using both locally and commercially developed systems. With regard to outcomes, we discovered strong evidence that CDSSs/KMSs that included the nine success factors/features favorably impacted health care processes, including facilitating preventive care services, ordering clinical studies, and prescribing treatments. This effect on health care processes spanned diverse venues and systems. In contrast to previous observations—where most reports of successful clinical decision support implementation were based on locally developed systems at four sites—this effect has now been observed at diverse community sites using commercially developed systems. In terms of CDSS knowledge sources, the most common source of knowledge incorporated into CDSSs was derived from structured care protocols (61 studies) and clinical practice guidelines (42 studies) that focused on a single or limited set of medical conditions.

Summary of Weaknesses or Gaps in the Evidence

We found that evidence demonstrating positive effects of clinical decision support on clinical and economic outcomes remains limited. These trends can likely be attributed to the relative difficulty of implementing RCT studies in real clinical settings as well as to logistical issues involved in measuring the direct clinical impact of CDSS/KMS interventions. We also found limited evidence showing an impact of clinical decision support on clinical workload and efficiency.

In spite of a favorable trend to fill a gap identified by a previous evidence report, which described insufficient data on commercial CDSSs/KMSs in community settings, the literature still lacks evidence about how the effectiveness of CDSSs to support wide-scale application for

the meaningful use of EHRs is affected by (1) the content of CDSSs, (2) the recipients of clinical decision support, (3) the types of outcomes reported in CDSS evaluations, and (4) the issues related to implementation and deployment of CDSSs.

Most of the published RCTs on CDSSs focused on a single or limited set of conditions. Studies are needed to determine how clinical decision support can be provided for multiple health issues simultaneously. Such studies will need to address reconciliation of advice across diverse combinations of comorbid conditions, prioritization of recommendations, and avoidance of “alert fatigue.” In a second issue related to CDSS/KMS content, we found a paucity of studies on KMSs (only three RCTs identified). Accordingly, studies need to be initiated to generate rigorous evidence to determine how information retrieval systems and point-of-care knowledge resources can most effectively be used to improve health care.

With regard to the recipients of clinical decision support, most studies concentrated on decision support delivered to physicians. As health care migrates to more team-oriented delivery models, future studies will need to investigate which care team members should receive clinical decision support advice to optimize effectiveness.

In the area of outcomes, relatively few studies reported clinical outcomes and even fewer addressed the cost implications of clinical decision support.

Finally, with regard to deficiencies in the best literature, we discovered relatively few RCTs that rigorously evaluated issues related to CDSS implementation, workflow, and the delivery of care. In a similar vein, we found few studies that investigated how CDSSs could be effectively ported to different settings. Most of the reports focused on the use of a CDSS at a single institution or at closely related institutions. The portability issue will need to accommodate the discovery that user involvement in CDSS development is a feature associated with successful implementation.

To frame the context for the relevance of this report, we highlight the increasing political interest and financial investment of the U.S. government in resources for health information technology. The meaningful use of CDSSs/KMSs needs to be objectively informed regarding the role that CDSSs/KMSs can and should play in the reshaping of health care delivery. Stage 1 meaningful use guidelines specify the implementation of a single clinical decision support rule. Ensuring successful CDSS implementation across the national landscape and preparing for the subsequent rounds of meaningful use standards is no longer just about getting the “right” information to the “right” person. Moving clinical decision support from isolated implementations at well-established institutions to broad penetration will require a better understanding of what the right information is and when and how it is delivered to the right person.

Ideally, the requirements for Stages 2 and 3 of meaningful use need to be more direct and based on demonstrated evidence of clinical effectiveness of CDSS tools. For example, a recent summary report has identified the lack of integration of health information technology into clinician workflow in a meaningful way as a potential contributor to the mixed success of clinical decision support. It follows, therefore, that further understanding is needed about when to provide decision support that fits into clinician workflow and workload and how such support translates into provider acceptance, satisfaction, and improved quality of care. Another gap we identified from the evidence that may have consequences for the meaningful use of clinical decision support is how to best present the knowledge to providers.

Limitations of the Review Process

Our systematic review has several limitations. First, we acknowledge a publication bias in that studies with positive outcomes are more likely than negative studies to be reported in the medical literature. Accordingly, the literature favors features that lead to CDSS success and may underreport features that result in CDSS implementation failures. In terms of reporting, this literature is also likely to contain a bias for the selective reporting of favorable outcomes at the exclusion of unfavorable outcomes. We explored the possibility of publication bias, and there was no consistent bias for most endpoints. The one exception was the clinical study adherence where there was a strong suggestion of publication bias. Thus, these results should be viewed with caution.

A second limitation of the literature is that the studies were extremely heterogeneous with regard to the systems, populations, settings, and outcomes. Consequently, it was difficult to derive general observations about CDSSs since each system and setting had unique characteristics that may be critical but not identified or transferable. We sought to minimize this limitation in our meta-analysis by including studies with a common endpoint within the outcome categories; still, it was difficult to isolate the effect of individual factors or features.

A third limitation is that we chose to concentrate primarily on RCTs for the bulk of the evidence for this report and thus excluded findings from quasi-experimental and observational studies. While RCTs provided the best evidence on CDSS effectiveness, these RCTs may provide less information regarding issues related to CDSS implementation, impact on workflow, and factors affecting usability.

A fourth limitation is related to the variable descriptions of intervention details provided in each publication. We abstracted specific data pertaining to the design and user interaction with each system that were commonly reported in informatics journal publications but which were less frequently described in clinically oriented publications. Conceivably, some studies did not report detailed system descriptions due to article length restrictions.

Implications for Future Research

Future research in the effectiveness of CDSSs/KMSs needs to investigate issues related to the breadth of content, content delivery, decision support recipients, outcomes, and implementation. First, in the area of content, CDSSs/KMSs need to mature to the next generation, in which the breadth of comorbid conditions for a given patient is routinely addressed. Such studies will need to explore how advice about multiple care issues and disparate CDSSs/KMSs can be reconciled and how recommendations should be prioritized to avoid alert fatigue. Additionally, further investigation is needed to better understand (1) how local adoption of general knowledge into CDSSs/KMSs affects outcomes and provider acceptance, (2) whether specific types of general knowledge are better suited for implementation in CDSSs/KMSs, and (3) how differences in types of general knowledge contained in locally developed and commercially developed CDSSs/KMSs improve health care quality.

Along related lines of inquiry, studies are also needed to determine how CDSS/KMS content can be delivered most effectively for each CDSS/KMS niche. Such studies can determine if interruptive (pop-up alerts and reminders) or noninterruptive (order sets, smart forms, dashboards) are preferable; or how users should interact with the content from a specific type of CDSS (push versus pull, mandatory versus voluntary versus no user response, explanation versus no explanation for noncompliance, etc.). Future studies will also need to explore who the optimal recipients of clinical decision support advice should be. With the growth of team-based care delivery models, studies are needed to ascertain who on the team, other than physicians, should receive which type of advice, how the delivery of advice can be orchestrated to facilitate team-based care coordination, and how the delivery of advice can be best integrated into team-based care.

More studies are needed to demonstrate how CDSSs/KMSs can be part of comprehensive programs designed to impact hard clinical outcomes to make real differences in health and wellness and not just improve health care process measures. Additionally, the costs of CDSSs/KMSs need to be investigated, and the economic attractiveness of CDSSs/KMSs needs to be determined. The case needs to be made for cost-effectiveness and subsequent return on investment in order to promote and expand CDSS/KMS utilization. Future studies also need to explore the unintended consequences of CDSSs/KMSs, particularly as multiple comorbid conditions are included and recommendations are delivered to multiple members of a care delivery team. As outcomes are measured with disparate CDSSs/KMSs in diverse environments, the need to standardize metrics and models for workload, efficiency, costs, health care process measures, and clinical outcomes across systems will need to be addressed. Research is needed to determine what metrics best assess CDSS/KMS effectiveness and how these metrics can be standardized. Standardization of these outcomes and metrics will also facilitate the evaluation of CDSSs/KMSs.

Finally, in the area of future investigation, studies evaluating the impact of KMSs are needed across the board. The KMS field is in its infancy, and such studies need to demonstrate when and how knowledge retrieval systems and point-of-care knowledge references are effective and useful. For both CDSSs and KMSs, additional research is needed to determine the best study designs to evaluate the effectiveness of these interventions.

With regard to promoting extensive use of CDSSs/KMSs, the following important needs must be addressed. First, there is a need for consistent underlying frameworks for describing CDSSs such as the “CDS Five Rights” to aid in the aggregation and synthesis of results. Second, models for porting CDSSs/KMSs across settings will need to be developed and evaluated. Studies will need to validate the concept of clinical decision support knowledge sharing across applications and institutions as proposed in recent position papers. Can centralized knowledge repositories be effective in meeting CDSS/KMS needs for the region or the nation as a whole? At the level of individual systems, it will be useful to identify which CDSS/KMS features genuinely make a difference in effectiveness and user satisfaction. Third, from the analysis conducted through this report, we have identified a cluster of features associated with a favorable impact of a CDSS/KMS; however, many features are interrelated, and the available studies do not allow us to isolate individual features or even feature groups. As CDSSs/KMSs become more ubiquitous, studies can be performed that assess them with and without selected features in order to determine with greater clarity the relative importance of individual features.

Fourth, in addition to the features of the CDSS/KMS itself, characteristics of the environment and workflow in which a CDSS/KMS is deployed and characteristics of the intended users need

to be identified and investigated so that the impact of these characteristics on the success of the CDSS/KMS can be determined. Fifth, well-described RCTs are most needed to investigate the impact of those characteristics; however, exploration into the strengths and limitations of the evidence provided by quasi-experimental and observational studies is also warranted. Once the system, environment, workflow, and user characteristics are delineated with regard to their influence on CDSS/KMS effectiveness, the system, environment, workflow, and users can be proactively adapted to optimize CDSS/KMS integration. Lastly, as CDSSs/KMSs continue to play a critical role in health care reform, future research is needed to understand (1) how CDSSs/KMSs can aid in the transformation of care delivery models such as accountable care organizations and patient-centered medical homes, (2) how to integrate CDSSs/KMSs with workflow tools such as medical registries and provider-provider messaging capabilities, and (3) how to integrate CDSSs/KMSs with workflow-oriented quality improvement programs.

Glossary

AHRQ	Agency for Healthcare Research and Quality
CI	confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CDSS	clinical decision support system
CPOE	computerized physician/provider order entry
EHR	electronic health record
KMS	knowledge management system
OR	odds ratio
RCT	randomized controlled trial

References

Please refer to the reference list in the full report for documentation of statements contained in the Executive Summary.

Introduction

Background

This evidence report is part of a three-report series focusing on the strategic goals of the Agency for Healthcare Research and Quality's (AHRQ's) health information technology portfolio. The first report addresses the use of health information technology to improve the quality and safety of medication management. The second report investigates the use of health information technology to support patient-centered care, coordination of care, and electronic exchange of health information to improve quality of care. This report specifically explores facilitating health care decisionmaking through health information technology. Supporting health care decisionmaking is a core element of the meaningful use criteria for electronic health records (EHRs).¹ As the expected level of sophistication of EHRs increases in the evolving definitions of meaningful use, the need for more sophisticated electronic clinical decision support systems and knowledge management systems (CDSSs/KMSs) is imperative, as is the need for better operational use of these systems. This increasing importance of CDSSs/KMSs acknowledges that EHRs alone are not an end but are instead a tool to augment the delivery of safe, evidence-based, high-quality health care through more consistent and sound decisionmaking.

Scope and Key Questions

Efforts to improve the quality and value of health care increasingly emphasize a critical role for the meaningful use of CDSSs/KMSs. Examples of electronic CDSSs include alerts, reminders, order sets, drug-dosage calculations, and care-summary dashboards that provide performance feedback on quality indicators or benchmarks. By comparison, examples of electronic KMSs include information retrieval tools and electronic resources that consist of distilled primary literature on evidence-based practices. The objective of clinical decision support is to apply clinical knowledge in the context of patient-specific information to aid clinicians in the process of making decisions. Electronic KMSs can further support decisionmaking in any care situation by providing a range of strategies and resources to create, represent, and distribute knowledge for application by a provider in clinical practice. As a form of health information technology, CDSSs/KMSs can serve as information tools to align clinician decisionmaking with best practice guidelines and evidence-based medical knowledge at the point of care as well as to assist with information management to support clinicians' decisionmaking abilities. Ultimately, when used effectively, CDSSs/KMSs can reduce workloads and improve both the quality of the health care outcomes and the efficiency of care delivery.² However, in order to improve the quality of health care, CDSSs/KMSs need to be effectively integrated into the process of routine care so that the right action to take becomes the easiest action to take and the action best supported by clinical evidence.

In spite of the increasing emphasis on the role of CDSSs/KMSs in improving care and lowering costs, substantial evidence supporting the widespread general use and effectiveness of

CDSSs/KMSs is still lacking. Until recently, most of the studies of CDSSs/KMSs have arisen out of four benchmark settings (Brigham and Women's Hospital/Partners Health Care, Department of Veterans Affairs, LDS Hospital/Intermountain Health Care, and Regenstrief Institute).³ Additionally, few studies report about the ways in which CDSSs/KMSs have been used optimally or about the features of a CDSS/KMS that lead to effective, sustained impact across a variety of clinical settings. Accordingly, a systematic review of the best research literature pertaining to CDSSs/KMSs was warranted in order to determine what is known about CDSSs/KMSs and what is lacking in our current understanding.

The key questions (KQs) considered in this systematic review were:

- **KQ 1:** What evidence-based study designs have been used to determine the clinical effectiveness of electronic knowledge management and CDSSs?
- **KQ 2:** What contextual factors/features influence the effectiveness or success of electronic knowledge management and CDSSs?
- **KQ 3:** What is the impact of introducing electronic knowledge management and CDSSs?
 - 3a. Changes in the organization of health care delivery
 - 3b. Changes in the workload and efficiency for the user
 - 3c. Changes in health care process measures and clinical outcomes
- **KQ 4:** What generalizable knowledge can be integrated into electronic knowledge management and CDSSs to improve health care quality?
 - 4a. Knowledge from published evidence about electronic knowledge management and CDSSs to improve health care quality based on different types of measures (health care process, relationship-centered, clinical, economic)
 - 4b. How a clinician's expertise/proficiency/informatics competency using the electronic knowledge management and CDSS affects patient outcomes (one type of measure)

Methods

In this chapter, we document the procedures used by the Duke Evidence-based Practice Center (EPC) to develop this systematic review of the evidence regarding health care decisionmaking through clinical decision support and knowledge management systems. To provide a context for the review, we first describe the role of the Technical Expert Panel (TEP). Next, we describe the topic development and present the KQs and analytic framework. We discuss the methods used to identify articles relevant to our KQs, our inclusion and exclusion criteria, and the process we used to abstract relevant information from eligible articles and generate our evidence tables. We discuss our criteria for evaluating the quality of individual articles and synthesizing the evidence. Finally, we describe the peer review process.

Role of the Technical Expert Panel

We identified experts in the fields of CDSS and KMS to serve as members of the project's TEP. We specifically selected individuals who had years of experience working with CDSSs/KMSs and who represented a broad range of perspectives, including CDSS/KMS developers, implementers, evaluators, policymakers, catalogers, and standards makers. Panel members had experience in both academic and industry environments. The TEP contributed to AHRQ's broader goals of (1) creating and maintaining science partnerships and public-private partnerships and (2) meeting the needs of an array of potential customers and users of this report. To ensure accountability and scientifically relevant work, we asked TEP members for input at key stages of the project. More specifically, TEP members participated in conference calls and email exchanges to refine the analytic framework and key questions at the beginning of the project, refine the scope, discuss inclusion and exclusion criteria, and provide input on methodology.

Members of our TEP were:

- Joan Ash, Ph.D., M.L.S., M.S., M.B.A., Associate Professor, Oregon Health & Science University (Portland, OR)
- David W. Bates, M.D., M.Sc., Medical Director, Clinical and Quality Analysis, Partners Healthcare System, Inc., and Professor of Medicine, Harvard Medical School (Boston, MA)
- Eta S. Berner, Ed.D., F.A.C.M.I., F.H.I.M.S.S., Professor, Health Informatics Program, Department of Health Services Administration, University of Alabama, Birmingham (Birmingham, AL)
- R. Brian Haynes, M.D., M.Sc., Ph.D., F.R.C.P.C., F.A.C.M.I., DeGroote School of Medicine, McMaster University (Hamilton, Ontario, Canada)
- Blackford Middleton, M.D., M.P.H., M.Sc., F.A.C.P., F.A.C.M.I., F.H.I.M.S.S., Corporate Director Clinical Informatics Research and Development, Partners Healthcare System, Inc., Center for Information Technology Leadership (Wellesley, MA)
- Ida Sim, M.D., Ph.D., Associate Professor of Medicine, Division of General Internal Medicine, and Director, Center for Clinical and Translation Informatics, University of California (San Francisco, CA)

- Dean F. Sittig, Ph.D., Associate Professor, University of Texas School of Health Information Sciences (Houston, TX)
- Paul C. Tang, M.D., M.S., Palo Alto Medical Foundation (Los Altos, CA)

Topic Development and Refinement

The specific aim of clinical decision support is to provide patient-specific recommendations generated through a comparison of patient information with a knowledge resource.^{4,5} In general, CDSSs/KMSs can enhance clinical effectiveness by improving the quality of care⁶ and patient outcomes by aiding health care providers in the decisionmaking process.^{7,8} However, in order for CDSSs/KMSs to improve the quality of health care, there needs to be evidence-based and practice-based information that provides evidentiary knowledge applicable to the clinical setting and the clinician and patient interaction.

Within electronic KMSs and CDSSs, there is a continuum of decision support interventions that have the goal of obtaining knowledge to inform a decision at the point of care or for a specific care situation. Table 1 further characterizes this continuum by showing three types of decision support interventions and how context-specific queries are processed by these interventions to submit patient-specific information and generate patient-specific recommendations. This report examines each type of decision support tool presented in the table.

Table 1. Continuum of decision support

Types of decision support interventions	Classic clinical decision support	Information retrieval tool	Knowledge resource
Example	Preventive care reminder	Infobutton	Epocrates
Process: Submit patient-specific information	Automated (computer)	Automated (computer)	Manual (human)
Process: Generate patient-specific recommendation	Automated (computer)	Manual (human)	Manual (human)

A **classic clinical decision support system** is defined as “any electronic system designed to aid directly in clinical decisionmaking, in which characteristics of individual patients are used to generate patient-specific assessments or recommendations that are then presented to clinicians for consideration.”⁹ An example of a classic CDSS is a preventive care reminder to remind the clinician of a specific action. For this type of decision support, the processes to submit patient-specific information and generate patient-specific recommendations are automated and performed by a computer.

A **knowledge management system** is defined as a tool that selectively provides information tailored to the characteristics or circumstances of a specific patient. Functionally, KMSs can be classified as information retrieval tools or knowledge resources.

An **information retrieval tool** is defined as an electronic tool designed to aid clinicians in the search and retrieval of context-specific knowledge from information sources based on patient-specific information from a clinical information system to facilitate decisionmaking at

the point of care or for a specific care situation. An example of an information retrieval tool is an info button embedded in a clinical information system, such as an EHR, that when selected provides context-specific links to various information sources. For this type of information support, the process to submit patient-specific information is automated and performed by a computer, and the process to generate patient-specific recommendations is manually performed by a human.

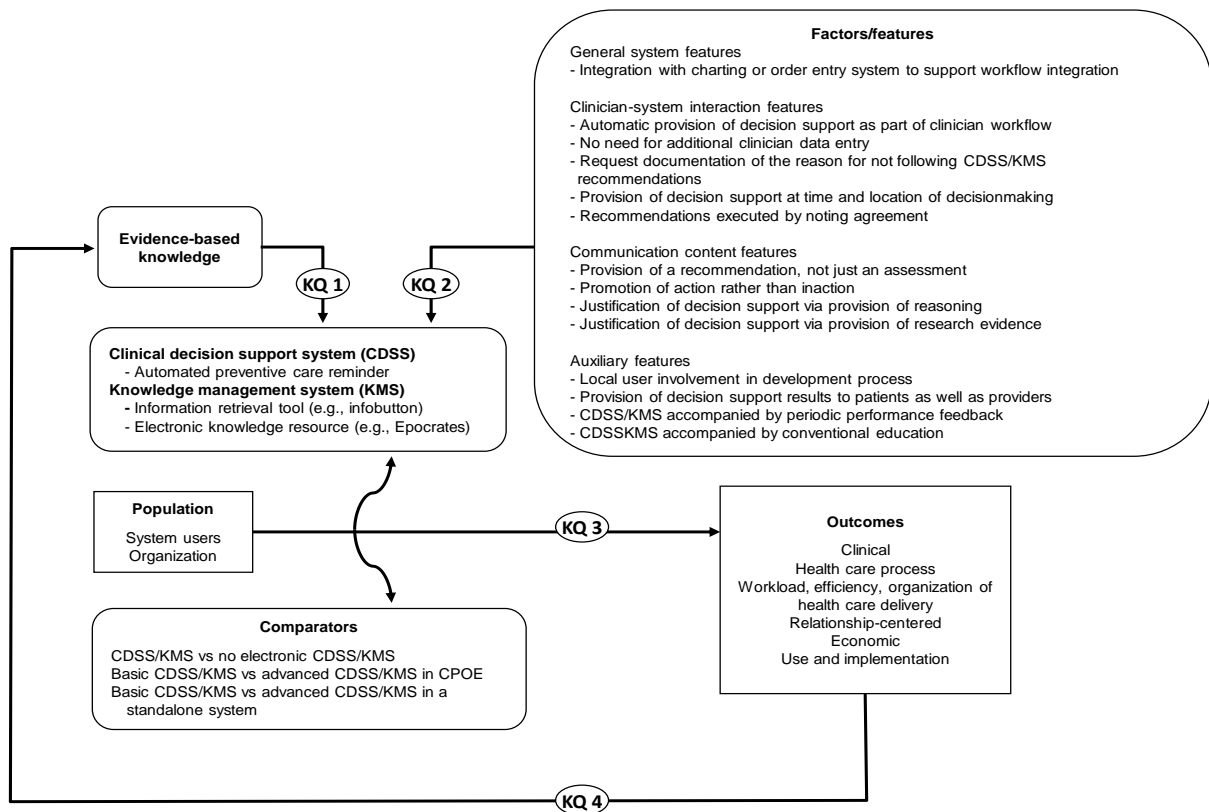
A **knowledge resource** is defined as an electronic resource comprising distilled primary literature that allows selection of content that is germane to a specific patient in order to facilitate decisionmaking at the point of care or for a specific care situation. Examples of knowledge resources include UpToDate, Epocrates[®], and MDConsult. For this type of decision support, the processes to submit patient-specific information and generate patient-specific recommendations are manually performed by a human.

Several previous reviews^{5,9-15} have examined the effects of CDSSs/KMSs. However, because different research inclusion and exclusion criteria were employed—which often included limitations for publication date, clinical setting (e.g., ambulatory, inpatient care), outcomes (e.g., clinical, process), or type/scope of CDSS (e.g., computerized reminders, computerized guidelines); narrowly-defined search strategies; exclusion of electronic information retrieval tools and knowledge resources; limited emphasis of what determines successful use and implementation of CDSSs and how those factors influence clinical outcomes and health care process measures—there are many unanswered questions regarding the impact of these tools in clinical practice and on patient outcomes. This report targets knowledge gaps from previous reviews as reflected in the KQs and evaluates the peer-reviewed research literature to provide information that will be useful for policymakers and decisionmakers engaged in using CDSSs and KMSs.

Analytic Framework

The analytic framework (Figure 1) illustrates (1) how the effectiveness or success of CDSSs/KMSs is influenced by evidence-based knowledge and contextual factors/features and (2) how interactions with CDSSs/KMSs by system users and health care organizations may result in outcomes such as changes in the individual, changes in the organization, and changes in health care quality. Internally, we used the analytic framework to refine the KQs, define the literature search and inclusion criteria, and clarify assumptions and relationships between the key concepts and evidence. Externally, we used the analytic framework to guide our discussions with the members of the TEP.

Figure 1. Analytic framework



Abbreviations: CDSS = clinical decision support system, CPOE = computerized physician order entry, KMS = knowledge management system, KQ = key question

Literature Search Strategy

Sources Searched

The comprehensive literature search included electronic searching of peer-reviewed literature databases. These databases included the Cumulative Index to Nursing and Allied Health Literature (CINAHL®), Cochrane Database of Systematic Reviews, MEDLINE® accessed via PubMed®, PsycINFO®, and Web of Science®. Searches of these databases were supplemented with manual searching of reference lists contained in all included articles and in relevant review articles.

Screening for Inclusion and Exclusion

We developed a list of article inclusion and exclusion criteria for the KQs (Table 2) and modified the list after discussion with the TEP. We examined 14 factors/features of a successful CDSS/KMS identified a priori from the Kawamoto et al. (2005)⁹ review as well as specific characteristics of those interventions (listed in Table 3).

Table 2. Inclusion and exclusion criteria

Category	Criteria
Study population	System user, defined as a health care provider who interacts with the KMS or CDSS. Includes nurses, nurse practitioners, care managers, physician assistants, training MDs (residents, fellows), attending physicians or general practitioners, pharmacists. Health care organization, defined as an organization that provides access to health care services delivered by medical and allied health professionals. Includes academic and community settings, clinics, practices, hospitals, long-term care facilities.
Study design	KQ 1: All study designs KQs 2–4: RCTs (parallel group, crossover, cluster)
Factors/interventions	Implemented electronic KMS and CDSS
Comparator	CDSSs/KMSs are compared with no electronic CDSS/KMS Basic CDSS is compared with advanced CDSS in computerized physician order entry (CPOE) or EHR Basic CDSS is compared with advanced CDSS in a standalone system
Study outcomes	Clinical outcomes (length of stay, morbidity, mortality, measure of health-related quality of life, adverse events) Health care process measures (recommended preventive care, clinical study, or treatment was ordered/completed and adhered to; user knowledge) Workload, efficiency, and organization of health care delivery (number of patients seen, clinician workload, efficiency) Relationship-centered outcomes (patient satisfaction) Economic outcomes (cost and cost-effectiveness) Health care provider use and implementation (acceptance, satisfaction, use, implementation)
Timing	No restrictions
Setting	No restrictions

Table 2. Inclusion and exclusion criteria (continued)

Category	Criteria
Publication languages	English only
Admissible evidence (study design and other criteria)	<p>Study must report one or more outcomes of interest (see above criteria)</p> <p>Study must report original data</p> <p>Study must report sufficient details for data extraction and analysis</p> <p>Intervention must be implemented in a real clinical setting</p> <p>Intervention must be aimed at health care providers</p> <p>Intervention must be used to aid decisionmaking at the point of care or for a specific care situation</p> <p>Study must evaluate the effectiveness of a KMS or CDSS</p>
Exclusions	<p>Title-and-abstract level (CDSS):</p> <p>Studies that describe nonelectronic CDSS interventions</p> <p>Studies where the CDSS intervention is not implemented in a real clinical setting (laboratory setting, use of simulated cases)</p> <p>Studies where the CDSS intervention is aimed at non–health care providers (patients, caretakers, administrators, etc.)</p> <p>Studies that do not report original research (editorials, commentaries, letters to the editor, etc.)</p> <p>Title-and-abstract level (KMS):</p> <p>Studies that describe nonelectronic KMS interventions</p> <p>Studies where the KMS intervention is not used to aid decisionmaking at the point of care or for a specific care situation</p> <p>Studies where the KMS intervention does not include an evaluation of clinician use at the point of care or for a specific care situation (survey, questionnaires, content analysis, interviews, etc.)</p> <p>Studies that do not include a comparator (descriptive study)</p> <p>Studies where the KMS intervention is not implemented in a real clinical setting (laboratory setting, use of simulated cases)</p> <p>Studies where the KMS intervention is used by nonclinicians (librarians, administrators, etc.)</p> <p>Studies that do not report original research (editorials, commentaries, letters to the editor, etc.)</p> <p>Full-text level:</p> <p>Studies with a sample size < 50</p> <p>Studies of closed-loop systems that do not involve a provider</p> <p>Studies of systems that require mandatory compliance with the CDSS intervention, defined as when the clinician at the point of care is not given a choice about whether to follow the CDSS recommendations (compliance is mandated by the study protocol)</p> <p>Studies that evaluate only the performance of the system as opposed to the impact on clinical practice</p>

Abbreviations: CDSS = clinical decision support system, CPOE = computerized physician order entry, EHR = electronic health record, KMS = knowledge management system, RCT = randomized controlled trial

Table 3. Factors and features of CDSS/KMS interventions

<p>Source/origin of system Locally developed Commercially available</p> <p>Content Objective of the intervention: <ul style="list-style-type: none"> ○ Diagnosis ○ Immunization ○ Pharmacotherapy ○ Lab test ordering ○ Chronic disease management ○ Initiating discussion with patient ○ Preventive care Relationship to point of care: <ul style="list-style-type: none"> ○ Synchronous ○ Asynchronous <p>Decision support Response requirement: <ul style="list-style-type: none"> ○ Noncommittal acknowledgement ○ Justification for not complying ○ No response requirement ○ Mandatory response ○ NR (assume no response requirement) ○ NR (unclear whether response requirement) <p>Information delivery Delivery format: <ul style="list-style-type: none"> ○ Online access ○ Integrated with CPOE or EHR system ○ Standalone system ○ Paper-based Delivery mode: <ul style="list-style-type: none"> ○ System-initiated ("push") ○ User-initiated ("pull") </p></p></p>	<p>Contextual factors/features influencing the use and implementation of CDSSs/KMSs</p> <p>General system features: <ul style="list-style-type: none"> ○ Integration with charting or order entry system to support workflow integration <p>Clinician-system interaction features: <ul style="list-style-type: none"> ○ Automatic provision of decision support as part of clinician workflow ○ No need for additional clinician data entry ○ Request documentation of the reason for not following CDSS recommendations ○ Provision of decision support at time and location of decisionmaking ○ Recommendations executed by noting agreement <p>Communication content features: <ul style="list-style-type: none"> ○ Provision of a recommendation, not just an assessment ○ Promotion of action rather than inaction (i.e., how the intervention enabled the recommended action to be performed by the provider; e.g., the recommendation included a link to add a new order or to revise or cancel an existing order) ○ Justification of decision support via provision of reasoning ○ Justification of decision support via provision of research evidence <p>Auxiliary features: <ul style="list-style-type: none"> ○ Local user involvement in development process ○ Provision of decision support results to patients as well as providers ○ CDSS accompanied by periodic performance feedback ○ CDSS accompanied by conventional education </p></p></p></p>
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Abbreviations: CDSS = clinical decision support system, CPOE = computerized physician order entry, EHR = electronic health record, KMS = knowledge management system

Process for Study Selection

Search strategies were specific to each database in order to retrieve the articles most relevant to the key questions. Our basic search strategy used the National Library of Medicine's Medical Subject Headings (MeSH) key word nomenclature developed for MEDLINE, limited to articles published in English, and a manual search of retrieved articles and published reviews. Search terms and strategies were developed in consultation with a medical librarian. The exact search strings used in our strategy are given in Appendix A.

Using the prespecified inclusion and exclusion criteria, titles and abstracts were examined independently by three reviewers for potential relevance to the key questions. Articles included by any reviewer underwent full-text screening. Given the large number of abstracts and after conferring with AHRQ Task Order Officers, we performed an initial independent abstract screening stage by a single reviewer. We then randomly selected 5 percent of the abstracts using a random number generator for a rescreen by a second reviewer. The agreement between the two reviewers was monitored, and discordant findings were reviewed as a team before proceeding to additional screening.

At the full-text screening stage, two independent reviewers read each article to determine if it met eligibility criteria. At the full-text review stage, paired researchers independently reviewed the articles and indicated a decision to "include" or "exclude" the article for data abstraction. When the paired reviewers arrived at different decisions about whether to include or exclude an article, they reconciled the difference through a third-party arbitrator. Articles meeting our eligibility criteria were included for data abstraction.

Data Extraction and Data Management

Data from included reports were abstracted into evidence tables by one reviewer and overread by a second reviewer. Data elements abstracted included descriptors to assess applicability, quality elements, intervention details, and outcomes. Disagreements were resolved by consensus or by obtaining a third reviewer's opinion when consensus could not be reached. Appendix B contains a sample data abstraction form, and Appendix C describes the guidance used by the data abstractors.

The final evidence tables are intended to provide sufficient information so that readers can understand the study and determine its quality. Evidence tables for all included studies are presented in Appendix D, organized alphabetically by author.

Individual Study Quality Assessment

We employed internal and external quality-monitoring checks through every phase of the project to reduce bias, enhance consistency, and verify accuracy. Examples of internal monitoring procedures include three progressively stricter screening opportunities for each article (abstract screening, full-text screening, and data abstraction), involvement of three

individuals in each data abstraction, and agreement of at least two investigators on all included studies.

The included studies were assessed on the basis of the quality of their reporting of relevant data. We evaluated the quality of individual studies using the approach described in AHRQ's *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (hereafter referred to as the *General Methods Guide*).¹⁶ To assess methodological quality, we employed the strategy to (1) apply predefined criteria for quality and critical appraisal and (2) arrive at a summary judgment of the study's quality. To indicate the summary judgment of the quality of the individual studies, we used the summary ratings of Good, Fair, or Poor. Appendix C describes our quality assessment process.

To assess applicability, we identified specific issues that may limit the applicability of individual studies or a body of evidence as recommended in the *General Methods Guide*. Appendix C describes our applicability assessment process.

Data Synthesis

Given that many studies did not have the statistical power to determine the benefit for the outcomes relevant to this review (which were often not the primary outcomes evaluated by study investigators), we considered synthesis (meta-analysis) in an attempt to overcome the type II error. We considered groups of studies to be suitable candidates for a quantitative synthesis when we were able to identify at least four studies that assessed the same outcome that could be expressed using a common endpoint.

Estimates of parameters for the meta-analyses were calculated using the DerSimonian and Laird (1986)¹⁷ random effects model as implemented in Comprehensive Meta-Analysis (CMA) (Version 2.2.055).

Most endpoints were combined using odds ratios, especially when event rates that approached 1.0 were involved. However, the clinical endpoints such as morbidity and length of stay were combined using relative risks because some of the results were given as events per time period instead of events per number of patients. For these endpoints, the event rates were low, and some of the studies reported risk ratios instead of relative risks. Given the heterogeneity of CDSSs and the lack of multiple studies evaluating the same CDSS, when studies were combined, pooling was performed without regard to the specific CDSS but rather by comparing the CDSS versus control intervention. All of the meta-analyses used random effects models to allow for this heterogeneity.

Grading the Body of Evidence for Each Key Question

The strength of evidence for each key question was assessed using the approach described in the *General Methods Guide*.¹⁶ The evidence was evaluated using the four required domains: risk of bias, consistency, directness, and precision. Additionally, when appropriate, the studies were evaluated for coherence, dose-response association, residual confounding, strength of association (magnitude of effect), publication bias, and applicability. The strength of evidence was assigned an overall grade of High, Moderate, Low, or Insufficient.

Peer Review and Public Commentary

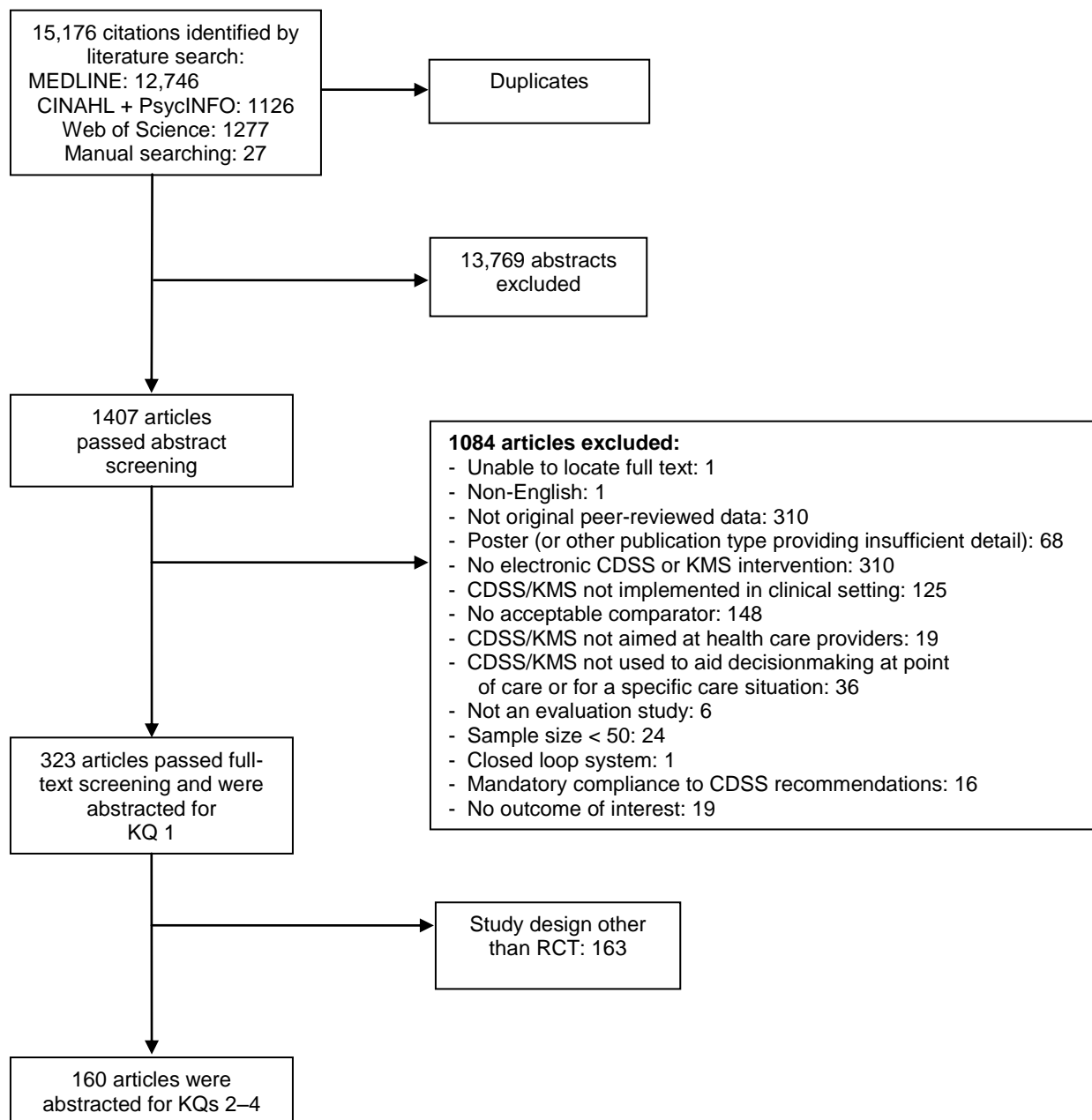
Our principal external quality-monitoring device was the peer review process. Nominations for peer reviewers were solicited from several sources, including the TEP and interested Federal agencies. The list of nominees was forwarded to AHRQ for vetting and approval. A list of peer reviewers submitting comments on the draft report is included in the Preface of this document.

Results

Literature Search Results

The flow of articles through the literature search and screening process is depicted in Figure 2. We identified 15,176 citations from all sources (after removing duplicates). After applying inclusion/exclusion criteria at the title-and-abstract level, 1407 full-text articles were retrieved and screened. Of these, 1084 articles were excluded at full-text review, with 323 articles remaining for data abstraction. Of these, 323 articles were abstracted for KQ 1 (representing 311 unique studies), and 160 articles (representing 148 unique studies) for KQs 2–4. Appendix E provides a complete listing of articles excluded at the full-text stage, with reasons for exclusion.

Figure 2. Literature search flow



Abbreviations: CDSS = clinical decision support system, KMS = knowledge management system, KQ = key question, RCT = randomized controlled trial

Key Question 1

KQ 1: What evidence-based study designs have been used to determine the clinical effectiveness of electronic knowledge management and CDSS?

Key Points

- Clinical effectiveness of CDSSs/KMSs as characterized by demonstrating an impact on a clinical outcome was most frequently assessed using a quasi-experimental study design (43 out of the 311 included studies).
- RCTs were the next most frequent study design used to assess clinical outcomes of CDSSs/KMSs (29 out of 311 included studies), followed by observational studies (17 out of 311 included studies).
- Our analysis suggests that more RCTs measuring clinical outcomes are needed to evaluate the comparative effectiveness of CDSSs/KMSs.

Detailed Analysis

The objective assessment of the clinical effectiveness of a CDSS/KMS intervention is important in understanding the value of that intervention in a clinical setting. Selection of appropriate study design is critical for the proper evaluation of clinical performance in a system.¹⁸ KQ 1 examined past use of different study designs in the existing CDSS/KMS evidence base in the evaluation of clinical effectiveness. Clinical effectiveness is simply defined as how well a particular intervention produces optimum processes and outcomes for patients. New CDSS/KMS interventions are invariably evaluated through a variety of direct, process-oriented measures that describe compliance with and acceptance of the system, but the clinical effectiveness of a CDSS/KMS is best evaluated with the direct measurement of patient-centric clinical outcomes following implementation.

While the responses to KQs 2–4 considered only those CDSS/KMS implementation studies that employed an RCT design, KQ 1 examined the relative prevalence of significant outcome measures not only in RCT studies but also in studies employing other evaluation designs (quasi-experimental, observational). KQ 1 thus presents a horizon scan of the current state of CDSS/KMS implementation studies in order to provide context for KQs 2–4 and to inform discussion of CDSS/KMS evaluation moving forward.

Types of study designs. There were 311 studies that met basic inclusion criteria. We categorized these studies as 1 of 12 study designs falling into 3 basic study types: RCT, quasi-experimental,

and observational. Table 4 describes the selected study designs and the number of included studies for each design.

Table 4. Types of evaluation studies included in this review

Study type and design	Description	Number of included studies (% of total number of studies)
Randomized controlled trials		148 (48%)
Cluster	Groups of participants are randomized to the same intervention together	50 (16%)
Crossover	Participants receive one treatment and have outcomes measured, and then receive an alternative treatment and have outcomes measured again	3 (1%)
Parallel	Participants are randomly assigned to two or more groups, with at least one control group, and evaluated under identical or similar circumstances/timing	92 (30%)
Other	All other RCT studies	3 (1%)
Quasi-experimental studies		121 (39%)
Nonrandomized	Assignment to intervention(s) or control group is not randomized	12 (4%)
Before/after	Participants are evaluated before and after the introduction of an intervention	75 (24%)
Time series	Participants are evaluated at multiple time points before and after the intervention	28 (9%)
Other	All other quasi-experimental studies	6 (2%)
Observational studies		42 (14%)
Cohort	Participants with and without the intervention under study are followed and evaluated over time	29 (9%)
Case-control	Participants are compared with the condition of interest to participants without the condition of interest who are otherwise similar	8 (3%)
Case series	Participants are tracked with the condition of interest and evaluated over time	3 (1%)
Other	All other observational studies	2 (1%)
Total number of included studies		311

Abbreviations: RCT = randomized controlled trial

Categories of outcomes. To evaluate the use of specific study designs on the evaluation of CDSS/KMS clinical effectiveness, we abstracted outcome data from all included studies, compiling the relative prevalence of six key outcome categories in each of the three study designs. We considered direct measurement of clinical outcomes the means of measuring clinical effectiveness while evaluating KQ 1. Table 5 summarizes the outcome categories abstracted from the included studies and gives specific examples. Further details on the relative prevalence of outcome categories by study design are in Table G-1 of Appendix G.

Table 5. Outcome categories abstracted

Outcome category	Examples
Clinical	Length of stay, morbidity, mortality, health-related quality of life, adverse events
Health care process	Adoption/implementation of CDSS/KMS-recommended preventive care/clinical study/treatment, patient adherence to CDSS/KMS recommendation, impact on user knowledge
Health care provider workload, efficiency, and organization	Number of patients seen/unit time, clinician workload, efficiency
Relationship-centered	Patient satisfaction
Economic	Cost, cost-effectiveness
Health care provider use and implementation	User acceptance, satisfaction, and use and implementation of CDSS/KMS

Abbreviations: CDSS = clinical decision support system, KMS = knowledge management system

Impact of study type on outcomes examined. Table 6 shows the prevalence of different outcome categories as they relate to basic study design. The total number of studies containing a particular outcome measure is given, followed by the percentage of studies containing the outcome measure over the total number of studies within the given study design. All three study designs reported health care process measures most frequently, with 86 percent of all RCTs, 75 percent of all quasi-experimental studies, and 69 percent of all observational studies including at least one process-level measure in their evaluation. The most frequent process measures reported in all three categories were outcomes that demonstrated compliance with CDSS/KMS-provided recommendations (Table G-2 in Appendix G). Other direct measures, such as the use of and satisfaction with CDSS/KMS by health care providers, were also frequently reported, especially in RCTs, with 35 percent of all RCTs containing outcomes related to CDSS/KMS use and implementation. Other outcomes related to CDSS/KMS use, including patient satisfaction (relationship-centered outcomes), efficiency (economic and workload outcomes), and patient well-being (clinical outcomes), were reported less frequently overall.

Table 6. Number of studies containing outcome measures by study type

Study type	Clinical	Health care process	User workload, efficiency, and organization	Relationship-centered	Economic	Use and implementation
RCT (N = 148)	29 (20%)	128 (86%)	7 (5%)	6 (4%)	26 (18%)	52 (35%)
Quasi-experimental (N = 121)	43 (36%)	91 (75%)	26 (21%)	3 (2%)	18 (15%)	36 (30%)
Observational (N = 42)	17 (40%)	29 (69%)	2 (5%)	0 (0%)	3 (7%)	10 (24%)

Abbreviations: RCT = randomized controlled trial

Outcomes in RCTs. In RCT studies, health care process measures were reported most frequently (Table 6), with compliance with CDSS/KMS-recommended treatment the most commonly reported specific outcome (reported in 67 RCT studies). Health care provider use and implementation was the second most commonly reported outcome category for RCT studies, with health care provider acceptance the most frequently occurring specific outcome in that category (reported in 24 RCT studies). Clinical outcomes were reported moderately frequently in RCT studies, with morbidity the most commonly reported clinical outcome. A complete breakdown of outcomes by specific study type can be found in Table G-2 of Appendix G.

Outcomes in non-RCTs. In non-RCT studies (quasi-experimental and observational), health care process measures were also the most frequently reported outcome type. Clinical outcomes were the second most commonly reported outcome for non-RCT studies, with mortality and morbidity being the most commonly reported clinical outcomes (Table G-2 of Appendix G).

Clinical outcomes. In Table 7, we further categorized the proportion of studies that measured clinical effectiveness into specific study type. This analysis demonstrates that 20 percent of all RCTs included clinical outcomes as at least one of their reported outcome measures, compared with 36 percent of quasi-experimental and 40 percent of observational studies including clinical outcomes.

Table 7. Proportion of specific study design containing clinical outcomes

Study type and design	Studies including clinical outcomes (% of total)
RCT	
Cluster (N = 50)	6 (12%)
Crossover (N = 3)	0 (0%)
Parallel (N = 92)	23 (25%)
Other (N = 3)	0 (0%)
Total RCT (N = 148)	29 (20%)
Quasi-experimental	
Nonrandomized (N = 12)	6 (50%)
Before/after (N = 75)	28 (37%)
Time series (N = 28)	8 (29%)
Other (N = 6)	1 (17%)
Total quasi-experimental (N = 121)	43 (36%)
Observational	
Cohort (N = 29)	14 (48%)
Case-control (N = 8)	2 (25%)
Case series (N = 3)	1 (33%)
Other (N = 2)	0 (0%)
Total observational (N = 42)	17 (40%)

Abbreviations: RCT = randomized controlled trial

Outcomes related to successful CDSS/KMS implementation. According to Davis' Technology Acceptance Model,¹⁹ users accept and use technology (such as a CDSS/KMS) based on two key factors: perceived usefulness and perceived ease-of-use. That is, a recommendation is likely to be successfully acted upon if health care providers perceive the CDSS/KMS intervention as useful in aiding critical decisionmaking at the point of care. Health care providers appear most comfortable considering recommendations when CDSS/KMS interventions provide adequate information toward decisive action in a timely manner. This finding seems to be consistent with studies reporting health care provider acceptance and satisfaction of using. Such studies are also likely to report health care process measures and/or clinical outcomes. In our studies, 19 articles (19%) reporting health care provider use and implementation outcomes also reported clinical outcomes. Similarly, 69 articles (70%) reporting health care provider use and implementation outcomes also reported health care process measures.

Discussion and Future Research

In the current body of literature, most CDSS/KMS implementation studies did not examine clinical outcomes—instead focusing on the more immediately measurable process-oriented measures. Of the included studies that examined clinical outcomes, very few were RCT studies. These trends can likely be attributed to the relative difficulty of implementing RCT studies in real clinical settings as well as the logistical issues involved in measuring the indirect clinical impact of CDSS/KMS interventions.

Challenges in conducting RCT studies in real clinical settings. One of the challenges in conducting RCT studies in real clinical settings is the enforcement of true randomization without allowing contamination. Clinicians frequently consult with one another about treatment options or medications, especially when they change their shift. Also, clinicians may be tempted to share their experiences of using CDSSs/KMSs with their colleagues and inadvertently influence their attitude toward the use of CDSSs/KMSs.¹⁸ Therefore, avoiding contamination among clinicians assigned to CDSS/KMS interventions within the same ward or hospital setting is usually difficult to achieve. We found 50 of the included RCTs (34%) conducted cluster RCTs, where groups of patients and clinicians, rather than individuals, are randomized in order to protect against contamination across trial groups.

Large randomized trials related to the use of CDSSs/KMSs tended to occur most often in well-established institutions that relied upon locally developed information systems such as Brigham and Women's Hospital/Partners Health Care/Massachusetts General Hospital in Boston, Regenstrief Institute in Indianapolis, and LDS Hospital/Intermountain Healthcare in Utah. This trend may be related to factors common at these research-intensive institutions, such as the availability of well-defined electronic medical records system, infrastructure supporting the implementation of a CDSS/KMS to selected groups, and a clinician culture that supports the exploration of CDSS/KMS adoption as part of their clinical practice. These factors may well explain the higher adoption rate of CDSSs/KMSs among these institutions, which subsequently provided them with the opportunity to conduct more randomized trials to evaluate the clinical impact of CDSS/KMS interventions.

Challenges in measuring clinical outcomes. All three study types reported a much higher prevalence of health care process measures (outcomes directly related to the implementation of, and compliance to, the CDSS/KMS intervention being evaluated) than of clinical outcomes (patient-centric outcomes often separated from the actual CDSS/KMS temporally and practically). This difference is likely due to the fact that, regardless of design, process measures (e.g., compliance with CDSS/KMS-recommended drug dosage) are generally easier and faster to measure and evaluate than clinical outcomes (e.g., length of stay, morbidity). The impact of CDSSs/KMSs on clinical outcomes related to the CDSS/KMS implementation must often necessarily occur for several days to several months after the initial implementation, and measuring such impacts often requires costly and cumbersome followup, delaying evaluation of the CDSS/KMS. In situations where the health care process measures and clinical outcomes are closely aligned (e.g., a CDSS that provides drug-dosage calculations based on patient parameters), measuring the process may serve as an acceptable surrogate for a clinical outcome. In cases where the CDSS/KMS process is not closely related to clinical effectiveness (e.g.,

systems that recommend treatment plans from evidence-based standards), clinical outcomes will need to be measured directly to understand the true effects of CDSSs/KMSs.

Given the challenges inherent both in implementing RCTs and in measuring the clinical impact of interventions in real clinical settings, the relative lack of studies that reported on RCTs assessing a clinical outcome is not surprising. Although studies that both follow RCT design and directly measure patient-centered clinical outcomes would be ideal, such studies are clearly not always feasible—logistically or economically. Whether studies should dedicate presumably limited resources either to adhering to RCT design or to measuring clinical outcomes depends on the nature of the CDSS/KMS being evaluated. If the CDSS/KMS itself is closely related to clinical outcomes (as discussed above), then process-oriented measures are likely sufficient, and resources should be dedicated to the execution of RCT studies. If, however, the CDSS/KMS process is linked only indirectly to clinical effectiveness, then health care process measures will not be sufficient. In these cases, measuring clinical outcomes directly becomes necessary to evaluate clinical effectiveness. When limited resources will necessarily be devoted to the time and effort required to measure clinical outcomes, quasi-experimental and observational studies can be effective choices for study design, provided they are conducted as rigorously as possible.

Key Question 2

KQ 2: What contextual factors/features influence the effectiveness or success of electronic knowledge management and CDSSs?

Key Points

- A meta-analysis of included studies confirmed the three key factors/features identified in the review by Kawamoto et al. (2005)⁹ that were associated with a successful CDSS that improved clinical practice, although we were unable to distinguish the impact of a specific factor/feature. These factors were significant across all three endpoints assessed: (1) adherence to performing preventive care, (2) adherence to performing a clinical study, and (3) adherence to prescribing a treatment. The three features are:
 - Automatic provision of decision support as part of clinician workflow
 - Provision of decision support at time and location of decisionmaking
 - Provision of a recommendation, not just an assessment
- The meta-analysis also identified six additional factors/features that were correlated with the success of a CDSS across all three endpoints:
 - Integration with charting or order entry system to support workflow integration
 - Promotion of action rather than inaction
 - No need for additional clinician data entry
 - Justification of decision support via provision of research evidence
 - Local user involvement in the development process
 - Provision of decision support results to patients as well as providers
- Additionally, one factor/feature was found to correlate with a successful CDSS across two of the three endpoints evaluated:
 - Justification of decision support via provision of reasoning

- Four factors/features were significant for only one endpoint:
 - Request documentation of the reason for not following CDSS recommendations (adherence to prescribing a treatment, only four studies in the group)
 - Recommendations executed by noting agreement (adherence to performing a clinical study, only two studies in the group)
 - A CDSS accompanied by periodic performance feedback (adherence to performing a clinical study, only three studies in the group)
 - A CDSS accompanied by conventional education (adherence to performing a clinical study, nine studies in the group)

Detailed Analysis

This section of the evidence report examines the factors/features that influence the effectiveness or success of CDSSs/KMSs. We present findings from the literature search on the generalized factors/features of successful CDSSs and then the factors/features of CDSSs according to outcomes.

Within this body of evidence, we examined the inclusion of 14 factors/features in electronic CDSSs that were identified from a previous review⁹ and from suggestions from the TEP that were viewed as potentially important in determining a CDSS's success in improving clinical practice. To further assess the impact of various factors/features on the success of a CDSS, we used meta-analysis to analyze the 14 most common features across the three outcomes for which we had the most studies—adherence to performing a preventive care service, adherence to performing a clinical study, and adherence to prescribing a treatment. The majority of the 148 included studies described CDSSs that included the following five factors/features:

1. Provision of decision support at the time and location of decisionmaking (n = 125; 84.5%)
2. Automatic provision of decision support as part of clinician workflow (n = 116; 78.4%)
3. Provision of a recommendation, not just an assessment (n = 109; 73.6%)
4. Integration with charting or order entry to support workflow integration (n = 96; 64.9%)
5. No need for additional clinician data entry (n = 84; 56.8%)

Of the 14 electronic factors/features that we identified, three had been shown in a previous review to be strongly associated with improving clinical practice: (1) automatic provision of decision support as part of clinician workflow, (2) provision of decision support at time and location of decisionmaking, and (3) provision of a recommendation, not just an assessment. From the meta-analysis conducted for this review, we identified six additional factors/features that correlated with a successful CDSS implementation: (4) the incorporation with charting or order entry system to support workflow integration, (5) the promotion of action rather than inaction, (6) no need for additional clinician data entry, (7) justification of decision support via provision of research evidence, (8) local user involvement in the development process, and (9) provision of decision support results to patients as well as providers. The local user involvement factor/feature was found to be present in 50 locally developed systems and 4 commercially

developed systems. Thus, while this feature was present across both types of systems, it was proportionally more frequently associated with locally developed systems.

We observed that two studies (1.4%) included all nine of those factors. One hundred forty-six (98.6%) of the 148 studies included some combination of the 9 factors—8 studies (5.4%) included 8 factors; 19 studies (12.8%) included 7 factors; 29 studies (19.6%) included 6 factors; 29 studies (19.6%) included 5 factors; 23 studies (15.5%) included 4 factors; 17 studies (11.5%) included 3 factors; 11 studies (7.4%) included 2 factors; and 10 studies (6.8%) included 1 factor.

The following section presents findings from the literature search on three key categories of outcomes (clinical, health care process measures, health care provider use) related to the effectiveness or success of CDSSs/KMSs. Within each category, we present general observations of the factors/features that the majority of systems possessed, followed by an examination of the factors/features of the CDSSs for each outcome.

Clinical Outcomes

General observations. The six studies that evaluated the effectiveness or success of CDSSs/KMSs on clinical outcomes and reported a significant reduction in length of stay, morbidity, mortality, and adverse events consistently had two of the previously identified key factors/features identified in the Kawamoto et al. (2005)⁹ review:

1. Automatic provision of decision support as part of clinician workflow²⁰⁻²⁴
2. Provision of a recommendation, not just an assessment^{20,21,23-27}

Factors/features of the six studies that evaluated CDSSs on clinical outcomes across settings. Three studies (50%) evaluated in the *academic setting* consistently had two of the previously identified key factors/features (automatic provision of decision support as part of clinician workflow and provision of decision support at time and location of decisionmaking) and one newly identified factor/feature: local user involvement in the development process.²¹⁻²³ Four studies (66.7%) conducted in the *ambulatory setting* consistently had two of the previously identified key factors/features (automatic provision of decision support as part of clinician workflow and provision of decision support at time and location of decisionmaking).^{20,22,24,26,27} Two studies (33.3%) evaluated in the *hospital setting* consistently had the three previously identified key factors/features and three newly identified factors/features: integration with charting or order entry system, promotion of action rather than inaction, and local user involvement in development process.^{21,23} All CDSS interventions (100%) implemented in *locally developed systems* consistently had two of the previously identified key factors/features: automatic provision of decision support as part of clinician workflow and provision of decision support at time and location of decisionmaking.

Length of stay. We identified 6 of the 148 eligible studies (4.1%) that evaluated inpatient or emergency department length of stay as an outcome of CDSS/KMS effectiveness or success. These studies are summarized in Table H-1 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to length of stay. Length of stay was defined over a fixed time interval and was converted to a fraction (ratio) by dividing by the length of the time interval. This creates a

unitless ratio as described by Kleinbaum, Kupper, and Morgenstern.²⁸ The ratio of two such measures is similar to a relative risk, which is the ratio of two proportions (which are also unitless). Of the six studies, five (83.3%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{23,26,27,29-31} All of the studies had one of the previously identified key factors/features associated with CDSS success (provision of a recommendation, not just an assessment). Sixty-seven percent of the studies had two of the previously identified key factors/features (automatic provision of decision support and provision of a recommendation, not just an assessment) and one newly identified factor/feature: local user involvement in the development process.

One of the six studies found a significant reduction in length of stay.²³ Paul et al. (2006) evaluated a standalone system that focused on decreasing inappropriate antimicrobial use by recommending the three “best” antibiotic regimens in 2326 patients over 7 months and reported that the intervention group had significantly lower length of stay than the control group (RR 0.9082; 95% CI 0.8392 to 0.9828). That system included the following factors/features: integration with charting or other entry system; automatic provision of decision support; provision of decision support at time and location of decisionmaking; provision of a recommendation, not just an assessment; promotion of action rather than inaction; and local user involvement in the development process. Another study that almost reached significance in the meta-analysis^{26,27} assessed an intervention that provided clinicians in 64 community clinics and 7412 patients with recommendations to improve appropriate guideline-based diabetes testing and found that intervention subjects had shorter inpatient durations than control subjects (0.99 days versus 1.1; $P = 0.01$). The intervention included three factors/features: provision of a recommendation, not just an assessment; local user involvement in the development process; and CDSS accompanied by periodic performance feedback.

Morbidity. We identified 22 of the 148 eligible studies (14.9%) that evaluated morbidity as an outcome of CDSS/KMS effectiveness or success. These studies are summarized in Table H-2 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to morbidity. Of the 22 studies, 16 (72.7%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{20-24,26,27,32-43} The studies consistently had two of the previously identified key factors/features: automatic provision of decision support as part of clinician workflow and provision of a recommendation, not just an assessment.

Three of the 22 studies reported a significant reduction in morbidity.^{21,22,26,27} Kucher et al. (2005)²¹ evaluated alerts that identified patients at risk for developing deep vein thrombosis (DVT) among 2506 high-risk hospitalized patients over 40 months (RR 0.60; 95% CI 0.43 to 0.84). McDonald et al. (1984)²² investigated reminders regarding preventive care services to improve provider adherence in 12,467 patients for 2 years and found that intervention patients had significantly fewer hospitalizations and emergency department visits than control patients (RR 0.69; 95% CI 0.52 to 0.91). Khan et al. (2010)^{26,27} evaluated recommendations to improve appropriate guideline-based diabetes testing and reported that intervention patients had fewer hospitalizations (0.17 admissions versus 0.20; $P = 0.01$) and emergency department visits (0.27 visits versus 0.36; $P < 0.0001$) than control patients (RR 0.75; 95% CI 0.70 to 0.80). Those CDSSs included the following factors/features:

- Two included automatic provision of decision support as part of clinician workflow^{21,22}
- Two included provision of decision support at time and location of decisionmaking^{21,22}
- Two included provision of a recommendation, not just an assessment^{21,26,27}
- One included integration with charting or order entry system²¹
- One included no need for additional data entry²¹
- One included promotion of action rather than inaction²¹
- Two included justification of decision support via provision of reasoning^{21,22}
- Two included justification of decision support via research evidence^{21,22}
- Two included local user involvement in development process^{21,22}
- One included provision of decision support results to patients as well as providers^{26,27}
- One included a CDSS accompanied by periodic performance feedback^{26,27}

Mortality. We identified 7 of the 148 eligible studies (4.7%) that evaluated mortality as an outcome of CDSS/KMS effectiveness or success. These studies are summarized in Table H-3 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to mortality. Of the 7 studies, 6 (85.7%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{20,23,24,30,44} The studies consistently had two of the previously identified factors/features (automatic provision of decision support as part of clinician workflow and provision of a recommendation, not just an assessment) and three newly identified factors/features: integration with charting or order entry system; no need for additional data entry; and promotion of action rather than inaction.

Two of the six studies reported a significant reduction in mortality.^{20,24} Ansari et al. (2003)²⁰ assessed treatment reminders to improve the appropriate use of beta blockers for patients with congestive heart failure in 169 patients for 1 year and found a significant reduction in mortality (RR 0.12; 95% CI 0.016 to 0.87). Roumie et al. (2006)²⁴ evaluated guideline-based recommendations for patients with uncontrolled hypertension in 1341 patients for 6 months and reported that the intervention groups had a significantly lower mortality rate than the control group (RR 0.24; 95% CI 0.06 to 0.88). Those CDSSs included the following factors/features:

- Two included automatic provision of decision support as part of clinician workflow^{20,24}
- One included provision of decision support at time and location of decisionmaking²⁰
- Two included provision of a recommendation, not just an assessment^{20,24}
- Two included integration with charting or order entry system^{20,24}
- Two included no need for additional data entry^{20,24}
- One included promotion of action rather than inaction²⁰
- One included justification of decision support via provision of research evidence²⁴
- One included a CDSS accompanied by conventional education²⁰

Adverse events. We identified 5 of the 148 eligible studies (3.4%) that evaluated adverse events as an outcome of CDSS/KMS effectiveness or success. These studies are summarized in Table H-4 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to adverse events. All of the studies (100%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{30,36,37,44-46} The studies consistently had the three previously identified factors/features and two newly identified factors/features:

integration with charting or order entry system and local user involvement in the development process.^{30,36,44-46}

None of the six studies found a significant reduction in adverse events. Of the studies that reported adverse events data, McGregor et al. (2006)³⁰ evaluated alerts in a commercially developed system to detect potentially inappropriate antimicrobial therapy in 4507 patients for 12 weeks and reported that fewer intervention patients experienced diarrhea as a side effect of antimicrobial therapy (5.7% versus 6.6%; $P = 0.21$). That CDSS included the following factors/features: integration with charting or other entry system; automatic provision of decision support; no need for additional data entry; provision of decision support at time and location of decisionmaking; provision of a recommendation, not just an assessment; promotion of action rather than inaction; and local user involvement in the development process.

Health Care Process Measures

General observations. Fifty-two studies that evaluated the effectiveness or success of CDSSs on health care process measures and reported a significant improvement in the appropriate ordering/completion of preventive care services, clinical studies, and treatment consistently had the nine key factors/features correlated with a successful CDSS, three previously reported in 2005⁹ and six identified through meta-analysis for the current report.

Previously identified factors/features and the relevant included studies were:

1. Automatic provision of decision support as part of clinician workflow^{21,23,29-32,35,38,47-83}
2. Provision of decision support at time and location of decisionmaking^{21,23,29-32,35,38,47-60,62-64,67-74,76-91}
3. Provision of a recommendation, not just an assessment^{21,23,29-32,35,38,41,47-54,56,57,59,61-68,70,71,74,75,77,79,80,82-84,86,87}

Newly identified factors/features and the relevant included studies were:

1. Integration with charting or order entry system^{21,23,29,30,35,47-54,56-59,62-66,68-70,72-74,76-83,88}
2. No need for additional data entry^{21,29-31,35,38,48,50-54,56-60,62-66,68-70,72-74,76-79,81-84}
3. Promotion of action rather than inaction^{21,23,29,30,47-49,51,52,56,57,59,60,62,64-66,68,70,82-86,88}
4. Justification of decision support via provision of research evidence^{21,29,49,50,52,61,79,83,85-87}
5. Local user involvement in the development process^{21,23,29-32,35,49-53,59,60,65,66,74,81,85-87,89}
6. Provision of decision support results to patients as well as providers^{32,52,56,57,65,66,84}

Factors/features of the 52 studies that evaluated CDSSs on health care process measures across settings. Twenty-four studies (46.2%) evaluated in the *academic setting* consistently had the three key factors/features previously associated with a successful CDSS and two newly identified key factors/features (integration with charting or order entry system to support workflow and no need for additional clinician data entry).^{21,23,29,30,35,48,51,53,60-66,69,72,75,76,82,83,85,87,90,91}

Sixteen studies (30.8%) evaluated in the *community setting* consistently had the three previously identified key factors/features.^{32,41,47,52,54-57,59,67,68,74,78,80,81,84,86}

Four studies (7.7%) evaluated in both *academic and community settings* consistently had the three previously identified key factors/features and two newly identified key factors/features

(integration with charting or order entry system to support workflow and promotion of action rather than inaction).^{49,58,71,88} Four studies (7.7%) evaluated in the *VA setting* consistently had the three previously identified key factors/features and two newly identified key factors/features (integration with charting or order entry system to support workflow and no need for additional clinician data entry).^{38,50,70,79} Thirty-seven studies (71.2%) were conducted in the *ambulatory setting* and consistently had the three previously identified key factors/features.^{32,41,47,49,50,52,54-63,65,66,68-81,84-89} Nine studies (17.3%) conducted in the *hospital setting* consistently had the three previously identified key factors/features and three newly identified key factors/features (integration with charting or order entry system, no need for additional data entry, and promotion of action rather than inaction).^{21,23,29,30,35,48,51,64,82} Four studies (7.7%) conducted in the *emergency department* consistently had the three previously identified key factors/features.^{31,67,83,90,91} Thirty-five CDSS interventions (67.3%) implemented in *locally developed systems* consistently had the three previously identified key factors/features.^{21,23,29,31,32,35,38,41,48-52,60-65,67,70,72,73,75,76,79-88} Eleven CDSS interventions (21.2%) implemented in *commercially developed systems* consistently had two of the previously identified key factors/features (automatic provision of decision support as part of clinician workflow and provision of decision support at time and location of decisionmaking) and two newly identified key factors/features (integration with charting or order entry system and no need for additional data entry).^{30,47,53,56-59,68,74,77,78,89}

Preventive care adherence. We identified 43 of the 148 eligible studies (29.1%) that evaluated adherence to order/complete a preventive care service as an outcome of CDSS effectiveness or success. These studies are summarized in Table H-5 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to ordering or completing preventive care services. Of the 43 studies, 25 included data with a common dichotomous endpoint and were included in the meta-analysis.^{4,21,40,41,47,50,51,55-57,60,63,68,71,75,76,84,85,89,92-98} Across the studies, we examined the specific factors/features of each CDSS, and those odds ratios were combined using the DerSimonian and Laird random effects model.¹⁷ The odds ratios listed by factor indicate the summary odds ratios of studies that included the specific factor/feature as compared to those that did not. Findings from this analysis are listed in Table 8. (Note that we attempted to perform a meta-regression on several of the endpoints. However, studies tended to have similar factors present, creating a high degree of correlation. As a result, the random effects meta-regression models failed to converge.)

Table 8. Random effects estimates of the odds ratio for preventive care adherence

Factor	Number of studies	Estimated odds ratio	95% confidence limits
All studies	25	1.42	1.27 to 1.58
Integration with charting or order entry system to support workflow integration*	13	1.47	1.21 to 1.77
Automatic provision of decision support as part of clinician workflow*	19	1.45	1.28 to 1.64
No need for additional clinician data entry*	15	1.43	1.22 to 1.69
Request documentation of the reason for not following CDSS recommendations	1	NA	NA
Provision of decision support at time and location of decisionmaking*	23	1.35	1.20 to 1.52

Table 8. Random effects estimates of the odds ratio for preventive care adherence (continued)

Factor	Number of studies	Estimated odds ratio	95% confidence limits
Recommendations executed by noting agreement	4	1.30	0.99 to 1.71
Provision of a recommendation, not just an assessment*	20	1.50	1.30 to 1.74
Promotion of action rather than inaction*	15	1.28	1.09 to 1.50
Justification of decision support via provision of reasoning*	8	1.51	1.22 to 1.87
Justification of decision support via provision of research evidence*	5	1.60	1.04 to 2.46
Local user involvement in development process*	11	1.45	1.23 to 1.73
Provision of decision support results to patients as well as providers*	6	1.18	1.02 to 1.37
CDSS accompanied by periodic performance feedback	2	1.03	0.80 to 1.34
CDSS accompanied by conventional education	6	1.32	0.94 to 1.85

Abbreviations: CDSS = clinical decision support system, NA = not applicable, * = statistically significant

This analysis confirmed that the three previously identified key factors/features critical for CDSS success had a statistically significant impact on promoting adherence to preventive care outcomes: automatic provision of decision support as part of clinician workflow (OR 1.45; 95% CI 1.28 to 1.64), provision of decision support at time and location of decisionmaking (OR 1.35; 95% CI 1.20 to 1.52), and provision of a recommendation, not just an assessment (OR 1.50; 95% CI 1.30 to 1.74). The analysis also supported the six newly identified factors/features universally associated with CDSS success: integration with charting or order entry system to support workflow integration (OR 1.47; 95% CI 1.21 to 1.77), no need for additional clinician data entry (OR 1.43; 95% CI 1.22 to 1.69), promotion of action rather than inaction (OR 1.28; 95% CI 1.09 to 1.50), justification of decision support via provision of research evidence (OR 1.60; 95% CI 1.04 to 2.46), local user involvement in development process (OR 1.45; 95% CI 1.23 to 1.73), and provision of decision support results to patients as well as providers (OR 1.18; 95% CI 1.02 to 1.37).

Finally, this analysis discovered one new factor/feature that also was associated with a successful CDSS: justification of decision support via provision reasoning (OR 1.51; 95% CI 1.22 to 1.87). Unfortunately, because many of the studies included more than one factor/feature, and because the studies did not specifically evaluate whether the systems with and without an individual factor differed in terms of their impact on the outcome of interest, it is difficult to determine the importance of individual factors/features.

Fifteen studies reported a significant improvement in preventive care adherence, and those CDSSs included the following factors/features:

- Eleven included automatic provision of decision support as part of clinician workflow^{21,47,50,51,55,60,63,68,71,75,76}
- Thirteen included provision of decision support at time and location of decisionmaking^{21,47,50,51,55,60,63,68,71,76,84,85,89}
- Ten included provision of a recommendation, not just an assessment^{21,41,47,50,51,63,68,71,75,84}
- Seven included integration with charting or order entry system^{21,47,50,51,63,68,76}
- Eight included no need for additional data entry^{21,50,51,60,63,68,76,84}

- One included request documentation of the reason for not following the CDSS recommendations⁶⁰
- Three included recommendations executed by noting agreement^{51,60,68}
- Seven included promotion of action rather than inaction^{21,47,51,60,68,84,85}
- Six included justification of decision support via provision of reasoning^{21,50,51,60,68,85}
- Three included justification of decision support via provision of research evidence^{21,50,85}
- Six included local user involvement in development process^{21,50,51,60,85,89}
- One included provision of decision support results to patients as well as providers⁸⁴
- Two included a CDSS accompanied by conventional education^{50,71}

Clinical study adherence. We identified 29 of the 148 eligible studies (19.6%) that evaluated adherence to order/complete a clinical study as an outcome of CDSS effectiveness or success. These studies are summarized in Table H-6 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to ordering or completing clinical studies. Of the 29 studies, 20 included data with a common dichotomous endpoint and were included in the meta-analysis.^{26,27,31,39,48,49,61,62,65-67,69,70,77,78,87,99-103}

Across the studies, we examined the specific factors/features of each CDSS, and those odds ratios were combined using the DerSimonian and Laird random effects model.¹⁷ The odds ratios listed by factor indicate the summary odds ratios of studies that included the specific factor/feature as compared to those that did not. Findings from this analysis are listed in Table 9.

Table 9. Random effects estimates of the odds ratio for clinical study adherence

Factor	Number of studies	Estimated odds ratio	95% confidence limits
All studies	20	1.72	1.47 to 2.00
Integration with charting or order entry system to support workflow integration*	11	1.56	1.29 to 1.87
Automatic provision of decision support as part of clinician workflow*	16	1.85	1.52 to 2.25
No need for additional clinician data entry*	11	1.58	1.31 to 1.89
Request documentation of the reason for not following CDSS recommendations	2	1.66	0.58 to 4.76
Provision of decision support at time and location of decisionmaking*	15	1.78	1.46 to 2.17
Recommendations executed by noting agreement*	2	1.43	1.15 to 1.78
Provision of a recommendation, not just an assessment*	15	2.01	1.63 to 2.48
Promotion of action rather than inaction*	9	1.52	1.23 to 1.87
Justification of decision support via provision of reasoning	4	1.48	0.97 to 2.25
Justification of decision support via provision of research evidence*	5	2.93	1.40 to 6.12
Local user involvement in development process*	10	1.41	1.18 to 1.70
Provision of decision support results to patients as well as providers*	5	1.41	1.26 to 1.58
CDSS accompanied by periodic performance feedback*	3	1.98	1.30 to 3.01
CDSS accompanied by conventional education*	9	1.39	1.13 to 1.71

Abbreviations: CDSS = clinical decision support system, * = statistically significant

This analysis confirmed that CDSSs that included the three previously identified key factors/features that are critical for CDSS success had a statistically significant impact on clinical study adherence outcomes: automatic provision of decision support as part of clinician workflow (OR 1.85; 95% CI 1.52 to 2.25), provision of decision support at time and location of decisionmaking (OR 1.78; 95% CI 1.46 to 2.17), and provision of a recommendation, not just an assessment (OR 2.01; 95% CI 1.63 to 2.48). The analysis also supported the six newly identified factors/features universally associated with CDSS success: integration with charting or order entry system to support workflow integration (OR 1.56; 95% CI 1.29 to 1.87), no need for additional data entry (OR 1.58; 95% CI 1.31 to 1.89), promotion of action rather than inaction (OR 1.52; 95% CI 1.23 to 1.87), justification of decision support via provision of research evidence (OR 2.93; 95% CI 1.40 to 6.12), local user involvement in development process (OR 1.41; 95% CI 1.18 to 1.70), and provision of decision support results to patients as well as providers (OR 1.41; 95% CI 1.26 to 1.58).

Finally, this analysis discovered three new factors/features that were also associated with a successful CDSS: recommendations executed by noting agreement (OR 1.43; 95% CI 1.15 to 1.78), CDSSs accompanied by periodic performance feedback (OR 1.98; 95% CI 1.30 to 3.01), and CDSSs accompanied by conventional education (OR 1.39; 95% CI 1.13 to 1.71). Unfortunately, because many of the studies included more than one factor/feature and because the studies did not specifically evaluate whether the systems with and without an individual factor differed in terms of their impact on the outcome of interest, it is difficult to determine the importance of individual factors/features.

Thirteen studies reported a significant improvement in clinical study adherence, and those CDSS interventions included the following factors/features:

- Twelve included automatic provision of decision support as part of clinician workflow^{31,48,49,61,62,65-67,69,70,77,78}
- Ten included provision of decision support at time and location of decisionmaking^{31,48,49,62,67,69,70,77,78,87}
- Eleven included provision of a recommendation, not just an assessment^{31,48,49,61,62,65-67,70,77,87}
- Nine included integration with charting or order entry system^{48,49,62,65,66,69,70,77,78}
- Nine included no need for additional data entry^{31,48,62,65,66,69,70,77,78}
- One included request documentation of the reason for not following the CDSS recommendations⁴⁸
- Two included recommendations executed by noting agreement^{65,66}
- Six included promotion of action rather than inaction^{48,49,62,65,66,70}
- Two included justification of decision support via provision of reasoning^{49,70}
- Three included justification of decision support via provision of research evidence^{49,61,87}
- Five included local user involvement in development process^{31,49,65,66,87}
- Two included provision of decision support results to patients as well as providers^{65,66}
- Two included CDSS accompanied by periodic performance feedback^{70,87}
- Five included CDSS accompanied by conventional education^{49,67,70,77,78}

Treatment adherence. We identified 67 of the 148 eligible studies (45.3%) that evaluated treatment adherence as an outcome of CDSS effectiveness or success. These studies are summarized in Table H-7 of Appendix H.

We conducted a meta-analysis that focused on CDSS studies in which at least one outcome was related to ordering treatments or prescribing therapies. Of the 67 studies, 46 studies included data with a common dichotomous endpoint and were included in the meta-analysis.^{20,23,24,29,30,32,35,38-41,47,49,52-54,56-59,61,64,72-74,77,79-83,86,88,90-92,104-114} Across the studies, we examined the specific factors/features of each CDSS, and those odds ratios were combined using the DerSimonian and Laird random effects model.¹⁷ The odds ratios listed by factor indicate the summary odds ratios of studies that included the specific factor/feature as compared to those that did not. Findings from this analysis are listed in Table 10.

Table 10. Random effects estimates of the odds ratio for treatment adherence

Factor	Number of studies	Estimated odds ratio	95 % confidence limits
All studies	46	1.57	1.35 to 1.82
Integration with charting or order entry system to support workflow integration*	37	1.67	1.40 to 2.00
Automatic provision of decision support as part of clinician workflow*	39	1.60	1.34 to 1.90
No need for additional clinician data entry*	31	1.78	1.45 to 2.18
Request documentation of the reason for not following CDSS recommendations*	5	2.05	1.08 to 3.89
Provision of decision support at time and location of decisionmaking*	38	1.75	1.48 to 2.07
Recommendations executed by noting agreement	5	1.62	0.95 to 2.74
Provision of a recommendation, not just an assessment*	36	1.61	1.34 to 1.93
Promotion of action rather than inaction*	22	1.71	1.35 to 2.16
Justification of decision support via provision of reasoning*	13	1.69	1.21 to 2.35
Justification of decision support via provision of research evidence*	13	1.50	1.06 to 2.14
Local user involvement in development process*	21	1.95	1.42 to 2.66
Provision of decision support results to patients as well as providers*	5	1.97	1.20 to 3.21
CDSS accompanied by periodic performance feedback	2	1.39	0.88 to 2.20
CDSS accompanied by conventional education	8	1.28	1.03 to 1.60

Abbreviations: CDSS = clinical decision support system, * = statistically significant

This analysis confirmed that CDSSs that include the three previously identified key factors/features critical for CDSS success had a statistically significant impact on treatment adherence outcomes: automatic provision of decision support as part of clinician workflow (OR 1.60; 95% CI 1.34 to 1.90), provision of decision support at time and location of decisionmaking (OR 1.75; 95% CI 1.48 to 2.07), and provision of a recommendation, not just an assessment (OR 1.61; 95% CI 1.34 to 1.93). The analysis also supported the six newly identified factors/features

universally associated with CDSS success: integration with charting or order entry system to support workflow integration (OR 1.67; 95% CI 1.40 to 2.00), no need for additional data entry (OR 1.78; 95% CI 1.45 to 2.18), promotion of action rather than inaction (OR 1.71; 95% CI 1.35 to 2.16), justification of decision support via provision of research evidence (1.50; 95% CI 1.06 to 2.14), local user involvement in development process (OR 1.95; 95% CI 1.42 to 2.66), and provision of decision support results to patients as well as providers (1.97; 95% CI 1.20 to 3.21).

Finally, this analysis also identified two factors/features that were significant, namely: request documentation of the reason for not following CDSS recommendations (2.05; 95% CI 1.08 to 3.89) and justification of decision support via provision reasoning (OR 1.69; 95% CI 1.21 to 2.35). Unfortunately, because many of the studies included more than one factor/feature and because the studies did not specifically evaluate whether the systems with and without an individual factor differed in terms of their impact on the outcome of interest, it is difficult to determine the importance of individual factors/features.

Twenty-six studies reported a significant improvement in treatment adherence, and those CDSSs included the following factors/features:

- Twenty-two included automatic provision of decision support as part of clinician workflow^{23,29,30,32,35,38,49,52-54,56-59,64,72-74,79-83}
- Twenty-five included provision of decision support at time and location of decisionmaking^{23,29,30,32,35,38,49,52-54,56-59,64,72-74,79-83,86,88,90,91}
- Twenty included provision of a recommendation, not just an assessment^{23,29,30,32,35,38,41,49,52-54,56,57,59,64,74,79,80,82,83,86}
- Twenty-one included integration with charting or order entry system^{23,29,30,35,49,52-54,56-59,64,72-74,79-83,88}
- Eighteen included no need for additional data entry^{29,30,35,38,52-54,56-59,64,72-74,79,81-83}
- Three included request documentation of the reason for not following the CDSS recommendations^{79,81,86}
- Two included recommendations executed by noting agreement^{59,72}
- Twelve included promotion of action rather than inaction^{23,29,30,49,52,56,57,59,64,82,83,86,88}
- Seven included justification of decision support via provision of reasoning^{29,49,82,83,86,88,90,91}
- Six included justification of decision support via provision of research evidence^{29,49,52,79,83,86}
- Twelve included local user involvement in the development process^{23,29,30,32,35,49,52,53,59,74,81,86}
- Three included provision of decision support results to patients as well as providers^{32,52,56,57}
- One included CDSSs accompanied by periodic performance feedback^{56,57}
- Four included CDSSs accompanied by conventional education^{49,54,56,57,80}

Health Care Provider Use

We identified 17 of the 148 eligible studies (11.5%) that evaluated provider use as an outcome of CDSS/KMS effectiveness or success. Those studies are summarized in Table H-8 of Appendix H.

The studies consistently had two of the three previously identified key factors/features: provision of decision support at time and location of decisionmaking and provision of a recommendation, not just an assessment.^{4,54,80,82,88,115-128} Nine studies (52.9%) evaluated in the *community setting* consistently had two of the three previously identified key factors/features: provision of decision support at time and location of decisionmaking and provision of a recommendation, not just an assessment.^{4,54,80,117,118,120-122,125,128} Thirteen CDSS interventions (76.5%) implemented in *locally developed systems* consistently had two of the three previously identified key factors/features: provision of decision support at time and location of decisionmaking and provision of a recommendation, not just an assessment.^{80,82,88,115-117,120-128} Three CDSS interventions (17.6%) implemented in *commercially developed systems* consistently had one of the three previously identified key factors/features: the provision of decision support at time and location of decisionmaking.^{4,118,119}

Key Question 3

KQ 3: What is the impact of introducing electronic knowledge management and CDSSs?

- a. Changes in the organization of health care delivery
- b. Changes in the workload and efficiency for the user
- c. Changes in health care process measures and clinical outcomes

Key Points

- There is strong evidence from the ambulatory setting that electronic CDSSs used at the point of care can enhance a variety of health care process measures.
- We found that 86.5 percent of the studies measured some type of health care process measures whereas only 19.6 percent of the studies assessed a clinical outcome, thus more emphasis on the impact of CDSSs on clinical outcomes such as mortality, morbidity, length of stay, and adverse events are needed.
- The evidence is scarce that these systems increase the value of care while decreasing costs.
- There is limited evidence examining the impact of decision support tools on provider attitudes, workload, and efficiency.
- Longer evaluation periods and larger sample sizes are needed to better assess the impact of CDSSs on outcomes.
- More emphasis on the impact of CDSSs on providers, efficiency, and workload is needed to better understand how provider interaction and attitudes impact the quality of care delivered.

Detailed Analysis

Highlighted papers. Given the size and complexity of the published evidence, we examined a set of 12 high-quality, recently published papers in which the interventions were thoroughly described to guide our analysis of the impact of CDSSs on 6 outcome categories. For each outcome of interest, we present a summary of the included studies, the meta-analysis results when applicable, and a discussion of the key papers to help orient the reader to the broader evidence base and to inform the observations about the larger group of studies that evaluated each outcome category.^{25-27,49,53,70,78,101,105,115,116,119,129,130}

Six key categories of outcomes. From our examination of the impact of CDSSs and KMSs on clinical effectiveness and improved quality of care and patient outcomes, we present findings from the literature on six key categories of outcomes. During the initial review of the literature and data abstraction phase, we observed that the evidence concerning the organization of health care delivery (KQ 3a) was limited, and though we attempted to address this key question, we did not find evidence to support the impact of CDSSs/KMSs. The key categories of outcomes related to KQs 3b and 3c are:

1. **Clinical outcomes** (length of stay, morbidity, mortality, measure of health-related quality of life, adverse events)
2. **Health care process measures** (the recommended preventive care, clinical study, or treatment was ordered, completed, and adhered to; user knowledge)
3. **User workload and efficiency outcomes** (number of patients seen, clinician workload, efficiency)
4. **Relationship-centered outcomes** (patient satisfaction)
5. **Economic outcomes** (cost and cost-effectiveness)
6. **Use and implementation outcomes** (acceptance, satisfaction, use, implementation)

Impact on Clinical Outcomes

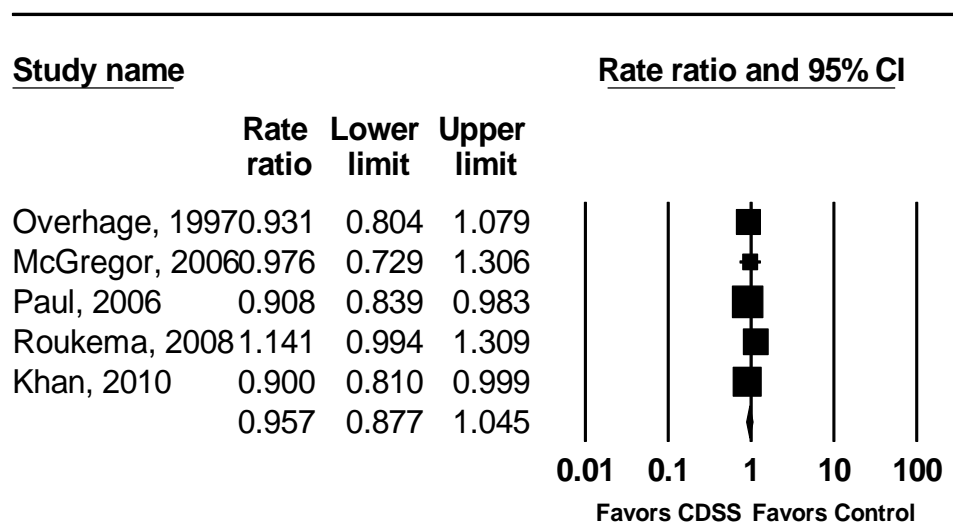
Length of stay. We identified 6 of the 148 eligible studies (4.1%) that specifically examined the impact of CDSSs/KMSs on length of stay. These studies are summarized in Table I-1 of Appendix I.

Of these six studies, four (66.7%) were conducted in the U.S.,^{26,27,29,30,34} one (16.7%) in Europe,³¹ and one (16.7%) in multiple countries.²³ Four of the studies (66.7%) were implemented in an academic setting,^{23,29,30,34} and one (16.7%) in the community setting,^{26,27} with one (16.7%) setting not reported.³¹ Three studies (50%) evaluated the systems in the inpatient environment,^{23,29,30} one (16.7%) in the ambulatory environment,^{26,27} and two (33.3%) in the emergency department.^{31,34} Duration of the evaluation period across the studies ranged from 12 weeks³⁰ to 2.3 years.³¹ Five interventions (83.3%) were implemented using a system developed within the specific health care organization,^{23,26,27,29,31,34} and one (16.7%) was implemented using a commercially available system.³⁰ Three systems (50%) aided health care providers with tasks for diagnosis,^{23,31,34} three (50%) for pharmacotherapy,^{23,29,30} one (16.7%) for chronic disease management,^{26,27} and two (33.3%) for laboratory test ordering.^{29,31} All of the systems (100%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter.^{23,26,27,29-31,34} Two (33.3%) of the systems did not have a response

requirement,^{23,34} one (16.7%) required a noncommittal acknowledgement,²⁹ and in three studies (50%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{26,27,30,31} In three studies (50%), the recommendations were integrated within a CPOE or EHR system;²⁹⁻³¹ two (33.3%) were delivered via fax or computer printout^{26,27,34} and one (16.7%) via a standalone system.²³ The recommendations were automatically delivered to the health care provider in all of the studies.^{23,26,27,29-31,34} All six studies (100%) received a “Good” quality score.^{23,26,27,29-31,34}

We conducted a meta-analysis of the effect of CDSSs on length of stay (Figure 3). Of the six studies, five (83.3%) provided the necessary endpoint data to be included in meta-analysis.^{23,26,27,29-31} The interventions included recommendations for appropriate antibiotic therapy,³⁰ guideline-based reminders for corollary orders,²⁹ diagnostic management of children with fever,³¹ risk assessment calculators for infection and antibiotic treatment recommendations,²³ and guideline-based diabetes testing recommendations.^{26,27} The combined relative risk for all studies was 0.96 (95% CI 0.88 to 1.05). However, if the Roukema et al.³¹ study, which was conducted in the pediatric population in the emergency department setting rather than the hospital setting, was excluded from the analysis, the combined relative risk for all studies was 0.91 (95% CI 0.86 to 0.97).

Figure 3. Meta-analysis of length of stay outcomes



One high-quality, recently published paper^{26,27} was examined in detail to guide observations about this group of studies. Khan et al. (2010)^{26,27} investigated guideline-based diabetes testing recommendations for 7412 patients from 64 community clinics and found that overall inpatient length of stay was significantly lower in the intervention group (0.99 versus 1.1 days; $P = 0.01$)

and for the following intervention subgroups: seniors (1.22 versus 1.44 days; $P = 0.002$) and men (0.94 versus 1.1 days; $P = 0.03$).

In addition to the Khan et al.^{26,27} study, which achieved statistically significant results in the community ambulatory setting with a locally developed CDSS that automatically delivered system-initiated (push) recommendations asynchronously to the provider, there is evidence from four studies conducted in the academic setting of locally developed CDSSs that automatically delivered system-initiated (push) recommendations synchronously at the point of care demonstrated a trend toward reducing length of stay.^{23,29,30,34} This finding was supported by evidence collected from three studies that included more than 2000 patients;^{23,29,30} however, only one study³⁴ included an evaluation period longer than 1 year. Notably, two studies were published after 2008.^{26,27,34} As mentioned previously, the Roukema et al. (2008)³¹ study reported that an intervention designed to promote the appropriate ordering of laboratory tests for children in the emergency department increased the median (25th to 75th percentile) length of stay from 123 (83–179) to 138 (104–181) minutes.

From the research included in this section, we concluded that limited evidence suggests that CDSSs are effective at reducing length of stay or demonstrating a trend toward reducing length of stay.

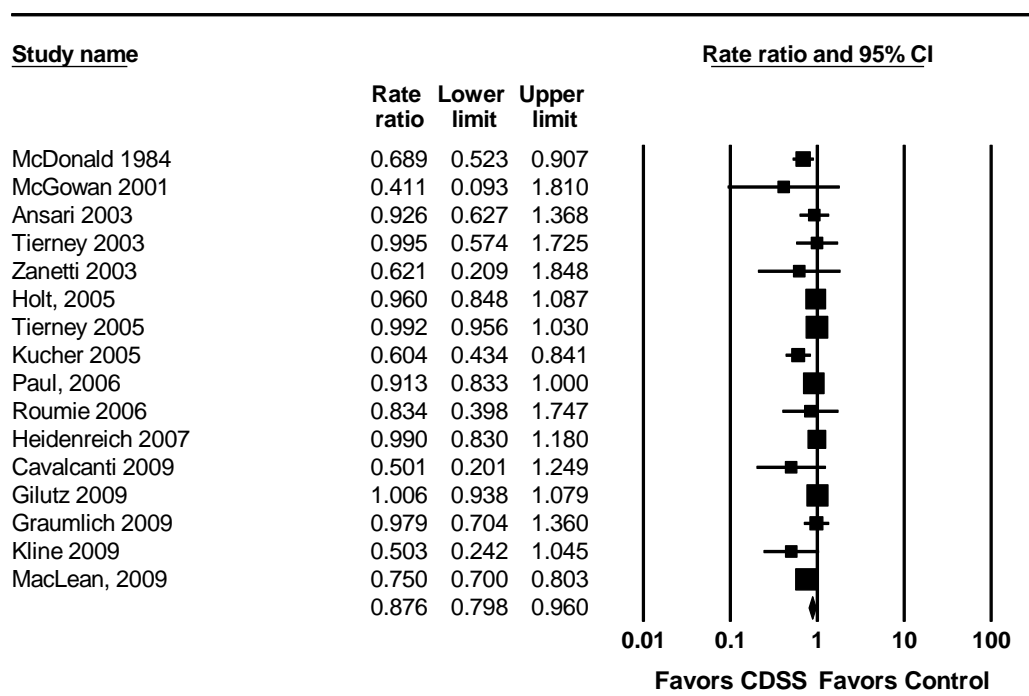
Morbidity. We identified 22 of the 148 eligible studies (14.9%) that specifically examined the impact of CDSSs/KMSs on morbidity. These studies are summarized in Table I-2 of Appendix I.

Of these 22 studies, 16 (72.7%) were conducted in the U.S.,^{20-22,24,26,27,34-40,68,75,108,111,113} 3 (13.6%) in Europe,^{32,41-43} 1 (4.5%) in Brazil,³³ and 2 (8%) in multiple countries.^{23,131} Eleven of the studies (50%) were implemented in an academic setting,^{21-23,34-37,39,40,75,108,131} 5 (22.7%) in a community setting,^{26,27,32,41-43,68} 2 (9.1%) in both academic and community settings,^{24,33} 3 (13.6%) in a VA setting,^{20,38,111} and one (4.5%) with the setting not reported.¹¹³ Six studies (27.3%) evaluated the systems in the inpatient environment,^{21,23,33,35-37,131} 13 (59.1%) in the ambulatory environment,^{20,22,24,26,27,32,39-43,68,75,108,111} 1 (4.5%) in both inpatient and ambulatory,³⁸ 1 (4.5%) in the emergency department,³⁴ and one did not have the setting reported.¹¹³ Duration of the evaluation period across the studies ranged from 3 months³⁵ to 4.5 years.³⁸ Twenty interventions (90.9%) were implemented using a system developed within the specific health care organization,^{20-24,26,27,32-41,75,108,111,113,131} and 2 (18.2%) were implemented using a commercially available system.^{42,43,68} Four systems (18.2%) aided health care providers with tasks for diagnosis,^{23,34,42,43,131} 9 (40.9%) for pharmacotherapy,^{20,22-24,33,35,38,41,113} 10 (45.5%) for chronic disease management,^{20,22,24,26,27,32,39-41,108,111} 2 (9.1%) for laboratory test ordering,^{22,68} and 6 (27.3%) for additional clinical tasks.^{21,22,36,37,41-43,68} Sixteen of the systems (72.7%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{20-23,32-40,68,108,111,131} 3 (13.6%) delivered recommendations outside of the health care provider–patient encounter,^{26,27,75,113} 1 delivered recommendations both during and outside of the health care provider–patient encounter,^{42,43} and 2 (9.1%) were not clearly described.^{24,41} Three of the interventions (13.6%) required a mandatory response,^{21,35,68} 4 (18.2%) did not have a response requirement,^{23,34,111,131} 4 (18.2%) required a noncommittal acknowledgement,^{22,40,42,43,108} and in 11 studies (50%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{20,24,26,27,32,33,36-39,41,75,113} In 8 studies (36.4%), the recommendations were integrated within a CPOE or EHR system,^{20,21,24,35,39,42,43,68,108} 7 (31.8%) were delivered via fax or computer printout,^{22,26,27,34,38,41,75,111} 6 (27.3%) via a standalone system,^{23,32,33,36,37,113,131} and 1 (4.5%) was

integrated within a CPOE or EHR and delivered via fax or computer printout.⁴⁰ The recommendations were automatically delivered to the health care provider in 17 studies (77.3%),^{20-24,26,27,34,35,38-43,68,75,108,111} in 2 studies (9.1%), the health care provider had to initiate an action to receive the recommendation,^{32,131} and in 3 studies (13.6%) the mode was not clearly described.^{33,36,37,113} Thirteen studies (59.1%) received a “Good” quality score,^{20-24,26,27,34-38,40,75,108} 7 (31.8%) had a “Fair” score,^{32,33,42,43,68,111,113,131} and 2 (9.1%) received a “Poor” score.^{39,41}

We conducted a meta-analysis of the effect of CDSSs on morbidity (Figure 4). Of the 22 studies, 16 (72.7%) provided the necessary endpoint data to be included in the meta-analysis.^{20-24,26,27,32-43} The combined relative risk of morbidity outcomes was 0.88 (95% CI 0.80 to 0.96).

Figure 4. Meta-analysis of morbidity outcomes



One high-quality, recently published paper^{26,27} was examined in detail to guide observations about this group of studies. Khan et al. 2010^{26,27} assessed guideline-based diabetes recommendations to improve cholesterol, creatinine, proteinuria, and A1C testing and found that the overall number of hospitalizations was significantly lower in the intervention group for all subjects (0.17 versus 0.20, $P = 0.01$) and for the following subgroups: seniors (0.21 versus 0.27, $P = 0.001$) and men (0.17 versus 0.21, $P = 0.02$). The number of emergency department visits was significantly lower for all intervention subjects (0.27 versus 0.36, $P < 0.0001$) and for the following intervention subgroups: seniors (0.21 versus 0.36, $P < 0.0001$), men (0.23 versus 0.36, $P < 0.0001$), and women (0.30 versus 0.37, $P = 0.01$) in the intervention group.

From the research included in this section, we concluded that there is modest evidence from 7 studies (31.8%) conducted in the academic community inpatient and ambulatory settings that locally developed CDSSs integrated in a CPOE or EHR system or nonintegrated (paper or standalone system) that automatically delivered system-initiated (push) recommendations or required user-initiated (pull) requests for recommendations synchronously at the point of care or asynchronously outside the point of care are effective at reducing the proportion of patients who are admitted or readmitted to the hospital or emergency department,^{22,26,27,34,41,75} or who experience a hypoglycemia episode,³³ or who have deep-vein thrombosis or pulmonary embolism at 30 days.²¹ However, the majority of those interventions were conducted in the academic ambulatory setting and evaluated locally developed nonintegrated CDSSs that automatically delivered system-initiated (push) recommendations synchronously at the point of care. This finding was supported by evidence from six studies that included evaluation periods of at least 1 year^{21,22,33,34,41,75} and from five studies that were evaluated with more than 2000 patients.^{21,22,26,27,41,75} Notably, four studies were published after 2008.^{26,27,33,34,41} In addition to the seven studies (31.8%) that reported statistical significance, there is evidence from the academic, community, and VA inpatient, ambulatory, and emergency department settings that locally developed CDSSs demonstrated a trend toward a reduction in morbidity. These studies described interventions that were integrated in a CPOE or EHR system and nonintegrated (paper-based or standalone system), delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated), and provided recommendations synchronously at the point of care. Examples of improved morbidity included a reduction in the proportion of patients who are admitted or readmitted to the hospital or emergency department,^{20,24,32,36,37} a reduction in significant cardiovascular diagnosis³⁴ and lower cardiovascular event rates,^{42,43} and a reduction in the number of patients who experienced surgical site infections,³⁵ have a shorter duration of fever,²³ or have a colorectal adenoma detected.⁶⁸ However, the majority of the studies were conducted in the community ambulatory setting and evaluated CDSSs that were locally developed, integrated in a CPOE or EHR system, and automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care. This supporting evidence was determined from five studies that included evaluation periods of at least 1 year^{20,36,37,42,43,68} and three studies that were evaluated with more than 2000 patients.^{23,42,43,68} However, only four studies were published after 2008.^{34,36,37,42,43,68} While representing only a limited subset of studies, in these studies there was no significant effect of a mandatory clinician response on patient morbidity.

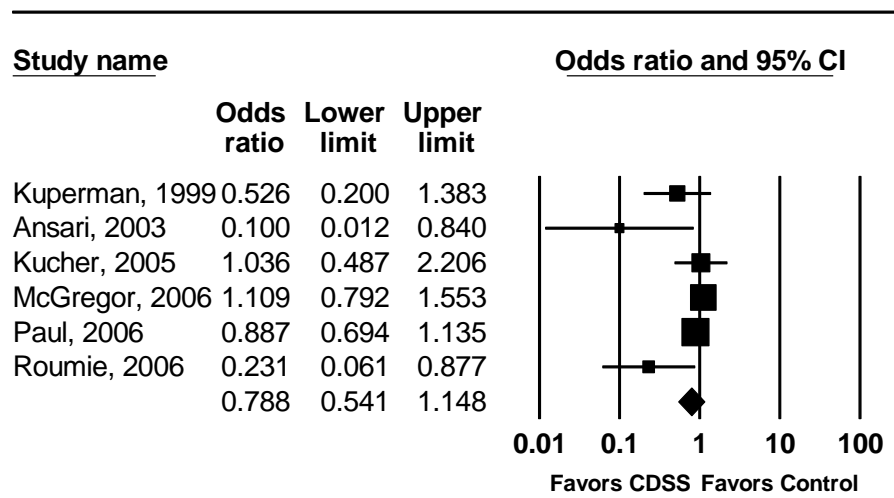
Mortality. We identified 7 of the 148 eligible studies (4.7%) that specifically examined the impact of CDSSs/KMSs on mortality. These studies are summarized in Table I-3 of Appendix I.

Of these seven studies, six (85.7%) were conducted in the U.S.^{20,21,24,30,44,113} and one (14.3%) in multiple countries.²³ Four of the studies (57.1%) were implemented in an academic setting,^{21,23,30,44} one (14.3%) in both academic and community settings,²⁴ one (14.3%) in a VA setting,²⁰ and 1 (14.3%) had a setting that was unclear.¹¹³ Four studies (57.1%) evaluated the systems in the inpatient environment,^{21,23,30,44} two (28.6%) in the ambulatory environment,^{20,24} and 1 (14.3%) had an environment that was unclear.¹¹³ Duration of the evaluation period across the studies ranged from 12 weeks³⁰ to 3 years and 4 months.²¹ Six interventions (85.7%) were implemented using a system developed within the specific health care organization,^{20,21,23,24,44,113} and one (14.3%) was implemented using a commercially available system.³⁰ One system (4.3%) aided health care providers with tasks for diagnosis,²³ five (71.4%) for

pharmacotherapy,^{20,23,24,30,113} two (28.6%) for chronic disease management,^{20,24} and two (28.6%) for additional clinical tasks.^{21,44} Five systems (71.4%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{20,21,23,30,44} one (14.3%) delivered recommendations outside of the health care provider–patient encounter,¹¹³ and one system (14.3%) was not clearly described.²⁴ Two of the interventions (28.6%) required a mandatory response,^{21,44} one (14.3%) did not have a response requirement,²³ and in three studies (42.9%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{20,24,30,113} In four studies (57.1%), the recommendations were integrated within a CPOE or EHR system,^{20,21,24,30} two (28.6%) via a standalone system,^{23,113} and one (14.3%) delivered via pager and integrated within a CPOE or EHR.⁴⁴ The recommendations were automatically delivered to the health care provider in six studies (85.7%),^{20,21,23,24,30,44} with one study (14.3%) having a mode that was unclear.¹¹³ Six studies (85.7%) received a “Good” quality score,^{20,21,23,24,30,44} and one received a “Fair” quality score.¹¹³

We conducted a meta-analysis of the effect of CDSSs on mortality (Figure 5). Of the seven studies, six (85.7%) provided the necessary endpoint data to be included in meta-analysis.^{20,23,24,30,44} The combined odds ratio was 0.79 (95% CI 0.54 to 1.15). Thus, patients in the intervention group with a CDSS had an odds of dying that was 79 percent as large as those in the control group, and this combined effect did not reach statistical significance.

Figure 5. Meta-analysis of mortality outcomes



None of the 10 key papers reported data describing the impact of CDSSs on mortality. Of the studies that reported mortality data, Ansari et al. (2003)²⁰ was conducted in the ambulatory VA setting for 1 year with 169 patients and found that a locally developed CDSS integrated in a CPOE or EHR system that promoted the appropriate use of beta blockers for CHF patients was effective at reducing patient mortality by 12 percent ($P = 0.05$). Roumie et al. (2006)²⁴ assessed a

locally developed CDSS integrated in a CPOE or EHR that promoted guideline-based hypertension treatment in the academic and community ambulatory settings with 1341 patients, 182 residents, staff physicians, nurse practitioners, and physician assistants for 6 months and reported that 3 (0.6%) patients died in the provider education and electronic alert group; 4 (0.9%) patients died in the provider education, alert, and patient education group; and 8 (2.5%) patients died in the provider education group ($P = 0.027$).

In addition to the two studies that showed statistical significance, there is evidence from two studies conducted in the academic inpatient setting of locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care demonstrated a trend toward reducing patient mortality.^{23,44} Notably, none of these studies were published after 2008. While this represented only a limited subset of studies, there was no significant effect of a mandatory clinician response on mortality.

From the research included in this section, we concluded that limited evidence suggests that CDSSs are effective at reducing patient mortality or demonstrating a trend toward reducing patient mortality.

Health care-related quality of life (HRQOL). We identified 6 of the 148 eligible studies (4.1%) that specifically examined the impact of CDSSs/KMSs on HRQOL or functional status. These studies are summarized in Table I-4 of Appendix I.

Of these six studies, five (83.3%) were conducted in the U.S.^{26,27,39,40,108,111} and 1 (16.7%) in Europe.¹³² Three of the studies (50%) were implemented in an academic setting,^{39,40,108} two (33.3%) in a community setting,^{26,27,132} and one (16.7%) in a VA setting.¹¹¹ Five studies (83.3%) evaluated the systems in the inpatient environment^{39,40,108,111,132} and one (16.7%) in the ambulatory setting.^{26,27} Duration of the evaluation period across the studies ranged from 6 months¹³² to 2 years and 4 months.^{39,40} All interventions (100%) were implemented using a system developed within the specific health care organization.^{26,27,39,40,108,111,132} Five systems (83.3%) aided health care providers with tasks for chronic disease management^{26,27,39,40,108,111} and one (16.7%) for additional clinical tasks.¹³² Four of the systems (66.7%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{39,40,108,111} and 2 (33.3%) delivered recommendations outside of the health care provider–patient encounter.^{26,27,132} Two of the interventions (33.3%) did not have a response requirement,^{111,132} two (33.3%) required a noncommittal acknowledgement,^{40,108} and in two studies (33.3%), it was unclear to the abstractor if such requirement was present.^{26,27,39} In two studies (33.3%), the recommendations were integrated within a CPOE or EHR system;^{39,108} three (50%) were delivered via fax or computer printout,^{26,27,111,132} and one (16.7%) was both within a CPOE or EHR and delivered via fax or computer printout.⁴⁰ The recommendations were automatically delivered to the health care provider in all six studies (100%).^{26,27,39,40,108,111,132} Three studies (50%) received a “Good” quality score,^{26,27,40,108} two (33.3%) had a “Fair” score,^{111,132} and one (16.7%) received a “Poor” score.³⁹

One high-quality, recently published paper^{26,27} was examined in detail to guide observations about this group of studies. Khan et al. (2010)^{26,27} assessed diabetes guideline-based testing recommendations and reported a significant improvement in patient exercise habits (adjusted effect +5.0, 95% CI +0.9, +9.1, $P = 0.017$) and a modest trend toward improved quality of life in the physical component score and patient diet.

Of the studies that reported quality-of-life data, two other studies of locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers were

effective at improving quality-of-life scores.^{111,132} One found that the intervention patients who were treated by providers who received evidence-based treatment recommendations for the management of chronic heart failure had significant improvements in the mental component score compared to patients in the control group at 6 and 12 months.¹¹¹ Another study reported that patients who received depression and anxiety treatment advice by intervention providers who utilized computer-based guidelines had significantly lower scores (a low score indicated better mental health) at 6 weeks ($P = 0.04$), but the significant effect was not maintained and at 6 months compared to usual care.¹³² In addition to those studies that demonstrated a statistical improvement in HRQOL, there is evidence that locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers demonstrated a trend toward improving patient quality of life.^{39,108} Murray et al. (2004)¹⁰⁸ found that patients who received care from intervention physicians who received evidence-based hypertension reminders had higher quality-of-life scores with the exception of the role of physician compared to those patients in the pharmacist intervention, dual-intervention, and control groups. Tierney et al. (2005)³⁹ reported that patients who were treated by physicians who received evidence-based treatment suggestions for asthma and chronic obstructive pulmonary disease (COPD) had greater quality-of-life scores for pain, general health, social function, and emotional subscales compared with the pharmacist intervention and control groups.

From the research included in this section, we concluded that limited evidence suggests that CDSSs are effective at improving or demonstrating a trend toward higher quality-of-life scores.

Adverse events. We identified 5 of the 148 eligible studies (3.4%) that specifically examined the impact of CDSSs/KMSs on adverse events. These studies are summarized in Table I-5 of Appendix I.

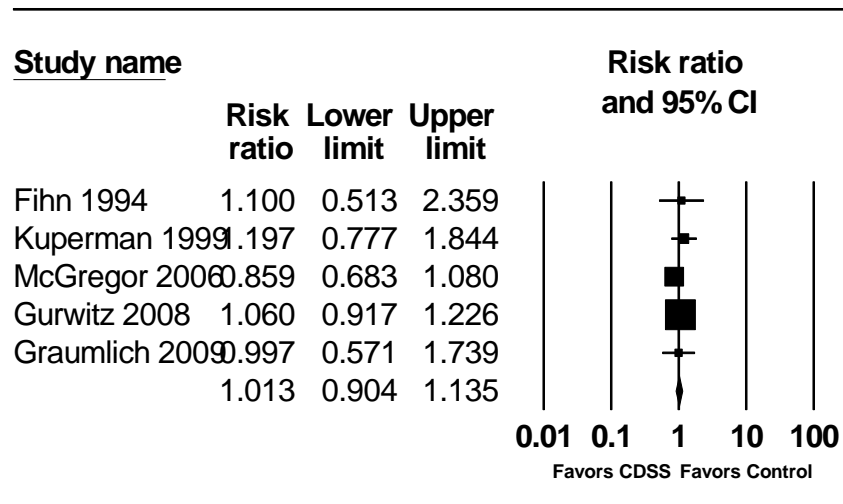
Examples of these outcomes included bleeding risks and thromboembolic complications;⁴⁵ diarrhea as a side effect of antimicrobial use as indicated by testing for *Clostridium difficile*;³⁰ adverse drug events from medication errors or from adverse drug reactions;⁴⁶ postdischarge adverse events related to medical management within 1 month after discharge;^{36,37} and adverse events including cardiopulmonary arrest, transfer to the intensive care unit (ICU), myocardial infarction, delirium, stroke, renal insufficiency, acute renal failure, dialysis, return to operating room, and death.⁴⁴

Of these 5 studies, 4 (80%) were conducted in the U.S.,^{30,36,37,44,45} and one (20%) was conducted in multiple countries.⁴⁶ Four of the studies (80%) were implemented in an academic setting,^{30,36,37,44,46} and one (20%) was in both academic and community settings.⁴⁵ Three studies (60%) evaluated the systems in the inpatient environment,^{30,36,37,44} one (20%) in the ambulatory environment,⁴⁵ and one (20%) in a long-term facility.⁴⁶ Duration of the evaluation period across the studies ranged from 12 weeks³⁰ to 26 months.^{36,37} Four interventions (80%) were implemented using a system developed within the specific health care organization,^{36,37,44-46} and one (20%) was implemented using a commercially available system.³⁰ Two systems (40%) aided health care providers with tasks for pharmacotherapy^{30,46} and three (60%) for additional clinical tasks.^{36,37,44,45} All five systems (100%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter.^{30,36,37,44-46} One of the interventions (20%) required a mandatory response,⁴⁴ one (20%) did not have a response requirement,⁴⁶ and in three studies (60%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{30,36,37,45} In two studies (40%), the recommendations were integrated within a CPOE or EHR system;^{30,46} one

(20%) was integrated within a CPOE or EHR and via pager,⁴⁴ one (20%) via a standalone system,^{36,37} and one (20%) had a format that was not clearly described.⁴⁵ The recommendations were automatically delivered to the health care provider in three studies (60%),^{30,44,45} in one study (20%), the health care provider had to initiate an action to receive the recommendation,⁴⁶ and in one study (20%) the mode was not clearly described.^{36,37} Three studies (60%) received a “Good” quality score,^{30,36,37,44} one (20%) had a “Fair” score,⁴⁶ and one (20%) received a “Poor” score.⁴⁵

We conducted a meta-analysis of the effect of CDSSs on adverse events using the five studies (Figure 6). The combined relative risk was 1.01 (95% CI 0.90 to 1.14). Thus, patients in the intervention group with a CDSS were as likely to experience an adverse event as patients in the control group.

Figure 6. Meta-analysis of adverse events



None of the 10 key papers reported data describing the impact of CDSSs on adverse events. Of the studies that reported adverse events data, one found that a commercially developed CDSS designed to detect potentially inappropriate antimicrobial therapy used the frequency of *C. difficile* testing as an indicator for the presence of diarrhea and adverse effect of antimicrobial use.³⁰ This study included 4507 patients for 12 weeks and reported that fewer intervention patients experienced diarrhea as a side effect of antimicrobial therapy (5.7% versus 6.6%; $P = 0.21$). The intervention was terminated at 12 weeks in order to expand the intervention to the control group. Although that one study demonstrated that CDSSs reduced or prevented adverse events, four studies did not observe any effect on reducing or preventing adverse events.^{36,37,44-46}

From the included evidence, we concluded that limited evidence suggests that CDSSs are effective at reducing or preventing adverse events.

Impact on Health Care Process Measures

Recommendations to order/complete a preventive care service. We identified 43 of the 148 eligible studies (29.1%) that specifically examined the impact of CDSSs/KMSs on the rates of ordering or completing recommended preventive care services. These studies are summarized in Table I-6 of Appendix I.

Of these 43 studies, 29 (67.4%) were conducted in the U.S.,^{21,22,39,47,50,51,58,60,68,71,75,76,84,85,92-94,96-98,126,133-142} 5 (11.6%) in Europe,^{4,41,56,57,74,123} 6 (14%) in Canada,^{63,89,95,143-145} 2 (4.7%) in Australia,^{55,146} and 1 (2.3%) in New Zealand.¹⁴⁷ Twenty of the studies (46.5%) were implemented in an academic setting,^{21,22,39,51,60,63,75,76,85,94-96,136-140,142,144-146} 15 (34.9%) in a community setting,^{4,41,47,55-57,68,74,84,92,93,97,133,134,141,143,147} 5 (11.6%) in both academic and community settings,^{58,71,98,126,135} 1 (2.3%) in a VA setting,⁵⁰ and 2 (4.7%) did not specify the location.^{89,123} Five studies (11.6%) evaluated the systems in the inpatient environment^{21,51,94,96,98} and 38 (88.4%) in the ambulatory environment.^{4,22,39,41,47,50,55-58,60,63,68,71,74-76,84,85,89,92,93,95,97,123,126,133-147}

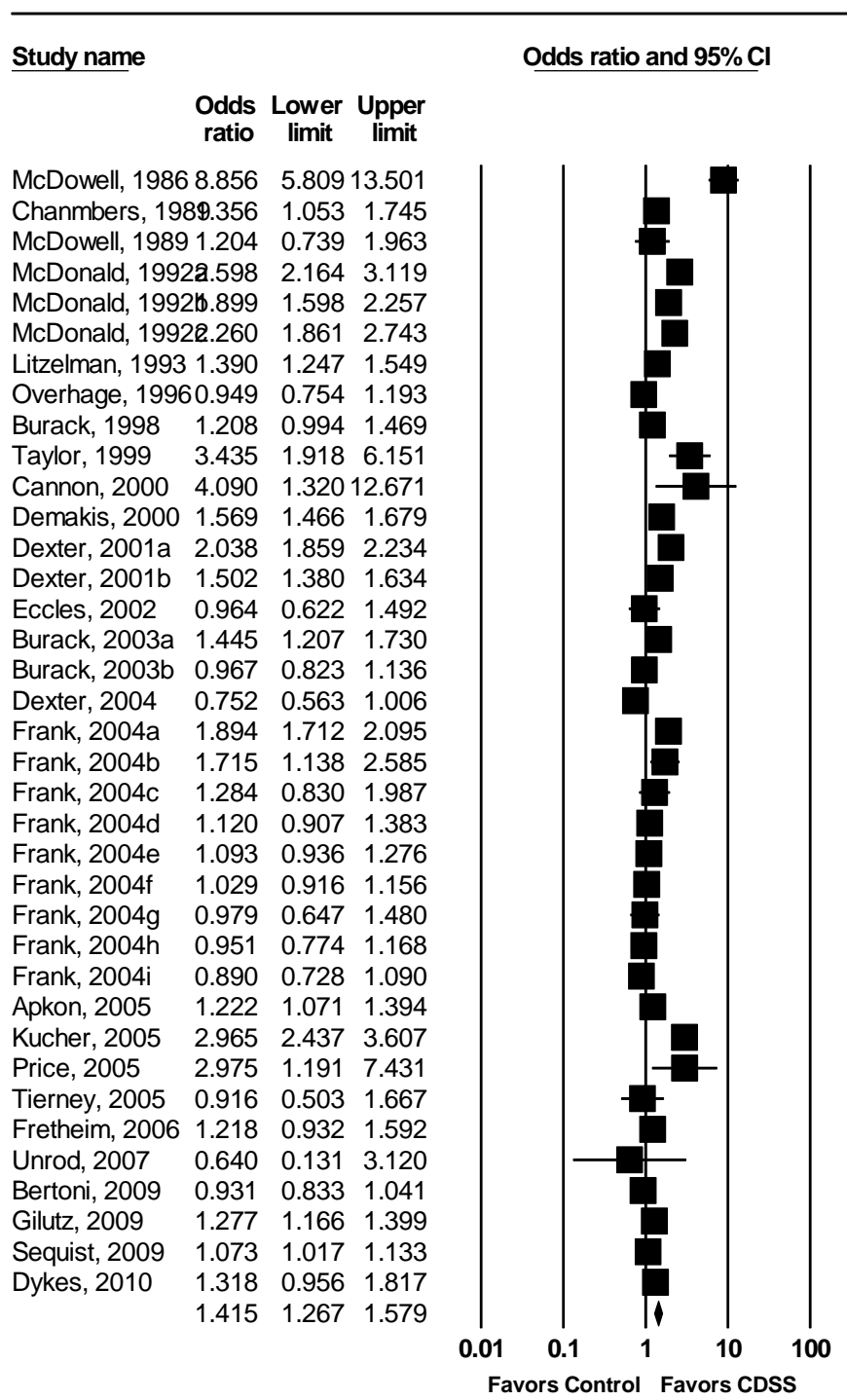
Duration of the evaluation period across the studies ranged from 6 weeks¹⁴⁶ to 40 months.²¹ Twenty-seven interventions (62.8%) were implemented using a system developed within the specific health care organization,^{21,22,39,41,50,51,60,75,76,84,85,92-98,123,126,133,134,136-139,142,144,145} 10 (23.3%) were implemented using a commercially available system,^{4,47,56-58,68,74,89,135,146,147} and 6 (14%) had a source that was not clearly described.^{55,63,71,140,141,143} Five systems (11.6%) aided health care providers with tasks for diagnosis,^{47,74,85,98,123} 7 (16.3%) for pharmacotherapy,^{22,41,51,56-58,126,146} 11 (25.6%) for chronic disease management,^{4,22,39,41,47,50,58,92,138,141,143} 10 (23.3%) for laboratory test ordering,^{22,58,60,68,71,123,126,138,140,142} 3 (7%) for initiating discussions with patients,^{71,97,143} and 35 (81.4%) for additional clinical tasks.^{21,22,41,47,50,51,55-58,60,63,68,71,74-76,84,89,93-96,98,123,126,133-140,142,144,145,147}

Forty (93%) of the systems delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{4,21,22,39,47,50,51,56-58,60,63,68,71,74,76,84,85,89,92-98,123,126,133-147} one (2.3%) delivered recommendations outside of the health care provider–patient encounter,⁷⁵ and for two studies (4.7%), the delivery mechanism for the CDSS was not clearly described.^{41,55} Four (9.3%) of the interventions required a mandatory response,^{21,51,68,85} 3 (7%) required the health care provider to justify the reason for not complying with the recommendation,^{133,134,137,139,140} 11 (25.6%) did not have a response requirement,^{47,56,57,84,92,93,95,126,138,144,145,147} 5 (11.6%) required a noncommittal acknowledgement,^{22,58,96,136,142} 1 (2.3%) required both a mandatory response and justification for not complying with the recommendation;⁶⁰ and in 19 studies (44.2%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{4,39,41,50,55,63,71,74-76,89,94,97,98,123,135,141,143,146} In 13 studies (30.2%), the recommendations were integrated within a CPOE or EHR system,^{4,21,39,47,51,55-58,68,74,94,135,147} 20 (46.5%) delivered via fax or computer printout,^{22,41,60,63,71,75,76,84,93,95-97,133,134,137-142,144,145} 5 (11.6%) via a standalone system,^{85,89,92,123,146} 2 (4.7%) via online recommendations,^{136,143} 2 (4.7%) were integrated both within a CPOE or EHR and delivered via fax or computer printout,^{50,126} and 1 (2.3%) was via online recommendations and computer printout.⁹⁸ The recommendations were automatically delivered to the health care provider in 35 studies (81.4%);^{4,21,22,39,41,47,50,51,56-58,60,63,68,71,74-76,84,85,93-97,126,133-135,137-142,144-146} in 6 studies (14%), the health care provider had to initiate an action to receive the recommendation,^{89,92,98,123,136,147} and in 2 studies (4.7%) the mode for assessing the CDSS was not clearly described.^{55,143} Twenty studies (46.5%) received a “Good”

quality score,^{21,22,47,50,51,71,74-76,84,92-94,96,133,134,138,141,142,146,147} 16 (37.2%) had a “Fair” score,^{4,55-57,60,63,68,85,95,97,98,135,137,139,140,143-145} and 7 (16.3%) received a “Poor” score.^{39,41,58,89,123,126,136}

We conducted a meta-analysis (Figure 7) that focused on CDSS studies in which at least one outcome was related to ordering or completing preventive care services. Of the 43 studies that assessed a response to recommendations for ordering treatment or prescribing therapies, 25 studies (58.1%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{4,21,40,41,47,50,51,55-57,60,63,68,71,75,76,84,85,89,92-98} Clinical decision support systems were found to have a statistically significant impact on the ordering or completing of preventive care services, with the overall effect of clinical decision support having an odds ratio of 1.42 (95% CI 1.27 to 1.58).

Figure 7. Meta-analysis of recommended preventive care service ordered



We examined one high-quality, recently published paper⁹² in which the CDSS intervention was thoroughly described to guide observations about this group of studies. Bertoni et al. (2009)⁹² evaluated a handheld CDSS that calculated the Framingham risk score for cardiac disease and delivered recommendations for lipid screening and management-based national guidelines at 66 community clinics. They found that the lipid level screening rate increased in both the intervention and control practices (43.6% to 49% [intervention]; 40.1% to 50.8% [control]; net difference -5.3% P = 0.22).

From the research studies cited above, we concluded that there is strong evidence from 21 studies (48.8%) conducted in the academic, community, and VA inpatient and ambulatory settings that locally and commercially developed CDSSs are effective at improving appropriate ordering of preventive care procedures. These interventions were integrated in a CPOE or EHR system and nonintegrated (paper-based, online system, or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{21,22,41,47,50,51,58,60,71,74-76,84,85,94,136-141,143}

However, the majority of the studies were conducted in the academic ambulatory settings and evaluated CDSSs that were locally developed, nonintegrated, automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care, and did not require a mandatory clinician response. This conclusion is supported by evidence from 12 studies that included evaluation periods longer than 1 year^{21,22,41,50,51,58,71,75,84,94,140,141} and 12 studies that were evaluated with more than 2000 patients.^{21,22,41,50,51,58,60,75,84,94,140,141} However, only five studies were published after 2008.^{41,58,74,141,143}

With regard to improving the quality of care, very few of the studies demonstrated effectiveness of CDSSs designed to promote the appropriate ordering of preventive care procedures on clinical outcomes^{21,22,41,75} or on economic outcomes.⁴⁷ In addition to the 21 studies (48.8%) that achieved statistical significance, there is supportive evidence from the academic and community inpatient and ambulatory settings of locally and commercially developed CDSSs that demonstrated a trend toward improving the appropriate ordering of preventive care procedures. These interventions were integrated in a CPOE or EHR system and nonintegrated (paper-based, online system, or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{55-57,63,68,89,93,95,97,98,123,133-135,142,144-147} However, the majority of these studies were conducted in the academic or community ambulatory settings and the interventions were locally developed, nonintegrated, automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care, and did not require a mandatory clinician response demonstrated a trend toward improving appropriate ordering of preventive care procedures. This observation showing a trend for effectiveness is supported by evidence from 7 studies that included evaluation periods longer than 1 year^{56,57,68,93,95,133,134,144,145} and 11 studies that were evaluated with more than 2000 patients.^{55-57,68,93,98,133-135,142,144-146} However, only three of these studies were published after 2008.^{68,98,135} Notably, with regard to improving the quality of care, very few of the studies that demonstrated a trend toward effectiveness of CDSSs to promote the appropriate ordering of preventive care procedures on clinical outcomes^{56,57,68,98} or on economic outcomes.^{56,57,63,95,123,144}

With regard to the future direction of the field of using mobile devices to enhance the delivery and quality of care, one study demonstrated that use of a handheld computer-based decision support program at the point of care led to higher rates of preventive care screening in the intervention group for cervical and colorectal cancer, hyperlipidemia, hypertension, and in promoting prophylaxis with acetylsalicylic acid.⁸⁹ However, another study found no effect of the intervention on lipid screening between the intervention and control group as screening rates increased for both groups.⁹²

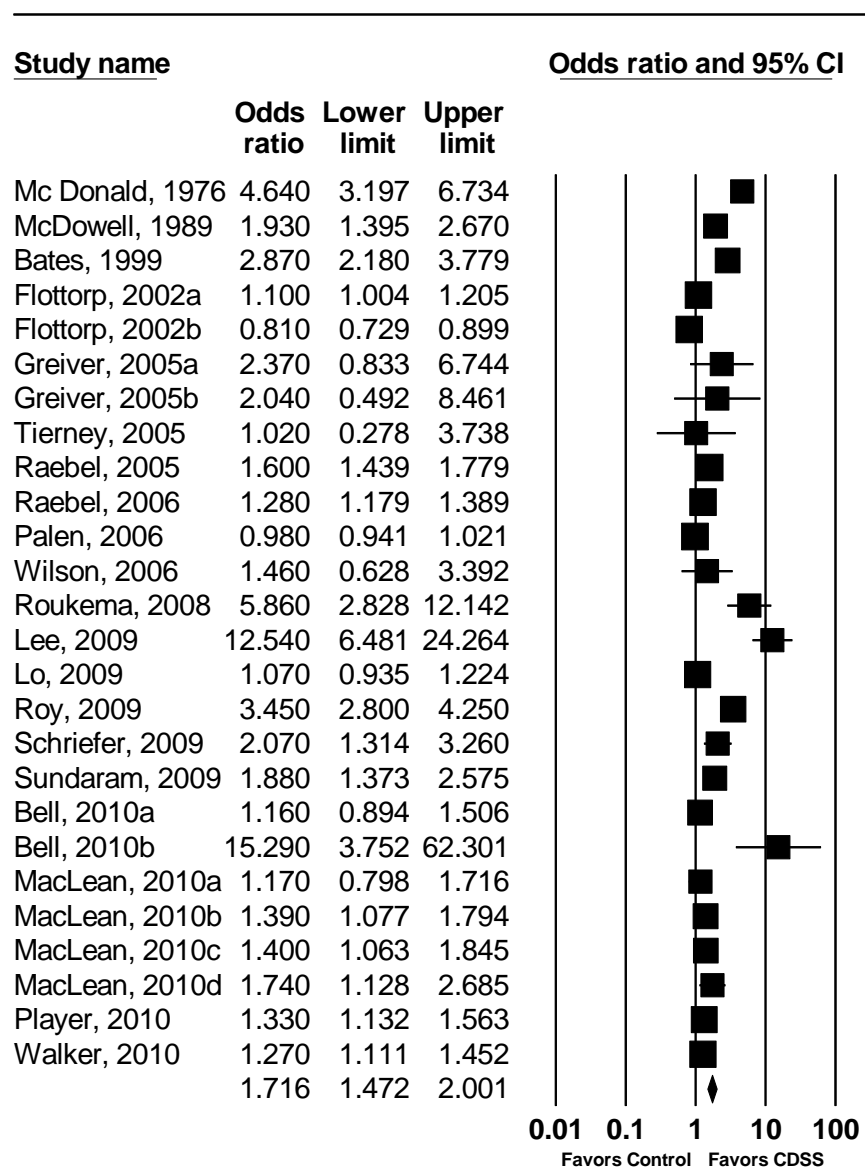
Recommendations to order/complete a clinical study. We identified 29 of the 148 eligible studies (19.6%) that specifically examined the impact of CDSSs/KMSs on the ordering and completion of recommended clinical studies. Examples of these interventions included reminders to order blood tests when ordering a medication, alerts to update a laboratory test, recommendations to refer patients for genetic testing, notices for x-ray orders, and suggestions to diagnose dementia and obesity. These studies are summarized in Table I-7 of Appendix I.

Of these 29 studies, 17 (58.6%) were conducted in the U.S.,^{26,27,39,48,49,61,65,66,69,70,77,87,101,102,148-151} 7 (24.1%) in Europe,^{31,67,99,103,118,128,152} 3 (10.3%) in Canada,^{62,100,153} 1 (3.4%) in Australia,⁷⁸ and 1 (3.4%) in an unspecified country.¹⁵⁴ Nine of the studies (37.5%) were implemented in an academic setting,^{39,48,61,62,65,66,69,87,148} 6 (25%) in a community setting,^{67,99,103,118,128,152} 5 in both academic and community settings,^{49,100,101,149,153} 1 (4.2%) in a VA setting,⁷⁰ and 3 (12.5%) in settings not clearly described.^{31,102,154} Two studies (6.9%) evaluated the systems in the inpatient environment,^{48,148} 24 (82.8%) in the ambulatory environment,^{26,27,39,49,61,62,65,66,69,70,77,78,87,99-103,118,128,149-152,154} and 3 (10.3%) in the emergency department.^{31,67,153} Duration of the evaluation period across the studies ranged from 14 weeks¹⁵⁴ to 2.4 years.⁴⁹ Twenty interventions (69%) were implemented using a system developed within the specific health care organization,^{26,27,31,39,48,49,61,62,65,67,70,87,100,101,103,128,148,149,151,153,154} 7 (24.1%) were implemented using a commercially available system,^{77,78,99,102,118,150,152} and 2 (6.9%) were implemented in a site that was not clearly described.^{66,69} Nine systems (31%) aided health care providers with tasks for diagnosis,^{31,62,67,69,77,87,100,148,152} 2 (6.9%) for pharmacotherapy,^{61,77} 5 (17.2%) for chronic disease management,^{26,27,39,49,69,152} 16 (55.2%) for laboratory test ordering,^{31,48,61,65,66,70,78,100-102,128,149-151,153,154} 2 (6.9%) for initiating discussions with patients,^{78,103} and 4 (13.8%) for additional clinical tasks.^{99,103,118,148} Twenty-seven of the systems (93.1%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{31,39,48,49,62,65-67,69,70,77,78,87,99-103,118,128,148-154} and two (6.9%) delivered recommendations outside of the health care provider–patient encounter.^{26,27,61} Six of the interventions (20.7%) required a mandatory response,^{65,66,78,148,151,153} 2 (6.9%) required the health care provider to justify the reason for not complying with the recommendation,^{48,70} 5 (17.2%) did not have a response requirement,^{62,101,128,149,154} 1 (3.4%) required a noncommittal acknowledgement,¹⁰² and in 15 studies (51.7%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{26,27,31,39,49,61,67,69,77,87,99,100,103,118,150,152} In 20 studies (69%), the recommendations were integrated within a CPOE or EHR system,^{31,39,48,49,65,66,69,70,77,78,101,102,128,148-154} 3 (10.3%) were delivered via fax or computer printout,^{26,27,61,62} 3 (10.3%) via a standalone system,^{67,87,100} and 3 (10.3%) via other delivery methods.^{99,103,118} The recommendations were automatically delivered to the health care provider in 21 studies (72.4%);^{26,27,31,39,48,49,61,62,65,66,69,70,77,78,101,102,149-154} in 5 studies (17.2%), the health care provider had to initiate an action to receive the recommendation,^{67,100,103,128,148} and in 3 studies (10.3%) the mode of CDSS delivery was not

clearly described.^{87,99,118} Sixteen studies (55.2%) received a “Good” quality score,^{26,27,31,49,61,65,66,69,70,78,101,102,128,149,152-154} 9 (31%) had a “Fair” score,^{48,62,67,77,87,118,148,150,151} and 4 (13.8%) received a “Poor” score.^{39,99,100,103}

We conducted a meta-analysis (Figure 8) that focused on CDSS studies in which at least one outcome was related to ordering or completing of recommended clinical studies. Of the 29 studies that assessed a response to recommendations for ordering or completing clinical studies, 20 (69.0%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{26,27,31,39,48,49,61,62,65-67,69,70,77,78,87,99-103} Clinical decision support systems were found to have a statistically significant impact on the ordering or completing of clinical studies with the overall effect of clinical decision support having an odds ratio of 1.72 (95% CI 1.47 to 2.00). Note that there was a strong suggestion of publication bias in these studies (see Appendix I), and therefore these results should be viewed with caution.

Figure 8. Meta-analysis of recommended clinical studies ordered



Five high-quality, recently published papers^{26,27,49,70,78,101} in which the CDSS interventions were thoroughly described were examined in detail to guide observations about this group of studies. Bell et al. (2010)⁴⁹ assessed treatment reminders to improve provider adherence to national asthma guidelines at 12 academic and community clinics for 2.4 years and found that rates of performing spirometry significantly improved in the suburban intervention practices ($P = 0.003$).^{26,27} evaluated recommendations to improve appropriate guideline-based diabetes testing and reported that intervention patients were significantly more likely to receive guideline-

appropriate testing for cholesterol (OR 1.39, 95% CI 1.07 to 1.80, $P = 0.012$), creatinine (OR 1.40; 95% CI 1.06 to 1.84, $P = 0.018$), and proteinuria (OR 1.74; 95% CI 1.13 to 1.69, $P = 0.012$). Walker et al. (2010)⁷⁸ assessed guideline-based reminders to discuss chlamydia testing for women 16 to 24 years of age in 68 community clinics for 12 months and found that the rate of chlamydia testing significantly increased across intervention and control groups but that the intervention clinics had a greater increase in testing (27%; OR 1.3, 95% CI 1.1 to 1.4). Lo et al. (2009)¹⁰¹ assessed reminders to order appropriate laboratory tests in 22 clinics for 6 months and reported that there was no difference between intervention and control provider with regard to appropriately ordering laboratory tests within 14 days of a medication prescription (41% versus 39%) (OR 1.048, 95% CI 0.753 to 1.457, $P = 0.782$). Sundaram, et al., (2009)⁷⁰ evaluated reminders to assess HIV risk behaviors or to offer HIV testing on 32 providers for 9 months and reported no change in testing rates between the intervention and control providers (0.29% versus 0.52%) ($P = 0.75$).

From the research reported in this section, we concluded that there is modest evidence from 19 studies (65.5%) conducted in the academic and community inpatient and ambulatory settings that locally and commercially developed CDSSs are effective at improving appropriate ordering of clinical studies. These studies included interventions that: were integrated in a CPOE or EHR system and nonintegrated (paper-based or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{26,27,31,48,49,61,65-67,69,77,78,87,118,128,150-154} However, the majority of these studies were conducted in the academic and community ambulatory settings and evaluated locally developed CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response. Of those studies that reported a statistically significant effect, 9 studies included evaluation periods longer than 1 year^{31,49,65,66,78,118,128,150,153} and 9 were evaluated with more than 2000 patients.^{26,27,48,49,65,66,77,151-153} Additionally, 10 of these studies were published after 2008.^{26,31,49,67,69,77,78,87,150,153}

With regard to improving the quality of care, very few of the studies that demonstrated effectiveness of CDSSs assessed the effect of appropriate ordering of clinical studies on clinical outcomes^{26,27,31} or on economic outcomes.^{26,27,48,151} In particular, while the Roukema et al.³¹ study evaluated a decision support intervention in the pediatric emergency department that successfully promoted appropriate ordering of laboratory tests, it was also associated with an increase in length of stay. In addition to the 19 studies (65.5%) that reported statistical significance, there is limited supporting evidence from the academic and community ambulatory settings that locally and commercially developed CDSSs demonstrated a trend toward improving appropriate ordering of clinical studies. These studies described interventions that were integrated in a CPOE or EHR system and nonintegrated (paper-based or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care.^{62,99-101,103,149} However, the majority of these studies were conducted in the community ambulatory setting and the CDSSs were locally developed, automatically delivered system-initiated (push) recommendations synchronously at the point of care, and did not require a mandatory clinician response. This observation showing a trend for effectiveness is supported by evidence from one study that included an evaluation period longer than 1 year⁹⁵ and three studies that were evaluated with more than 2000 patients.^{62,99} However, only two of these studies were

published after 2008.^{101,149} Notably with regard to improving the quality of care, none of the studies that demonstrated a trend toward effectiveness of CDSSs assessed the effect of appropriate ordering of clinical studies on clinical outcomes, and very few assessed the effect on economic outcomes.^{62,103}

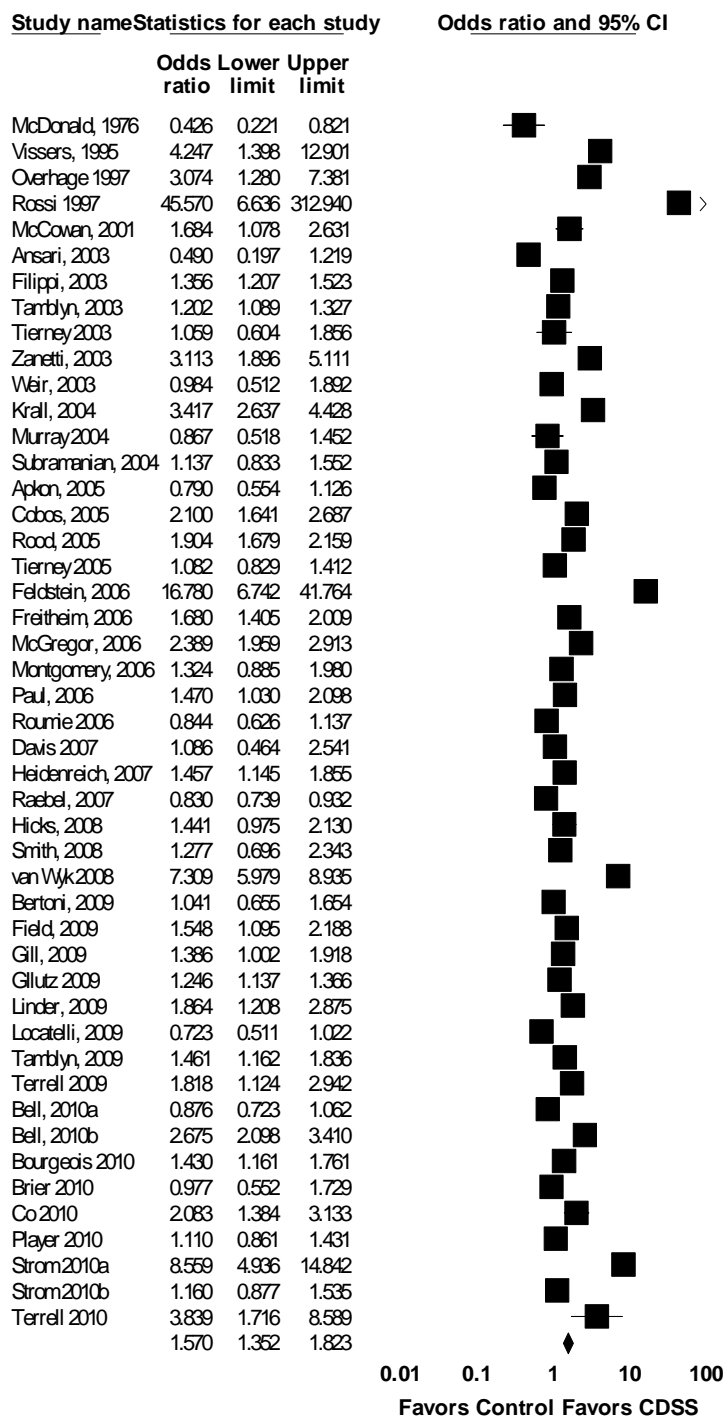
Recommendations to order/prescribe treatment. We identified 67 of the 148 eligible studies (45.3%) that specifically examined the impact of CDSSs/KMSs on the ordering and prescribing of therapy. These studies are summarized in Table I-8 of Appendix I.

Of these 67 studies, 42 (62.7%) were conducted in the U.S.,^{20,24,25,29,30,35,38-40,44,45,47,49,52,58,59,61,77,79-83,88,92,104,105,108-111,113,114,119,125,126,155-162} 18 (26.9%) in Europe,^{32,41,54,56,57,64,74,86,90,91,99,106,107,163-170} 4 (6%) in Canada,^{53,72,73,127} 1 (1.5%) in multiple countries,²³ and 1 (1.5%) location was not reported.¹¹² Twenty-four of the studies (35.8%) were implemented in an academic setting,^{23,25,29,30,35,39,40,44,53,61,64,72,82,83,90,91,108,109,114,155-159,162,166} 22 (32.8%) in a community setting,^{32,41,47,52,54,56,57,59,74,80,81,86,92,99,107,110,125,160,161,163,165,169,170} 12 (17.9%) in both academic and community settings,^{24,49,58,88,104-106,112,119,126,164,167,168} 4 (6%) in a VA setting,^{20,38,79,111} 1 (1.5%) in both academic and VA settings,⁴⁵ and 4 (6%) did not have the setting clearly reported.^{73,77,113,127} Thirteen studies (19.4%) evaluated the systems in the inpatient environment,^{23,29,30,35,44,64,82,114,156,158,159,161,169} 47 (70.1%) in the ambulatory environment,^{20,24,32,39-41,45,47,49,52,54,56-59,61,72-74,77,79-81,86,88,92,99,104-111,119,125-127,155,157,160,162-168,170} 2 (3%) in both inpatient and outpatient environments,^{38,112} 3 (4.5%) in the emergency department,^{25,83,90,91} 1 (1.5%) in a long-term care facility,⁵³ and 1 (1.5%) in an unreported setting.¹¹³ Duration of the evaluation period across the studies ranged from 10 weeks⁶⁴ to 4.2 years.¹⁰⁴ Forty-eight interventions (71.6%) were implemented using a system developed within the health care organization,^{20,23-25,29,32,35,38-41,44,45,49,52,61,64,72,73,79-83,86,88,92,104,105,108,110,111,113,125-127,155-162,164,165,167-170} 14 (20.9%) were implemented using a commercially available system,^{30,47,53,56-59,74,77,99,107,114,119,163,166} and 5 sources (7.5%) were not clearly described.^{54,90,91,106,109,112} Nine systems (13.4%) aided health care providers with tasks for diagnosis,^{23,47,74,77,81,88,90,91,107,125} 45 (67.2%) for pharmacotherapy,^{20,23-25,29,30,35,38,41,53,54,56-59,61,72,73,77,79,80,82,83,88,104,107,109,110,112-114,119,125-127,155-157,159-162,165-170} 5 (7.5%) for laboratory test ordering,^{29,58,61,80,126} 25 (37.3%) for chronic disease management,^{20,24,32,39-41,47,49,52,58,64,80,81,86,88,92,105,106,108,110,111,157,162-165} and 9 (13.4%) for additional clinical tasks.^{25,44,45,47,74,90,91,99,126,158} Fifty-eight of the systems (86.6%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{20,23,25,29,30,32,35,38-40,44,45,47,49,52-54,56-59,64,72-74,77,79-83,86,88,92,99,104-106,108-111,114,119,125-127,155-160,162,163,165-170} 4 (6%) delivered recommendations outside of the health care provider–patient encounter,^{61,112,113,161} 2 (3%) provided recommendations using both mechanisms,^{90,91,164} and 3 (4.5%) did not clearly describe how the CDSS was delivered.^{24,41,107} Thirteen (19.4%) of the interventions required a mandatory response,^{25,35,44,59,82,83,90,91,109,110,114,119,159,160} 5 (7.5%) required the health care provider to justify the reason for not complying with the recommendation,^{79,81,86,127,158} 6 (9%) required a noncommittal acknowledgement,^{29,40,53,58,108,156} and 43 (64.2%) did not have a response requirement.^{20,23,24,30,32,38,39,41,45,47,49,52,54,56,57,61,64,72-74,77,80,88,92,99,104-107,111-113,125,126,155,157,161-170} In 39 studies (58.2%), the recommendations were integrated within a CPOE or EHR system;^{20,24,25,29,30,35,39,47,49,52-54,56-59,64,72-74,77,80-83,88,104,105,107-109,114,119,127,155,156,158-160,167,168} 1 (1.5%) provided recommendations via an online system, 8 (11.9%) delivered recommendations via fax or computer printout,^{38,41,61,79,111,112,157,161,162} 12 (17.9%) via a standalone system,^{23,32,86,90-92,106,113,125,165,166,169,170} 5 (7.5%) had a combination of two of these formats,^{40,44,110,126,164} and 3 (4.5%) did not clearly describe the format.^{45,99,163} The

recommendations were automatically delivered to the health care provider in 54 studies (80.6%).^{20,23-25,29,30,35,38-41,44,45,47,49,52-54,56-59,61,64,72-74,77,79,81-83,86,104,105,108-112,114,119,126,127,155-162,167-170} in 9 studies (13.4%), the health care provider had to initiate an action to receive the recommendation,^{32,80,90-92,107,125,164-166} 1 study (1.5%) delivered recommendations using both modes,⁸⁸ and mode was not reported in 3 studies (4.5%).^{99,106,163} Thirty-five studies (52.2%) received a “Good” quality score,^{20,23-25,29,30,35,38,40,44,47,49,52,53,59,61,64,72-74,79,88,90-92,105,108-110,112,119,158,159,161,164,165} 24 (35.8%) had a “Fair” score,^{32,54,56,57,77,80-83,86,104,106,107,111,113,114,125,127,155,157,160,162,166-170} and 8 (11.9%) received a “Poor” score.^{39,41,45,58,99,126,156,163}

We conducted a meta-analysis (Figure 9) that focused on CDSS studies in which at least one outcome was related to ordering treatments or prescribing therapies. Of the 67 studies that assessed a response to recommendations for ordering treatment or prescribing therapies, 46 studies (68.7%) included data with a common dichotomous endpoint and were included in the meta-analysis.^{20,23,24,29,30,32,35,38-41,47,49,52-54,56-59,61,64,72-74,77,79-83,86,88,90-92,104-114} The overall effect of clinical decision support on treatment or prescribing outcomes was statistically significant and estimated as an odds ratio of 1.57 (95% CI 1.35 to 1.82). Thus, intervention providers with decision support were 1.6 times more likely to order the appropriate treatment or prescribe the correct therapy than control providers.

Figure 9. Meta-analysis of recommended treatment studies ordered



Six high-quality, recently published papers^{49,53,92,105,119} Terrell et al. (2009)²⁵ in which the CDSS interventions were thoroughly described were examined in detail to guide observations about the larger group of studies that evaluated treatment and prescribing outcomes. Bell et al. (2010)⁴⁹ evaluated treatment reminders to improve provider adherence to asthma guidelines in part through the appropriate ordering and completion of clinical studies and found that the number of prescriptions for controller medication significantly increased in the intervention urban practices ($P = 0.006$). Bertoni et al. (2009)⁹² assessed a PDA-based decision support system that calculated the Framingham risk score and provided recommendations for lipid screening and management-based national guidelines and related to the appropriate ordering and completion of preventive care services. They reported that the appropriate treatment of cholesterol levels decreased in both the intervention and control practices but that the net change favored the intervention practices (+9.7%, CI 2.8% to 16.6%, $P < 0.01$) and that overtreatment of dyslipidemia with inappropriate prescriptions decreased in the intervention practices (net change, -4.9%, $P = 0.01$). Field et al. (2009)⁵³ evaluated medication dose adjustment recommendations for long-term care residents with renal insufficiency in 22 long-term care units for 12 months and reported that overall final medication orders were more often appropriate in the intervention units (RR 1.2 [1.0, 1.4]). Fortuna et al. (2009)¹¹⁹ evaluated prescribing alerts for hypnotic medications embedded in an EHR among 257 providers over 12 months and found that the relative risk of prescribing a medication was less in both the alert group (RR 0.74; 95% CI 0.57 to 0.96) and the alert-plus-provider-education group (RR 0.74; 95% CI 0.58 to 0.97). Hicks et al. (2008)¹⁰⁵ investigated diabetes and coronary artery disease treatment reminders to improve provider adherence to national guidelines in 14 clinics for 18 months and found a significant improvement in the rates at which appropriate medications were prescribed ($P < 0.001$). Terrell et al. (2009)²⁵ investigated prescribing alerts that targeted potentially inappropriately prescribed medications for elderly patients on 63 emergency department physicians for 2.5 years. They reported that there were significantly fewer inappropriate prescriptions in the intervention group compared to the control group (OR 0.59; 95% CI 0.41 to 0.85).

From the research studies cited above, we concluded that there is strong evidence from 40 studies (59.7%) conducted in the academic, community, and VA inpatient and ambulatory settings that locally and commercially developed CDSSs are effective at improving appropriate ordering of treatment. This statement is supported by studies describing interventions that were integrated in a CPOE or EHR system and nonintegrated (paper-based or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{23,25,29,35,38,41,44,45,49,52-54,56-59,61,73,74,77,79-81,83,86,88,92,104,105,109,113,126,155,156,158,159,161,163,165,166,169}

However, the majority of the studies were conducted in the academic or community ambulatory settings and evaluated CDSSs that were locally developed, integrated in a CPOE or EHR system, automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care, and did not require a mandatory clinician response.

Of the studies that achieved a statistically significant effect, 13 studies included evaluation periods longer than 1 year.^{25,38,41,49,53,56-58,83,86,104,105,109,163} and 18 were evaluated with more than 2000 patients.^{23,25,29,41,49,54,56-59,73,83,86,88,92,105,126,156} Additionally, 15 of these studies were published after 2008.^{25,41,49,53,58,73,74,77,80,81,83,88,92,105,113} Notably with regard to improving the quality of care, only a few of the studies that demonstrated effectiveness of CDSSs assessed the effect of appropriate ordering of treatment on clinical outcomes^{23,29,35,38,41,44,45,56,57,75,113} or on

economic outcomes.^{23,29,56,57,86,163} In addition to the 40 studies (59.7%) that reported statistical significance, there is supportive evidence from the academic, community, and VA inpatient and ambulatory settings of locally and commercially developed CDSSs that demonstrated a trend toward improving appropriate ordering of treatment. These studies described interventions that were integrated in a CPOE or EHR system and nonintegrated (paper-based or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{30,32,39,40,64,72,82,90,91,99,108,111,112,125,127,157,160,162,164,170} However, the majority of the studies were conducted in the academic ambulatory settings and evaluated CDSSs that were locally developed, integrated in a CPOE or EHR system, automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care, and did not require a mandatory clinician response. This observation showing a trend for effectiveness is supported by evidence from 7 studies that included evaluation periods longer than 1 year,^{39,40,72,111,125,157,160,162} and 7 studies were evaluated with more than 2000 patients.^{30,72,99,127,157,160,162,164} However, only three of these studies were published after 2008.^{82,127,164} With regard to improving the quality of care, only a few of the studies that demonstrated a trend toward effectiveness of CDSSs assessed the effect of appropriate ordering of treatment on clinical outcomes^{30,32,39,40,108,111} or on economic outcomes.^{30,39,40,108}

Impact on user knowledge. We identified 5 of the 148 eligible studies (3.4%) that specifically examined the impact of CDSSs/KMSs on user knowledge. These studies are summarized in Table I-9 of Appendix I.

Of these 5 studies, one (20%) was conducted in the U.S.,¹¹⁷ two (40%) in Europe,^{118,123} one (20%) in Canada,¹⁴³ and one (20%) in multiple countries.¹⁷¹ Three of the studies (60%) were implemented in a community setting^{117,118,143} and two (40%) in an unreported setting.^{123,171} Four of the studies (80%) evaluated the systems in the ambulatory environment^{117,118,123,143} and one (20%) did not clearly report the setting.¹⁷¹ Duration of the evaluation period across the studies ranged from 3 months¹⁷¹ to 1 year.¹¹⁸ Two interventions (40%) were implemented using a system developed within the specific health care organization,^{117,123} two (40%) were implemented using a commercially available system,^{118,171} and one (20%) did not specify a source of the CDSS/KMS.¹⁴³ One system (20%) aided health care providers with tasks for diagnosis,¹²³ one (20%) for chronic disease management,¹⁴³ one (20%) for laboratory test ordering,^{123,126} one (20%) for initiating discussions with patients,¹⁴³ and three (60%) for additional clinical tasks.^{117,118,171} Four (80%) of the systems delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter^{117,118,123,143} and one (20%) did not report a relation.¹⁷¹ One (20%) of the interventions required a mandatory response,¹⁷¹ one of the interventions (20%) did not have a response requirement,¹¹⁷ and in three studies (60%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{118,123,143} In one study (20%), the recommendations were integrated within a CPOE or EHR system;¹¹⁷ 1 (20%) via a standalone system,¹²³ 2 (40%) delivered online,^{143,171} and the format of one study (20%)¹¹⁸ was not clear. In three studies (60%) the health care provider had to initiate an action to receive the recommendation^{117,123,171} and two studies (40%) did not clearly describe how recommendations were delivered.^{118,143} No studies received a “Good” quality score, four (80%) had a “Fair” score,^{117,118,143,171} and one (20%) received a “Poor” score.^{123,126}

None of the 10 key papers reported data describing the impact of CDSSs/KMSs on user knowledge. Of the studies that reported user knowledge data, Alper et al. (2005)¹⁷¹ reported that an electronic knowledge resource accessed by providers during and outside of the health care provider–patient encounter increased the number of questions answered (75.8% versus 71.2%) and the number of questions for which the answer changed decisionmaking (64.6% versus 23.4%); however, the number of questions for which the providers did not find an answer that could have changed decisionmaking did not improve with access to the resource (19.6% versus 23.4%). Del Fiore et al. (2008)¹¹⁷ found providers reported that in 62% of sessions, the use of an information retrieval tool embedded in an EHR system that provided access to topic or nonspecific links to clinical resources to aid in answering clinicians’ questions at the point of care enhanced their decisions or knowledge. Holbrook et al. (2009)¹⁴³ found that 48% of providers who used a Web-based diabetes tracker that included diabetes care reminders reported that their knowledge of diabetes blood sugar control targets had improved. Emery et al. (2007)¹¹⁸ reported that a cancer risk assessment tool improved clinician confidence in managing the risk of familial cancer. Hobbs et al. (1996)¹²³ found that providers reported their knowledge of lipid disorders improved; however, no distinction was made between those who received the intervention (a standalone decision support system for the management of hyperlipidemia) and those who did not.

From the research included in this section, we concluded that there is limited evidence regarding the effect of CDSSs/KMSs on user knowledge.

Impact on Workload and Efficiency

Number of patients seen/unit time. Of the eligible studies, none examined the impact of the CDSSs/KMSs on the number of patients seen/unit time.

Clinician workload. Of the eligible studies, none examined the impact of CDSSs/KMSs on clinician workload.

Efficiency. We identified 7 of the 148 eligible studies (4.7%) that specifically examined the impact of CDSSs/KMSs on efficiency. Examples of metrics used to assess efficiency included median search times or session times using the KMS, clinician response time, questionnaires assessing effort required to complete a process using the CDSS. These studies are summarized in Table I-10 of Appendix I.

Of these seven studies, five (71.4%) were conducted in the U.S.,^{30,36,37,110,117,151} one (14.3%) in Canada,¹⁷² and one (14.3%) was conducted in multiple countries.¹⁷¹ Four of the studies (57.1%) were implemented in an academic setting,^{30,36,37,151,172} two (28.6%) in a community setting,^{110,117} and one (14.3%) did not report a specific setting.¹⁷¹ Three studies (42.9%) evaluated the systems in the inpatient environment,^{30,36,37,172} three (42.9%) in the ambulatory environment,^{110,117,151} and one (14.3%) did not report a specific environment.¹⁷¹ Duration of the evaluation period across the studies ranged from 12 weeks^{30,171} to 30 months.¹¹⁰ Four interventions (57.1%) were implemented using a system developed within the specific health care organization,^{36,37,110,117,151} and three (42.9%) were implemented using a commercially available system.^{30,171,172} Two systems (28.6%) aided health care providers with tasks for pharmacotherapy,^{30,110} one (14.3%) for chronic disease management,¹¹⁰ two (28.6%) for lab test ordering,^{151,172} and three (42.9%) for additional clinical tasks.^{36,37,117,171} Five of the systems

(71.4%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{30,36,37,110,117,151} one (14.3%) delivered recommendations outside of the health care provider–patient encounter,¹⁷² and one (14.3%) delivered recommendations both in real time and outside of the health care provider–patient encounter.¹⁷¹ Three of the interventions (42.9%) required a mandatory response,^{110,151,171} one (14.3%) did not have a response requirement,¹¹⁷ and in three studies (42.9%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{30,36,37,172} In three studies (42.9%), the recommendations were integrated within a CPOE or EHR;^{30,117,151} one (14.3%) was delivered online,¹⁷¹ one (14.3%) via a standalone system,^{36,37} one (14.3%) via pager,¹⁷² and one (14.3%) was delivered online and via email.¹¹⁰ The recommendations were automatically delivered to the health care provider in four studies (57.1%);^{30,110,151,172} in two studies (28.6%), the health care provider had to initiate an action to receive the recommendation,^{117,171} and in one study (14.3%) the mode was not clearly described.^{36,37} Three studies (42.9%) received a “Good” quality score,^{30,36,37,110} four (57.1%) had a “Fair” score,^{117,151,171,172} and 0 received a “Poor” score.

None of the 10 key papers reported data describing the impact of CDSSs on efficiency. Of the studies that reported efficiency data, one observed that use of the KMS that provided topic and nonspecific infobutton links to clinicians at the point of care significantly reduced the time that health care providers spent seeking information according to an evaluation of 90 providers and 3,729 session duration from 43 seconds to 35.5 seconds ($P = 0.008$)¹¹⁷ McGregor et al. (2006)³⁰ found that clinicians who received CDSS alerts spent roughly one hour less each day resolving inappropriate antibiotic prescriptions in the intervention arm than the control arm of the trial. Alper et al. (2005)¹⁷¹ reported from 780 clinician queries with 52 physicians and nurse practitioners that the KMS had a positive trend on reducing the time searching and answering clinical questions using DynaMed when accessed during the health care provider–patient encounter as well as outside of the encounter; however, the study also reported that system use did not improve time searching for information or time for unsuccessful searches. Etchells et al. (2010)¹⁷² observed in a study with 165 critical laboratory values for 108 patients which were sent via an alphanumeric pager to the physician that median physician response time after receiving a critical value decreased from 39 minutes to 16 minutes ($P = 0.33$). However, two studies reported that use of the CDSS increased the time to complete a desired action. Graumlich et al. (2009)^{36,37} reported from a study with 70 physicians and 631 patients that clinicians found the effort to use the electronic discharge planning tool for discharge planning was more difficult than usual care (paper). Tierney et al. (1987)¹⁵¹ observed in a study of 111 physicians and 5946 patients that use of a CDSS that displayed past diagnostic test results to the clinician prior to ordering a new test increased the time to order by 4.5 seconds (8%) ($P < 0.01$).

From the research included in this section, we concluded that there is limited evidence of CDSSs/KMSs demonstrating improvement in efficiency.^{30,117,171,172} This finding is supported by evidence from studies that all included evaluation periods less than 6 months, although the McGregor article³⁰ reported that the study was discontinued at 12 weeks to implement the CDSS throughout the entire hospital based. Of note, only one of these studies evaluated the CDSS/KMS with more than 2000 patients³⁰ and only two were published after 2008.^{117,172}

Impact on Relationship-Centered Outcomes

Patient satisfaction. We identified 6 of the 148 eligible studies (4.1%) that specifically examined the impact of CDSSs/KMSs on patient satisfaction. Patient satisfaction was assessed qualitatively using either telephone interviews conducted by study personnel, mailed patient questionnaires, or occasionally on-site interviews during patient clinic visits. These studies are summarized in Table I-11 of Appendix I.

Of these six studies, four (66.7%) were conducted in the U.S.,^{34,36,37,39,47} one (16.7%) in Canada¹⁴³, and one (16.7%) did not report location.¹⁵⁴ Three of the studies (50%) were implemented in an academic setting,^{34,36,37,39} two (33.3%) in a community setting,^{47,143} and one (16.7%) did not report the setting.¹⁵⁴ One study (16.7%) evaluated the systems in the inpatient environment,^{36,37} four (66.7%) in the ambulatory environment,^{39,47,143,154} and one (16.7%) in the emergency department.³⁴ Duration of the evaluation period across the studies ranged from 14 weeks¹⁵⁴ to 28 months.³⁹ Four interventions (66.7%) were implemented using a system developed within the specific health care organization^{34,36,37,39,154} one (16.7%) was implemented using a commercially available system,⁴⁷ and one (16.7%) had a source that was not clearly described.¹⁴³ Two systems (33.3%) aided health care providers with tasks for diagnosis,^{34,47} two (33.3%) for chronic disease management,^{47,143} one (16.7%) for laboratory test ordering,¹⁵⁴ one (16.7%) for initiating discussions with patients,¹⁴³ and two (33.3%) for additional clinical tasks.^{36,37,47} All 6 of the systems (100%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter.^{34,36,37,39,47,143,154} Three of the interventions (50%) did not have a response requirement,^{34,47,154} and in three studies (50%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{36,37,39,143} In three studies (50%), the recommendations were integrated within a CPOE or EHR system;^{39,47,154} one (16.7%) was delivered online,¹⁴³ one (16.7%) via a standalone system,^{36,37} and one (16.7%) via fax or computer printout.³⁴ The recommendations were automatically delivered to the health care provider in four studies (66.7%),^{34,39,47,154} and in two studies (33.3%) the mode was not clearly described.^{36,37,143} Four studies (66.7%) received a “Good” quality score,^{34,36,37,47,154} one (16.7%) had a “Fair” score,¹⁴³ and one (16.7%) received a “Poor” score.³⁹

None of the 10 key papers reported data describing the impact of CDSSs on patient satisfaction. Of the studies that reported patient satisfaction data, one reported that patients who were treated by intervention providers who utilized a discharge planning application had a higher perception of discharge preparedness and satisfaction with medication information.^{36,37} Holbrook et al. (2009)¹⁴³ found that 75.9 percent of patients who received care from intervention providers who accessed a Web-based diabetes tracker to aid in therapeutic planning were more satisfied with the quality of their diabetes care. Kline et al. (2009)³⁴ reported that more intervention patients who were treated by intervention providers who received a printout of pretest probability of acute coronary syndrome were satisfied with the explanation of the medical problem than those patients in the control group. Feldstein et al. (2006)¹⁵⁴ observed that patients who received a new study drug, which subsequently required baseline laboratory testing found electronic recommendations presented to the physician during the patient visit, automated voice messages to the patient, and a call from a pharmacy team member all to be acceptable. Apkon et al. (2005)⁴⁷ reported that intervention patients who used problem-knowledge couplers to report their chief complaint and guide provider decisionmaking were less satisfied with the overall visit; however, intervention patients were more satisfied with their interaction with the provider than

those in the control group. An additional study by Tierney et al. (2005)³⁹ assessed patient satisfaction with the physician's communication abilities and pharmacy and found there was no effect on patient satisfaction between those who were treated by intervention providers who received guideline-based recommendations for the management of asthma and COPD and those patients who were treated by control providers.

From the research included in this section, we concluded that there is limited evidence that clinician use of CDSSs had a positive effect on patient satisfaction.^{34,36,37,143,154} This observation showing intervention patients were more satisfied than those in the control group is based on studies that included evaluation periods of at least 2 years^{36,37,143} and were published in 2009.^{34,36,37,143} Notably, two studies did not find that provider use of CDSSs increased satisfaction with the care received or overall visit.^{39,47}

Impact on Economic Outcomes

Cost. We identified 22 of the 148 eligible studies (14.9%) that specifically examined the impact of CDSSs/KMSs on cost. These studies are summarized in Table I-12 of Appendix I.

Of these 23 studies, 14 (63.6%) were conducted in the U.S.,^{26,27,29,30,39,40,47,48,108,110,148,151,173-175} 6 (27.3%) in Europe,^{56,57,86,103,123,129,130,163} 1 (4.5%) in multiple countries,²³ and 1 (4.5%) did not report a location.¹⁷⁶ Eleven (50%) of the studies were implemented in an academic setting,^{23,29,30,39,40,48,108,148,151,173,175} 10 (45.5%) in a community setting,^{26,27,47,56,57,86,103,110,129,130,163,174,176} and 1 (4.5%) did not report a setting.¹²³ Five studies (22.7%) evaluated the systems in the inpatient environment^{23,29,30,48,148} and 17 (77.3%) in the ambulatory environment.^{26,27,39,40,47,56,57,86,103,108,110,123,129,130,151,163,173-176} Duration of the evaluation period across the studies ranged from 25 days¹⁷⁶ to 2.5 years.¹¹⁰ Seventeen interventions (77.3%) were implemented using a system developed within the specific health care organization,^{23,26,27,29,39,40,48,86,103,108,110,123,148,151,173-176} and 5 (22.7%) were implemented using a commercially available system.^{30,47,56,57,129,130,163} Five systems (22.7%) aided health care providers with tasks for diagnosis,^{23,47,123,148,175} five (22.7%) for pharmacotherapy,^{23,29,30,56,57,110} nine (40.9%) for chronic disease management,^{26,27,39,40,47,86,108,110,129,130,163} six (27.3%) for laboratory test ordering,^{29,48,123,151,175,176} two (9.1%) for initiating discussions with patients,^{103,174} and seven (31.8%) for additional clinical tasks.^{47,56,57,103,123,148,173,174} Twenty of the systems (90.9%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{23,29,30,39,40,47,48,56,57,86,103,108,110,123,129,130,148,151,163,173,175,176} and 2 (9.1%) delivered recommendations outside of the health care provider–patient encounter.^{26,27,174} Five of the interventions (22.7%) required a mandatory response,^{110,129,130,148,151,175} two (9.1%) required the health care provider to justify the reason for not complying with the recommendation,^{48,86} five (22.7%) did not have a response requirement,^{23,47,56,57,173,176} three (13.6%) required a noncommittal acknowledgement,^{29,40,108} and in seven studies (31.8%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{26,27,30,39,103,123,163,174} In 11 studies (50%), the recommendations were integrated within a CPOE or EHR system,^{29,30,39,47,48,56,57,108,148,176} 3 (13.6%) were delivered via fax or computer printout,^{26,27,173,174} 1 (4.5%) was integrated within a CPOE or EHR and via delivered via fax or computer printout,⁴⁰ 4 (18.2%) via a standalone system,^{23,86,123,129,130} and 3 (13.6%) had other formats.^{40,110,163} The recommendations were automatically delivered to the health care provider

in 17 studies (77.3%),^{23,26,27,29,30,39,40,47,48,56,57,86,108,110,151,173-176} In four studies (18.2%), the health care provider had to initiate an action to receive the recommendation,^{103,123,129,130,148} and one (4.5%) study did not have a mode clearly reported.¹⁶³ Ten studies (45.5%) received a “Good” quality score,^{23,26,27,29,30,40,47,108,110,129,130,176} 7 (31.8%) had a “Fair” score,^{48,56,57,86,148,151,174,175} and 5 (22.7%) received a “Poor” score.^{39,103,123,163,173}

Two high-quality, recently published papers^{26,27,129,130} in which the CDSS interventions were thoroughly described were examined in detail to guide observations about this group of studies. Cleveringa et al. (2008)^{129,130} evaluated a standalone system that focused on decreasing cardiovascular risk in 3391 patients with type 2 diabetes over 12 months by including an algorithm based on the Dutch type 2 diabetes diagnostic and treatment guidelines. They found that use of the CDSS to provide patient-specific treatment recommendations reduced cardiovascular risk, but it was more costly as patients in the intervention group incurred higher total costs than those in the control group (€1,415, $P = \text{NS}$; ~\$1,967). Khan et al. (2010)^{26,27} assessed guideline-based diabetes recommendations to improve appropriate testing and they reported a significant reduction in hospitalization expenses for all subjects in the intervention group (\$3,113.19 versus \$3,480.14, $P = 0.02$) and the following intervention subgroups: seniors (age 65 years and older) (\$3,699.26 versus \$4,264.36, $P = 0.004$) and men (\$3,098.26 versus \$3,712.22, $P = 0.03$). A significant reduction in emergency department expenses was also found for all subjects in the intervention group (\$414.30 versus \$301.51, $P < 0.0001$) and for the following subgroups: seniors (\$270.45 versus \$443.27, $P < 0.0001$); men (\$299.18 versus \$410.91; $P < 0.0001$); and women (\$307.80 versus \$417.45, $P < 0.009$).

However, though there was an enormous variability in the studies reporting cost data, other studies found a cost savings between \$6,000 (through recommendations for the appropriate use of abdominal radiograph orders) and \$84,194 (through reminders about the appropriate use of antimicrobials). Of those reporting costs savings, Cobos et al. (2005)⁸⁶ reported a significant cost savings by reducing the number of lipid-lowering drug prescriptions during the 1-year evaluation period between 20.8 and 24.9% from a CDSS that provided hypercholesterolemia treatment and followup visit recommendations.⁸⁶ A second study published in 2008¹¹⁰ reported that a telemedicine intervention for the medication management of cardiovascular risk found that the intervention resulted in cost savings for outpatient costs (-\$288) (95% CI -\$25 to -\$550) and total costs (-\$2,311) (95% CI -\$266 to -\$4667).

From the research included in this section, we concluded that although one key paper found that the intervention increased costs, there is modest evidence from 13 studies (59.1%), including a second key paper conducted in the academic and community inpatient and ambulatory settings, that locally and commercially developed CDSSs demonstrated a trend toward lower treatment costs, total costs, and greater cost savings than the control groups and other non-CDSS intervention groups (e.g., patient education intervention, pharmacist intervention). These interventions were integrated in a CPOE or EHR system and nonintegrated (paper-based, online system, or standalone system); delivered recommendations automatically (system-initiated) and required user action to receive the recommendation (user-initiated); and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{23,26,27,29,30,40,48,56,57,86,110,148,151,174,175} However, the majority of these studies evaluated locally developed CDSSs integrated in a CPOE or EHR system that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory response in the community ambulatory settings. This observation showing a trend toward lower costs and greater cost savings is supported by evidence from five studies that

included evaluation periods longer than 1 year^{40,56,57,86,110,174} and nine studies with more than 2000 patients.^{23,26,27,29,30,48,56,57,86,151,175} Notably, all except two studies were published prior to 2008.^{26,27,110}

Cost-effectiveness. We identified 6 of the 148 eligible studies (4.1%) that specifically examined the cost-effectiveness of CDSSs/KMSs or the impact of CDSSs/KMSs on the cost-effectiveness of care. These studies are summarized in Table I-13 of Appendix I.

Of these six studies, two (33.3%) were conducted in Europe^{56,57,129,130} and four (66.7%) in Canada.^{62,63,95,144} Four of the studies (66.7%) were implemented in an academic setting^{62,63,95,144} and two (33.3%) in a community setting.^{56,57,129,130} All six studies (100%) evaluated the systems in the ambulatory environment.^{56,57,62,63,95,129,130,144} Duration of the evaluation period across the studies ranged from 10 weeks⁶³ to 15 months.⁶² Three interventions (50%) were implemented using a system developed within the specific health care organization,^{62,95,144} two (33.3%) were implemented using a commercially available system,^{56,57,129,130} and one (16.7%) did not clearly describe a source.⁶³ One system (16.7%) aided health care providers with tasks for diagnosis,⁶² one (16.7%) for pharmacotherapy,^{56,57} one (16.7%) for chronic disease management,^{129,130} and four (66.7%) for additional clinical tasks.^{56,57,63,95,144} All six of the systems (100%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter.^{56,57,62,63,95,129,130,144} One of the interventions (16.7%) required a mandatory response,^{129,130} four (66.7%) did not have a response requirement,^{56,57,62,95,144} and in one study (16.7%) it was unclear to the abstractor if such requirement was present.⁶³ In one (16.7%) study, the recommendations were integrated within a CPOE or EHR system;^{56,57} four (66.7%) were delivered via fax or computer printout^{62,63,95,144} and one (16.7%) via a standalone system.^{129,130} The recommendations were automatically delivered to the health care provider in five (83.3%) studies,^{56,57,62,63,95,144} and the health care provider had to initiate an action to receive the recommendation in one study (16.7%).^{129,130} One (16.7%) study received a “Good” quality score,^{129,130} and five (83.3%) had a “Fair” score.^{56,57,62,63,95,144}

One high-quality, recently published paper^{129,130} was examined in detail to guide observations about this group of studies. As described in the previous section, Cleveringa et al. (2008)^{129,130} evaluated a standalone system that provided clinicians with treatment recommendations for decreasing cardiovascular risk factors for type 2 diabetic patients and related to the resulting benefits cost-effectiveness. They found that the intervention group incurred higher total costs (€1,415; ~\$1,967) and exceeded the study’s established willingness to pay quality-adjusted life year threshold of €20,000 (~\$27,808). The remaining studies found that the intervention group tended to be more cost-effective in providing recommended preventive care, screenings, and treatment than usual care or other interventions (e.g., patient letters, telephone reminders). Rosser et al. (1992)¹⁴⁴ assessed the cost-effectiveness of three interventions for improving provider compliance with reminders for tetanus vaccination. The effectiveness of each intervention was assessed based on provider time, time to prepare and deliver recommendations, and supply costs of mailing patient reminder letters. Among the three groups, they found that the cost per additional vaccination was \$0.43 or \$0.22 depending on the salary level for the physician reminders; \$5.43 or \$4.43 depending on the nurse salary level for the telephone reminders; and \$6.05 for the patient letter reminders. McDowell et al. (1989)⁶² evaluated the cost-effectiveness of three interventions for improving blood pressure screening and assessed the effectiveness based on staff and material costs of delivering the recommendations. They reported that the cost per blood pressure reading was \$1.70 or \$1.33

depending on the salary level for physician reminders; \$31.27 or \$22.47 depending on the nurse salary level for telephone reminders; and \$14.37 for the patient letter reminders. Fretheim et al. (2006)^{56,57} evaluated the cost-effectiveness of prescribing recommendations for antihypertensive and cholesterol-lowering drugs and estimated that the cost of using the CDSS was \$183 per additional patient being started on a thiazide.

From the research included in this section, we concluded that there is conflicting evidence from the ambulatory setting regarding the cost-effectiveness of CDSSs that provided recommendations to providers synchronously at the point of care. This observation showing the interventions were more cost-effective for performing recommended process measures than the control groups is supported by studies with evaluation periods of at least 1 year and studies evaluated with more than 2000 patients.^{56,57,62,144} However, three studies reported that the intervention was not cost-effective.^{63,95,129,130} Notably, none of those studies that found favorable evidence on the cost-effectiveness of CDSSs were published after 2008; the most recent study was published in 2006,^{56,57} one in 1992,¹⁴⁴ and the other in 1989.⁶²

Impact on Use and Implementation Outcomes

Health care provider acceptance. We identified 24 of the 148 eligible studies (16.2%) that specifically examined the impact of health care provider acceptance of CDSSs/KMSs. These studies are summarized in Table I-14 of Appendix I.

Of these 24 studies, 17 (70.8%) were conducted in the U.S.,^{22,25,45,60,70,79,98,119,124,140,148,158,173,174,177-179} 5 (20.8%) in Europe,^{86,120-122,164,170} and 2 (8.3%) in Canada.^{73,127} Ten of the studies (41.7%) were implemented in an academic setting,^{22,25,60,124,140,148,158,173,177,178} 5 (20.8%) in a community setting,^{86,120-122,170,174} 3 (12.5%) in both academic and community settings,^{98,119,164} 2 (8.3%) in a VA setting,^{70,79} 1 (4.2%) in both academic and VA settings,⁴⁵ and 3 (12.5%) for which the setting was not clearly described.^{73,127,179} Three studies (12.5%) evaluated the systems in the inpatient environment,^{98,148,158} 19 (79.2%) in the ambulatory environment,^{22,45,60,70,73,79,86,119-122,124,127,140,164,170,173,174,178,179} 1 (4.2%) in a long-term care facility,¹⁷⁷ and 1 (4.2%) in the emergency department.²⁵ Duration of the evaluation period across the studies ranged from 1 month¹⁷⁰ to 2.5 years.²⁵ Twenty-one interventions (87.5%) were implemented using a system developed within the specific health care organization,^{22,25,45,60,70,73,79,86,98,120-122,124,127,148,158,164,170,173,174,177,179} 2 (8.3%) were implemented using a commercially available system,^{119,178} and 1 study (4.2%) did not clearly describe a source.¹⁴⁰ Three systems (12.5%) aided health care providers with tasks for diagnosis,^{98,148,178} 9 (37.5%) for pharmacotherapy,^{22,25,73,79,119,124,127,170,177} 5 (20.8%) for chronic disease management,^{22,86,120-122,164} 4 (16.7%) for laboratory test ordering,^{22,60,70,140} 1 (4.2%) for initiating discussions with patients,¹⁷⁴ and 12 (50%) for additional clinical tasks.^{22,25,45,60,98,140,148,158,164,173,174,179} Twenty-one of the systems (87.5%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{22,25,45,60,70,73,79,86,98,119-122,124,127,140,148,158,170,173,177,179} 2 (8.3%) delivered recommendations outside of the health care provider–patient encounter,^{174,178} and 1 (4.2%) in both real time and outside of the health care provider–patient encounter.¹⁶⁴ Four of the interventions (16.7%) required a mandatory response,^{25,119,148,178} 7 (29.2%) required the health care provider to justify the reason for not complying with the recommendation,^{70,79,86,127,140,158,164} 3 (12.5%) did not have a response requirement,^{124,173,177} 1

(4.2%) required a noncommittal acknowledgement,²² 1 (4.2%) required both a mandatory response and a reason for not complying,⁶⁰ and in 8 studies (33.3%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{22,45,73,98,120-122,170,174,179} In 11 studies (45.8%), the recommendations were integrated within a CPOE or EHR system;^{25,70,73,119-122,124,127,148,158,177} 6 (25%) were delivered via fax or computer printout,^{22,60,79,140,173,174} 3 (12.5%) via a standalone system,^{86,170,179} and 4 (16.7%) had other formats or combinations of formats.^{45,98,164,178} The recommendations were automatically delivered to the health care provider in 18 studies (75%),^{22,25,45,60,70,73,79,86,119,127,140,158,170,173,174,177-179} and the health care provider had to initiate an action to receive the recommendation in 6 studies (25%).^{98,120-122,124,148,164} Nine studies (37.5%) received a “Good” quality score,^{22,25,70,73,79,119,124,158,164} 11 (45.8%) had a “Fair” score,^{60,86,98,120-122,127,140,148,170,174,177} and 4 (16.7%) received a “Poor” score.^{45,173,178,179}

Three high-quality, recently published papers^{25,70,119} in which the CDSS interventions were thoroughly described were examined in detail to guide observations about this group of studies. Fortuna et al. (2009)¹¹⁹ evaluated prescribing alerts for heavily marketed hypnotic medications on health care provider acceptance. They found that only 23% of providers felt that recommendations that included alternative treatment suggestions and information on prescribing, patient education materials, and copayment for heavily marketed medications changed their prescribing decisions. Regarding health care provider acceptance, the Sundaram et al. (2009)⁷⁰ study found that providers were more likely to adhere to reminders to test for HIV rather than reminders to perform HIV risk assessment (11% versus 5%, $P < 0.01$). The reasons for not following recommendations due to lack of time or disagreement with the recommendation in general or for a specific patient visit decreased from the pre-intervention to post-intervention survey although more clinicians reported an increase in the recommendation not being received concurrently with the patient visit during the post-intervention survey. Terrell et al. (2009)²⁵ assessed prescribing alerts that targeted potentially inappropriately prescribed medications for elderly patients in the emergency department and reported that providers accepted only 43% of the recommendations, which included recommendations for alternative treatment.

From the research included in this section, we concluded that evidence suggests that high levels of acceptance (at a rate greater than 75%) of recommendations from CDSSs are the exception^{98,170,178} rather than the rule. We recognize, however, that many of the successful CDSS studies did not assess user acceptance but still showed that systems were effective, implying that they were accepted and used. In the 19 studies (79.2%) that reported provider acceptance rates, 9 studies from the academic and community ambulatory settings found rates of acceptance between 50 and 75 percent of locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care.^{22,86,120-122,158,170,173,174,178}

This observation showing provider acceptance of CDSSs greater than 50 percent is supported by evidence from six studies that included an evaluation period longer than 1 year^{22,86,120-122,174,178} and five studies that were evaluated with more than 2000 patients.^{22,86,98,120-122} Further, only two of those studies demonstrating provider acceptance greater than 50 percent were evaluated with more than 100 providers— McDonald et al.²² included 130 providers (115 residents, 11 faculty member physicians, 4 nurses), and Rothschild et al.¹⁵⁸ included 453 junior house staff (first-, second- and third-year residents). Notably, Dykes 2010 et al.⁹⁸ was the only study that demonstrated provider acceptance of the recommended action greater than 50% that was published after 2008. While representing only a limited subset of studies, in these studies there was no significant effect of a mandatory clinician response on

provider acceptance.^{86,178} Five studies captured some of the reasons clinicians did not accept the recommendations, citing disagreement with the recommended action for that specific visit,^{45,70} clinical judgment based on the patient's medical history,^{79,127} lack of facilities to fulfill lifestyle and relaxation recommendations,¹⁶⁴ lack of time,^{70,127} incorrect drug or disease information,¹²⁷ and not clinically important.¹²⁷

Health care provider satisfaction. We identified 19 of the 148 eligible studies (12.8%) that specifically examined health care provider satisfaction with CDSSs/KMSs. These studies are summarized in Table I-15 of Appendix I.

Of these 19 studies, 12 (63.2%) were conducted in the U.S.,^{36-38,47,68,70,81,110,117,119,124,126,173} 5 (26.3%) in Europe,^{32,90,91,103,118,167,168} 1 (5.3%) in multiple countries,¹⁷¹ and 1 (5.3%) with a location not reported.¹¹² Four of the studies (21.1%) were implemented in an academic setting,^{36,37,90,91,124,173} eight (42.1%) in a community setting,^{32,47,68,81,103,110,117,118} four (21.1%) in both academic and community settings,^{112,119,126,167,168} two (10.5%) in a VA setting,^{38,70} and one (5.3%) for which the setting was not reported.¹⁷¹ One study (5.3%) evaluated the systems in the inpatient environment,^{36,37} 14 (73.7%) in the ambulatory environment,^{32,47,68,70,81,103,110,117-119,124,126,167,168,173} 2 (10.5%) in both inpatient and ambulatory environments,^{38,112} 1 (5.3%) in the emergency department,^{90,91} and 1 (5.3%) for which the environment was not reported.¹⁷¹ Duration of the evaluation period across the studies ranged from 3 months¹⁷¹ to 4.5 years.³⁸ Twelve interventions (63.2%) were implemented using a system developed within the specific health care organization,^{32,36-38,70,81,103,110,117,124,126,167,168,173} 5 (26.3%) were implemented using a commercially available system,^{47,68,118,119,171} and 2 studies (10.5%) with a source that was not clearly described.^{90,91,112} Three systems (15.8%) aided health care providers with tasks for diagnosis,^{47,81,90,91} 7 (36.8%) for pharmacotherapy,^{38,110,112,119,124,126,167,168} 4 (21.1%) for chronic disease management,^{32,47,110} 3 (15.8%) for laboratory test ordering,^{68,70,126} 1 (5.3%) for initiating discussions with patients,¹⁰³ and 10 (52.6%) for additional clinical tasks.^{36,37,47,68,90,91,103,117,118,126,171,173} Sixteen of the systems (84.2%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter,^{32,36-38,47,68,70,81,103,110,117-119,124,126,167,168,173} 1 (5.3%) delivered recommendations outside of the health care provider–patient encounter,¹¹² and 2 studies (10.5%) did both.^{90,91,171} Five of the interventions (26.3%) required a mandatory response,^{68,90,91,110,119,171} 2 (10.5%) required the health care provider to justify the reason for not complying with the recommendation,^{70,81} 5 (26.3%) did not have a response requirement,^{47,117,124,126,173} and in 7 studies (36.8%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{32,36-38,103,112,118,167,168} In 8 studies (42.1%), the recommendations were integrated within a CPOE or EHR,^{47,68,70,81,117,119,124,167,168} 3 (15.8%) were delivered via fax or computer printout,^{38,112,173} 3 (15.8%) via a standalone system,^{32,36,37,90,91} and 5 (26.3%) through other methods.^{103,110,118,126,171} The recommendations were automatically delivered to the health care provider in 11 studies (57.9%),^{38,47,68,70,81,110,112,119,126,167,168,173} in 6 studies (31.6%), the health care provider had to initiate an action to receive the recommendation,^{32,90,91,103,117,124,171} and in 2 studies (10.5%) the mode of access was not clearly described.^{36,37,118} Nine studies (47.4%) received a “Good” quality score,^{36-38,47,70,90,91,110,112,119,124} 7 (36.8%) had a “Fair” score,^{32,68,81,117,118,167,168,171} and 3 (15.8%) received a “Poor” score.^{103,126,173}

Two high-quality, recently published papers^{70,119} were examined in detail to guide observations about this group of studies. Fortuna et al. (2009)¹¹⁹ evaluated the impact of hypnotic prescribing recommendations on health care provider satisfaction. They found that providers

perceived that the reminders did not interfere with workflow (70%), provided useful evidence to support decisions (88%), provided useful education materials (83%), and increased awareness of costs (71%); however, 47 percent reported that the reminders prompted them to spend more time discussing treatment with patients. Sundaram et al. (2009)⁷⁰ evaluated the impact of reminders for HIV risk assessment and testing onto health care provider satisfaction. They reported that 61 percent of providers specifically described the clinical practice reminders to be “useful” in a post-intervention survey.

From the research included in this section, we concluded that there is moderate evidence within the academic, community, and VA ambulatory settings that providers expressed satisfaction of locally and commercially developed CDSSs/KMSs. These interventions automatically delivered system-initiated (push) recommendations to providers and required user-initiated (pull) requests for recommendations; and provided recommendations synchronously at the point of care and asynchronously outside the point of care.^{32,38,47,68,70,81,90,91,103,110,112,117-119,124,126,167,168,171,173}

However, the majority of the studies evaluated locally developed CDSSs integrated in a CPOE or EHR system that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care. Notably, only four studies demonstrated a statistically significant effect of satisfaction among intervention providers compared with control providers^{81,103,124,171} and six studies also reported some provider dissatisfaction with the interventions^{32,47,70,90,91,112,118}. This observation showing provider satisfaction with of CDSSs/KMSs is supported by evidence from six studies that included an evaluation period longer than 1 year^{38,68,110,118,119,124} and two studies that were evaluated with more than 2000 patients.^{68,126} Further, one study evaluated provider satisfaction of the CDS/KMS with 257 providers¹¹⁹ and another with 346 providers.¹⁰³ Of note, six studies were published after 2008.^{68,70,81,110,117,119}

Health care provider use. We identified 17 of the 148 eligible studies (11.5%) that specifically examined health care provider use of CDSSs/KMSs using metrics such as the number of times the CDSS/KMS was accessed by the clinician or the number of times the CDSS provided a recommendation to the clinician. These studies are summarized in Table I-16 of Appendix I.

Of these 17 studies, 9 (52.9%) were conducted in the U.S.,^{80,82,88,115-117,119,124-126} 7 (41.2%) in Europe,^{4,54,118,120-123,128} and 1 (5.9%) in Canada.¹²⁷ Two of the studies (11.8%) were implemented in an academic setting,^{82,124} nine (52.9%) in a community setting,^{4,54,80,117,118,120-122,125,128} three (17.6%) in both academic and community settings,^{88,119,126} one (5.9%) in a VA setting,^{115,116} and two (11.8%) in settings that were not clearly described.^{123,127} One study (5.9%) was performed in an inpatient setting,⁸² and 16 studies (94.1%) evaluated the systems in the ambulatory environment.^{4,54,80,88,115-128} Duration of the evaluation period across the studies ranged from 6 months^{54,80,82,117,123,126,127} to 2 years.^{115,116,125} Thirteen interventions (76.5%) were implemented using a system developed within the specific health care organization,^{80,82,88,115-117,120-128} 3 (17.6%) were implemented using a commercially available system,^{4,118,119} and 1 (5.9%) had a source that was not clearly identified.⁵⁴ Three systems (17.6%) aided health care providers with tasks for diagnosis,^{88,123,125} 9 (52.9%) for pharmacotherapy,^{54,80,82,88,119,124-127} 6 (35.3%) for chronic disease management,^{4,80,88,115,116,120-122} 4 (23.5%) for laboratory test ordering,^{80,123,126,128} and 4 (23.5%) for additional clinical tasks.^{117,118,123,126} All 17 of the systems (100%) delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter.^{4,54,80,82,88,115-128} Two of the interventions (11.8%) required a mandatory response,^{82,119} one (5.9%) required the health care provider to justify the reason for not complying with the

recommendation,¹²⁷ four (23.5%) did not have a response requirement,^{117,124,126,128} and in ten studies (58.8%), it was assumed that there was no user response requirement or it was unclear to the abstractor if such requirement was present.^{4,54,80,88,115,116,118,120-123,125} In 13 studies (76.5%), the recommendations were integrated within a CPOE or EHR system;^{4,54,80,82,88,115-117,119-122,124,127,128} 1 (5.9%) was integrated within a CPOE or EHR and delivered via fax or computer printout,¹²⁶ 2 (11.8%) via a standalone system,^{123,125} and 1 study (5.9%) did not clearly describe how the CDSS was integrated.¹¹⁸ The recommendations were automatically delivered to the health care provider in seven studies (41.2%);^{4,54,82,115,116,119,126,127} in eight studies (47.1%), the health care provider had to initiate an action to receive the recommendation,^{80,117,120-125,128} one study (5.9%) delivered recommendations using both modes,⁸⁸ and one study (5.9%) had a mode that was not clearly described.¹¹⁸ Five studies (29.4%) received a “Good” quality score,^{88,115,116,119,124,128} ten (58.8%) had a “Fair” score,^{4,54,80,82,117,118,120-122,125,127} and two (11.8%) received a “Poor” score.^{123,126}

Two high-quality, recently published papers^{115,116,119} were examined in detail to guide observations about this group of studies. Bosworth et al. (2005, 2009)^{115,116} evaluated prescribing reminders for antihypertensive medications and found that during the 2-year evaluation period in which the CDSS intervention was displayed, providers interacted with the intervention in 57 percent of the visits (n = 528 of 929). Regarding health care provider use, Fortuna et al. (2009)¹¹⁹ reported that during the 1-year evaluation period, hypnotic prescribing recommendations were seen at least once by only 89 of 257 (35%) of providers.

From the research included in this section, we concluded that relatively few studies actually assessed use of the CDSS/KMS. Among the 12 studies (70.6%) that provided some statistical data pertaining to health care provider use, 8 (66.7%) documented that levels of CDSS/KMS were low (less than 50% of time or patient visits) or less than half of clinicians used the CDSS/KMS or received alerts to guide therapeutic action and only one documented use over 80 percent in a study evaluated for 6 months with 15,343 patients and 300 general practitioners.⁵⁴ Six of the seven studies that evaluated the interventions with more than 2000 patients^{4,88,120-122,126,127} all reported low levels of CDSS usage and four of the six studies that evaluated the interventions with more than 100 clinicians also reported low levels of CDSS usage.^{80,88,119,126} Among studies evaluating clinical or economic outcomes, none of these studies demonstrated provider use of CDSSs greater than 80 percent. As noted above regarding user acceptance, system use of successful CDSSs/KMSs by providers may be assumed in that these systems were shown to have an impact over the control groups, suggesting some level of reporting bias in this observation.

Implementation of CDSSs/KMSs. Only 5 of the 148 eligible studies (3.4%) specifically examined the impact of CDSSs/KMSs on implementation in practice as measured with other outcomes or over time. These studies are summarized in Table I-17 of Appendix I.

Of these five studies, three (60%) were conducted in the U.S.^{81,136,175}, one (20%) in Canada,¹⁰⁰ and one (20%) in both the U.S. and Canada.¹³¹ Three of the studies (60%) were implemented in an academic setting,^{131,136,175} one (20%) was in a community setting,⁸¹ and one (20%) in both academic and community settings.¹⁰⁰ One study (20%)¹³¹ evaluated the systems in the inpatient environment and four studies (80%) in the ambulatory environment.^{81,100,136,175} Duration of the evaluation period across the studies ranged from 6 months^{81,175} to 25 months.¹³¹ All five interventions (100%) were implemented using a system developed within the specific health care organization.^{81,100,131,136,175} Four systems (80%) aided health care providers

with tasks for diagnosis,^{81,100,131,175} two (40%) for laboratory test ordering,^{100,175} and two (40%) for additional clinical tasks.^{81,136} All five (100%) systems delivered recommendations in real time to enable decisionmaking during the health care provider–patient encounter.^{81,100,131,136,175} One of the interventions (20%) had a mandatory response requirement,¹⁷⁵ one (20%) did not have a response requirement,¹³¹ one (20%) required a response justification,⁸¹ one (20%) required a noncommittal acknowledgement,¹³⁶ and in one of the studies (20%), it was unclear to the abstractor if such requirement was present.¹⁰⁰ The recommendations were integrated in the system in two (40%) studies,^{81,175} delivered online in one study (20%)¹³⁶ and two (40%) via a standalone system.^{100,131} The recommendations were automatically delivered to the health care provider in two studies,^{81,175} and in three studies (60%), the health care provider had to initiate an action to receive the recommendation.^{100,131,136} No studies received a “Good” quality score, three (60%) had a “Fair” score,^{81,131,175} and two (40%) received a “Poor” score.^{100,136}

None of the 10 key papers reported data describing the impact of CDSSs on implementation. Of the studies that reported data for this outcome, the first found that a handheld decision support system at the point of care led to improvements in appropriate diagnostic management of angina, leading to an increase use of cardiac stress testing with the personal digital assistant compared to usual care (81% versus 50%).¹⁰⁰ Hamilton et al. (2004)¹³¹ found that a standalone application that recorded the mother’s contractions and the baby’s heart rate and displayed a graph of the measured dilation led to decreased rates of caesarian sections at 6 months, from 19.54 percent in all eligible women in the year preceding the trial to 17.04 percent ($P = 0.004$), to 16.62 percent by 12 months ($P = 0.00006$) compared to the previous year. Flanagan et al. (1999)¹³⁶ reported that online immunization reminders aided clinicians in making appropriate immunization decisions and that those intervention sessions were significantly less likely to include a vaccination order. Co et al. (2010)⁸¹ found no association between the number of times the clinician received a reminder and an increased likelihood of having a visit at which ADHD symptoms and treatments were discussed with the patient. Tierney et al. (1988)¹⁷⁵ observed that an intervention that presented clinicians with the predicted probabilities of test abnormalities when ordering diagnostic tests was able to significantly reduce costs, and upon discontinuation of the intervention, the postintervention levels of ordering returned to preintervention levels.

We concluded that there is limited evidence that locally developed CDSSs that provided recommendations synchronously at the point of care will impact implementation on practice.

Key Question 4

KQ 4: What generalizable knowledge can be integrated into electronic knowledge management and CDSSs to improve health care quality?

4.a. Knowledge from published evidence about electronic knowledge management and CDSSs to improve health care quality based on different types of measures (health care process, relationship-centered, clinical, economic)

4.b. How a clinician's expertise/proficiency/informatics competency in using the electronic knowledge management and CDSS affects clinical outcomes (one type of measure)

Key Points

- Multiple types of generalizable knowledge are incorporated into CDSSs/KMSs. These include knowledge from the evidence base derived from research, knowledge that incorporates local context, and knowledge from various databases or repositories of medical information.
- Highly synthesized forms of generalized knowledge such as clinical guidelines and local adaptation of clinical guidelines (structured care protocols) are the most common types of generalized knowledge incorporated into CDSSs/KMSs.
- A clinician's expertise/proficiency/informatics competency in using electronic knowledge management and CDSSs/KMSs has not been evaluated systematically in the literature; evaluation of factors such as the clinician's expertise, acceptance, and usage of CDSSs/KMSs should be part of the suite of outcomes used to measure the impact of CDSSs/KMSs.

The Institute of Medicine's report "Crossing the Quality Chasm" identified the use of information technologies to support clinical decisionmaking as a critical strategy in translating medical research into clinical practice.¹⁸⁰ Interest in the use of these technologies reflects a growing understanding that there is often a gap between scientific knowledge about best care and its application to clinical practice.¹⁸¹ The potential benefit of information technologies, and CDSSs in particular, lies in their ability to harness the vast and rapidly evolving medical knowledge base to deliver timely, contextually relevant, evidence-based information to health care providers that, when acted upon, can improve quality of care and patient outcomes. To deliver context-specific and patient-specific recommendations, however, medical declarative knowledge must be encoded into both human readable and machine-processable rules. Accordingly, knowledge sources that are up to date, clinically valid, trusted by health care providers, and easily integrated into CDSSs/KMSs are critical to the effective performance of CDSSs/KMSs.

In this section, we focus on the various types of generalizable knowledge integrated into CDSSs/KMSs and found in the current evidence base. While acknowledging the diversity of systems, settings, decision tasks, designs, and contextual variables related to implementation and methodological quality represented by the studies in this report, we defined the primary purpose of this analysis to be exploratory and hypothesis generating.

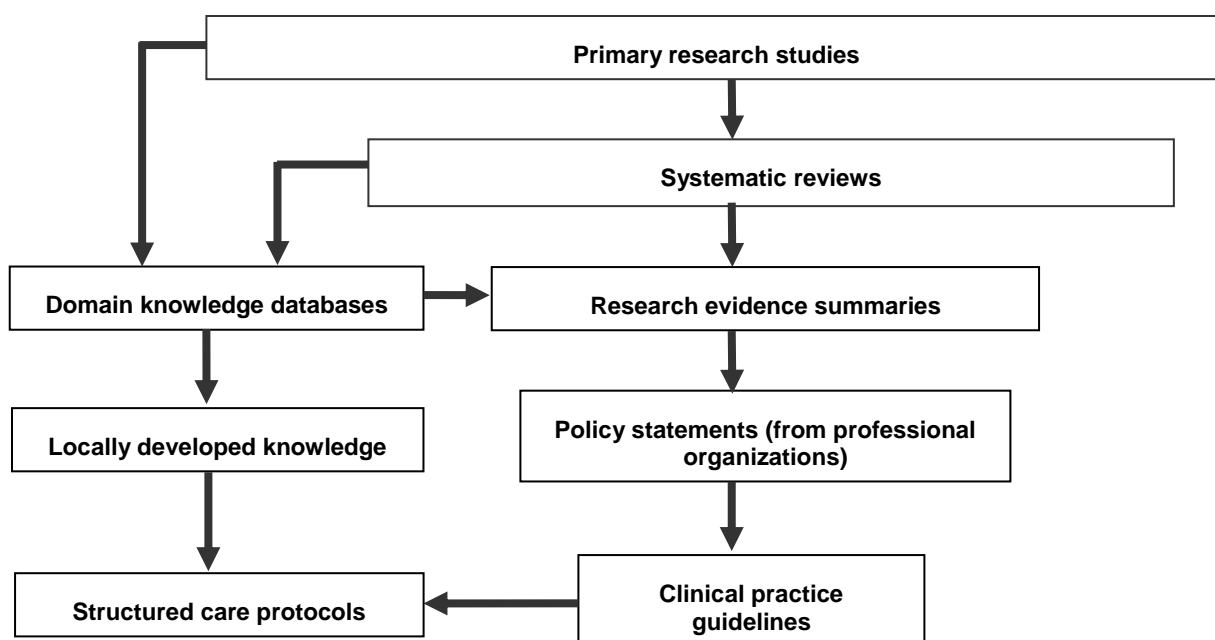
Detailed Analysis

KQ 4a. Using our 148 included RCT studies, we synthesized the published evidence to identify types and forms of generalizable knowledge that are integrated into CDSSs/KMSs with the aim of effecting improvements in health care quality. The types of generalizable knowledge identified were further categorized as either broad or targeted based on the scope and specificity

of information delivered. For example, a CDSS/KMS that delivered evidence-based information related to a specific condition, clinical issue, or process of care was considered to be targeted in application whereas a CDSS/KMS that delivered evidence related to multiple conditions, clinical issues, or drug interactions was considered to be broad in scope and applicability. The purpose of the classification is to examine if the specificity of information delivered has a potential impact on provider acceptance and, therefore, the degree of use of these information technologies. In addition, interventions that were broad in scope and applicability could potentially be seen as having a larger impact given their potential greater target population.

Generalizable knowledge incorporated into each of these studies was located on an evidence pyramid, a hierarchical organization of evidence in which each higher category is built on synthesis of evidence from the underlying categories (Figure 10).^{182,183}

Figure 10. Types of generalizable knowledge incorporated into CDSSs/KMSs



These five categories, in increasing order of research synthesis from least synthesized to most synthesized, were:

1. **Primary research studies:** Knowledge from original studies in the primary literature. For the purpose of this review, specific health care protocols or algorithms derived from the primary literature would also constitute primary research.
2. **Systematic reviews and meta-analyses:** Investigations to synthesize the results of multiple primary investigations. Evidence derived from databases of systematic reviews compiled by organizations such as the Cochrane Collaboration and the Evidence-based Practice Centers supported by the Agency for Healthcare Research and Quality is also included in this category.

3. **Research evidence summaries:** Synthesis of systematic reviews and meta-analyses to develop summary of evidence for particular clinical circumstances.
4. **Policy statements:** Recommendations from professional organizations (e.g., American Heart Association) and national organizations such as Centers for Disease Control and Prevention and the U.S. Preventive Services Task Force.
5. **Clinical practice guidelines:** Include “systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances.”¹⁸⁰

CDSSs/KMSs not only provide preappraised evidence-based knowledge (as in the categories above), but also harness patient-specific medical data from drug databases or other electronic databases such as patient records, insurance databases, or institutional databases related to laboratory tests ordered/performed, drugs prescribed, or prescriptions filled. Additional sources of knowledge incorporated into CDSSs/KMSs include knowledge from a local context or knowledge (protocols or algorithms) developed locally. An often-overlooked but key feature of the knowledge base incorporated into some CDSSs/KMSs is local, patient-level data (e.g., patients characteristics and outcomes in a specific ward who are on antimicrobial therapy) that can then be combined with evidence-based knowledge (guidelines on antimicrobial use) to deliver patient-specific recommendations. We defined these types of generalized knowledge as structured care protocols—refinements of general guidelines or policy statements that reflect local context (local norms, practices, and practical constraints).

To accommodate these sources of knowledge, we added three categories of generalized knowledge of particular relevance to the design of CDSSs/KMSs (for a total of eight categories). These were:

1. **Domain knowledge databases:** Repositories of domain-specific knowledge such as drug databases (Micromedex).
2. **Locally developed knowledge:** Evidence derived from the context of care, including collection of clinician and patient experiences. Typically, local knowledge is derived from data collected from local performance, planning, quality, outcome, and evaluation activity.¹⁸⁴⁻¹⁸⁶ Protocols, algorithms, or other forms of knowledge developed locally are also included in this category.
3. **Structured care protocols:** Local adaptation of clinical practice guidelines and other evidence-based knowledge. Structured care protocols incorporate knowledge such as local expertise (e.g., an expert panel of physicians at the local institution in which the intervention is implemented), aggregated patient-specific data drawn from various databases, and organized sources of clinical information such as online medical databases to realize forms of knowledge that are sensitive to and reflect local context or environment.

We used the above classification scheme to identify the source of generalized knowledge in each of the 148 articles included in the review. In addition, CDSSs/KMSs employing forms of knowledge from multiple sources from any of the categories described above were noted as having multiple forms of generalized knowledge. The classification scheme employed was not meant to suggest a comprehensive set of categories with a rigid relationship between them; instead, the purpose was to highlight, for the convenience of the reader, particular categories

suggested by the review of studies in this report, while acknowledging that other classification schemes, such as those discussed in Haynes (2007)¹⁸² and Dicenso et al. (2009)¹⁸³ are possible.

KQ 4b. We also abstracted data (when available) related to the clinician’s proficiency/expertise in using CDSSs/KMSs; the purpose was to understand aspects of system-user interaction that have the potential to impact effectiveness of CDSSs/KMSs. We interpreted the term “clinician expertise” broadly and included studies in this category as long as they provided some measure related to evaluation of the degree of familiarity/expertise of the clinician with the CDSSs/KMSs.

Clinician proficiency/expertise was defined differently across the studies but included such metrics as length and type of training provided on the CDSS/KMS, clinician degree of familiarity with the CDSS/KMS, and clinician/institutional experience with electronic medical records/computerized order entry systems in which a CDSS/KMS was embedded. Details of the implementation and environment of the CDSS/KMS (e.g., whether embedded in a routinely used EHR system or introduced for the first time) provided additional contextual elements to interpret clinician expertise.

Based on reported provider expertise, we classified studies into the following categories:

- Studies reporting clinician expertise either directly or indirectly through measures such as length of training provided on a CDSS/KMS or clinician/institutional experience with electronic medical records/computerized order entry systems in which a CDSS/KMS was embedded.
- Studies that did not report clinician expertise.
- Studies in which the output of a CDSS/KMS was presented to the clinician in paper-based format obviating the need for interaction with the CDSS/KMS.

Results for KQ 4a

The CDSSs/KMSs we evaluated in this review incorporated multiple types of generalized knowledge derived from the range of sources spanning the continuum of research evidence from primary studies and locally derived knowledge to domain knowledge databases and clinical guidelines. The various types of generalized knowledge incorporated into CDSSs are described in Table 11 with examples drawn from studies reviewed and the sources for the relevant included studies listed.

Table 11. Types and sources of generalizable knowledge incorporated into CDSSs/KMSs

Type of generalizable knowledge	Number of studies (%)	Example studies	Description
Primary research Knowledge identified directly from original studies in the primary literature	5 (3.4) ^a	Frame et al., 1994 ¹⁷⁴ Ornstein et al., 1991 ¹⁴⁰	Compliance with 11 health maintenance protocols identified in the literature Recommendations for serum cholesterol measurements, fecal occult blood testing, mammography, Pap smears, and tetanus immunizations identified from the literature
Systematic reviews Investigations to synthesize the results of multiple primary investigations	1 (0.7)	Christakis et al., 2001 ¹⁵⁵	Guidance derived primarily from systematic reviews integrated into a CDSS to improve antibiotic prescribing practices for otitis media in children
Research evidence summaries Synthesis of systematic reviews and meta-analyses to develop summary of evidence for particular clinical circumstances	1 (0.7)	Alper et al., 2005 ¹⁷¹	Evaluation of Dynamed, an evidence synthesis tool that incorporates the latest evidence from systematic reviews and primary research to deliver evidence summaries related to different clinic topics
Domain knowledge databases Repositories of domain-specific knowledge such as drug databases	1 (0.7)	Tamblyn et al., 2008 ¹²⁷	Commercially available drug knowledge database (MentoR, Vigilance Sante, Montreal, Quebec) was integrated into a CDSS to provide customizable alerts
Policy statements and recommendations Recommendations from professional and national organizations	13 (8.8) ^b	McPhee et al., 1989 ¹³⁹	American Cancer Society and National Cancer Institute guidelines for cancer screening
Clinical practice guidelines Systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances	42 (28.4) ^c	Bertoni et al., 2009 ⁹²	National Cholesterol Education Program clinical practice guidelines

Table 11. Types and sources of generalizable knowledge incorporated into CDSSs/KMSs (continued)

Type of generalizable knowledge	Number of studies (%)	Example studies	Description
Structured care protocols Local adaptation and synthesis of evidence-based guidelines and other evidence-based knowledge to develop structured care protocols	61 (41.2) ^d	Judge et al., 2006 ¹⁷⁷	CDSS was designed by a team of geriatricians, pharmacists, health services researchers, and information system professionals; team reviewed the types of preventable adverse events based on published research and pharmaceutical drug interaction databases. Medications not on formulary at the facility and medications never used in elderly patients or long-term care settings were excluded.
Locally developed knowledge Protocols, algorithms, or other forms of knowledge developed locally	15 (10.1) ^e	Cavalcanti et al., 2009 ³³ Hamilton et al., 2004 ¹³¹	Locally developed protocol for maintaining blood glucose level between 100 and 130 mg/dL Mathematical model for evaluating progress of labor in pregnant women
Databases/information Incorporation of knowledge from multiple sources	9 (6.1) ^f	Apkon et al., 2005 ⁴⁷	Knowledge database incorporating content from multiple sources including clinical textbooks, consensus reports, and clinical practice guidelines

a 82,114,140,153,174

b 24,54,62,63,68-70,76,86,95,135,137,139,159

c 4,20,32,38,39,41-43,49,56-58,71,74,77-81,85,88,89,92,97,99,100,106,108,113,115,116,118,120-122,129,130,144-146,150,157,162-165,178,179

d 21-23,25-27,29,33-35,40,46,48,50,51,53,60,61,64-66,72,83,84,90,91,93,94,96,101-103,105,107,109-111,119,123,125,126,128,132,134,136,138,141-143,147-149,152,154,156,158,160,161,165-168,173,176,177

e 31,36,37,44,45,52,55,59,67,98,131,151,169,170,172,175

f 30,47,73,75,87,104,112,117,124

Abbreviations: CDSS = clinical decision support system, mg/dL = milligrams per deciliter

Among the 148 studies evaluated in the review, the most common form of generalized knowledge incorporated into CDSSs/KMSs was structured care protocols (61 studies, 41.2%); the second most common form was clinical practice guidelines (42 studies, 28.4%). In terms of the focus of the generalized knowledge, the majority of CDSSs/KMSs (107 studies, 72.3%) incorporated targeted forms of knowledge (i.e., knowledge related to a specific guideline or medical condition); generalized knowledge dealing with multiple conditions and clinical situations was incorporated in 41 studies (27.7%).

We examined the relationship between the type of generalized knowledge incorporated into CDSSs/KMSs and specific quality-of-care and patient outcomes. The outcomes evaluated were (1) clinical outcomes, (2) health care process measures, and (3) health care provider use and implementation outcomes.

Clinical outcomes and types of generalizable knowledge. These outcomes included length of stay, morbidity, mortality, and adverse events.

Length of stay. We identified 6 of the 148 eligible studies (4.1%) that specifically examined the impact of CDSSs/KMSs on inpatient or emergency department length of stay.^{23,26,27,29-31,34} These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-1 of Appendix K.

The types of generalized knowledge used in these six CDSSs were structured care protocols (66.7%), locally developed knowledge (16.7%), and multiple types (16.7%). Generalized knowledge from primary research, systematic reviews, research evidence summaries, domain knowledge databases, policy statements, or clinical practice guidelines was not employed in the CDSSs reporting length of stay. The majority of CDSSs reporting length of stay data incorporated knowledge that was targeted toward a particular condition or intervention (83.3%). The only study (20%) that employed generalized knowledge that was broad in scope was the one by Overhage et al. (1997)²⁹ that incorporated 22 preventive care measures for inpatients based on recommendations of the U.S. Preventive Services Task Force. However, use of CDSS, in this case, did not lead to significant decrease in length of stay. The average length of stay for intervention was 7.62 days, and for control was 8.12 days; difference of -0.5 days (95% CI -0.17 to 1.19; P = 0.94). Irrespective of the scope or the type of generalized knowledge, data from this small set of studies show limited effects of CDSSs on length of stay.

Morbidity. We identified 22 of the 148 eligible studies (14.9%) that specifically examined the impact of CDSSs/KMSs on morbidity. These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-2 of Appendix K.

The types of generalized knowledge used in these 22 CDSSs were policy statements (9.1%), clinical practice guidelines (36.4%), structured care protocols (40.9%), locally developed knowledge (9.1%), and multiple types (4.5%). Generalized knowledge from primary research, systematic reviews, research evidence summaries, or domain knowledge databases was not employed in the CDSSs evaluated in these studies. Thus, these CDSSs primarily employed knowledge representing a high degree of evidence synthesis. For example, Kucher et al. (2005)²¹ used structured care protocols that combined local knowledge (derived from a patient database) and policy recommendations (North American and European consensus statements) and incorporated them in the form of a computer program linked to the patient database to identify hospitalized patients at risk for DVT. Kucher et al. (2005)²¹ reported that clinically diagnosed DVT or PE at 90 days occurred in 61 patients in the intervention group (4.9%) compared with

103 patients (8.2%) in the control group. The Kaplan-Meier estimates of the likelihood of freedom from DVT or PE at 90 days were 94.1 percent (95% CI 92.5 to 95.4%) and 90.6 percent (95% CI 88.7 to 92.2%), respectively ($p < 0.001$).

The majority of CDSSs reporting morbidity data incorporated knowledge that was targeted toward a particular condition or intervention (95.5%). One study employed knowledge that was broad in scope and addressed multiple conditions and drugs. McDonald et al. (1984)²² used a generalized knowledgebase consisting of 1491 physician-authored care rules that generated 751 different reminder messages addressing a variety of preventive care measures as well as treatments for acute conditions such as congestive heart failure.

Mortality. We identified 7 of the 148 eligible studies (4.7%) that specifically examined the impact of CDSSs/KMSs on mortality. These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-3 of Appendix K.

The types of generalized knowledge used in these seven CDSSs were policy statements (14.3%), clinical practice guidelines (28.6%), structured care protocols (28.6%), locally developed knowledge (14.3%), and multiple types (14.3%). Generalized knowledge from primary research, systematic reviews, research evidence summaries, or domain knowledge databases was not employed in the CDSSs evaluated in these studies. The majority of CDSSs reporting mortality data incorporated knowledge that was targeted toward a particular condition or intervention (85.7%). For example, the generalized knowledge used in the CDSS evaluated by Ansari et al. (2003)²⁰ was derived from guidelines on use of beta blockers for patients with chronic heart failure. Similarly, generalized knowledge used in the study by Roumie et al. (2006)²⁴ was derived from the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7). Structured care protocols in the form of a locally developed computer program that analyzed a patient database were used in a study by Kucher et al. (2005)²¹ to identify hospitalized patients at increased risk of venous thromboembolism. The only study (16.7%) that employed generalized knowledge that was broad in scope was the one by Kuperman et al. (1999),⁴⁴ in which the knowledge base consisted of 12 alerting rules that evaluated 12 conditions involving laboratory results and medications.

Of the studies that reported mortality data, only two studies reported statistically significant results. Ansari et al. (2003)²⁰ found that deployment of a targeted CDSS incorporating generalized knowledge from guidelines on beta blockers for patients with chronic heart failure led to a reduction in patient mortality by 12 percent ($P = 0.05$). This study was conducted in the ambulatory VA setting, and the intervention was evaluated for 1 year; however, the study included only 169 patients. The other study,²⁴ of 1341 patients, reported that in a locally developed CDSS integrated in a CPOE or EHR system based on the JNC 7–promoted guideline-based hypertension treatment, 3 (0.6%) patients died in the provider education and electronic alert group; 4 (0.9%) patients died in the provider education, alert, and patient education group; and 8 (2.5%) patients died in the provider education group ($P = 0.027$). Based on the data reported in these studies, there is limited evidence for the effectiveness of CDSSs in reducing mortality regardless of the type of knowledge used.

Adverse events. We identified 5 of the 148 eligible studies (3.4%) that specifically examined the impact of CDSSs/KMSs on adverse events.^{30,36,37,44-46} These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-4 of Appendix K.

The types of generalized knowledge used in these five CDSSs were structured care protocols (20%), locally developed knowledge (60%) and multiple types (20%). Generalized knowledge from primary research, systematic reviews, research evidence summaries, domain knowledge databases, policy statements, and clinical practice guidelines were not employed in the CDSSs evaluated in these studies. In terms of focus, knowledge incorporated in these systems was broad in two of the five studies and targeted in three of the five studies. Among these five studies, only one reported a reduction in adverse events.³⁰ McGregor et al. (2006) evaluated the utility of a CDSS in detecting potentially inappropriate antimicrobial therapy using the frequency of *C. difficile* testing as an indicator for the presence of diarrhea and adverse effect of antimicrobial use. They reported that 5.7 percent of intervention patients experienced diarrhea as a side effect of antimicrobial therapy compared with 6.6 percent of control patients ($P = 0.21$). The knowledge base for the CDSS used in this study was derived from multiple sources including local experts and a commercial pharmacy database.

Health care process measures and types of generalizable knowledge. These outcomes included adherence/completion of recommended preventive care, clinical study, or treatment.

Recommendations to order/complete a preventive care. We identified 43 of the 148 eligible studies (29.1%) that specifically examined the impact of CDSSs/KMSs on ordering or completing recommended preventive care services. These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-5 of Appendix K.

The types of generalized knowledge used in these 43 CDSSs were primary research (2.3%), policy statements (14%), clinical practice guidelines (30.2%), structured care protocols (44.2%), locally developed knowledge (4.7%) and multiple types (4.7%). Generalized knowledge from systematic reviews, research evidence summaries, or domain knowledge databases was not employed in the CDSSs evaluated in these studies. Thus, most of the CDSSs incorporated evidence-based knowledge representing a high degree of evidence synthesis such as structured care protocols (44.2%), and clinical guidelines (30.2%). Of the 43 studies that addressed recommendations to order/complete preventive services, 32 (74.4%) were targeted toward a single condition/intervention while 11 studies (25.6%) incorporated knowledge that was broad in scope and addressed multiple conditions/interventions.

Recommendations to order/complete a clinical study. We identified 29 of the 148 eligible studies (19.6%) that specifically examined the impact of CDSSs/KMSs on the ordering and completion of recommended clinical studies. These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-6 of Appendix K.

The types of generalized knowledge used in these 29 CDSSs were primary research (3.4%), policy statements (10.3%), clinical practice guidelines (27.6%), structured care protocols (44.8%), locally developed knowledge (10.3%) and multiple types (3.4%). Generalized knowledge from systematic reviews, research evidence summaries, and domain knowledge databases was not employed in the CDSSs evaluated in these studies. Thus, most of the CDSSs incorporated evidence-based knowledge representing a high degree of evidence synthesis such as structured care protocols (44.8%), and clinical guidelines (27.6%). A notable exception was the CDSS developed by Steill et al. (2009)¹⁵³ for selective ordering of cervical spine imaging—the only system that used primary research, a less synthesized form of knowledge, as the source of generalized knowledge. In this study, the intervention group showed a relative reduction in

cervical spine imaging of 12.8 percent (95% CI 9 to 16; 61.7 versus 53.3; $P = 0.01$) and the control group a relative increase of 12.5 percent (7 to 18; 52.8 versus 58.9; $P = 0.03$); changes were significant when both groups were compared ($P < 0.001$). The majority of CDSSs reporting clinical study adherence incorporated knowledge that was targeted toward a particular condition or intervention (75.9%). A knowledge base that was broad and targeted multiple interventions/conditions was used in 7 (24.1%) CDSSs.

Recommendations to order/complete a specific treatment. We identified 67 of the 148 eligible studies (45.3%) that specifically examined the impact of CDSSs/KMSs on the ordering and prescribing of therapy. These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-7 of Appendix K.

The types of generalized knowledge used in these 67 CDSSs were primary research (3.0%), systematic reviews (1.5%), domain knowledge databases (1.5%), policy statements (6%), clinical practice guidelines (32.8%), structured care protocols (38.8%), locally developed knowledge (9%), and multiple types (7.5%). Generalized knowledge from research evidence summaries was not employed in the CDSSs evaluated in these studies. Thus, most of the CDSSs incorporated evidence-based knowledge representing a high degree of evidence synthesis such as structured care protocols (38.8%) and clinical guidelines (32.8%). The majority of CDSSs reporting treatment adherence incorporated knowledge that was targeted toward a particular condition or intervention (76.1%). A knowledge base that was broad and targeted multiple interventions/conditions was used in 16 (23.9%) CDSSs.

Health care provider use and types of generalizable knowledge. These outcomes include the impact on health care provider use.

Impact on health care provider use. We identified 17 of the 148 eligible studies (11.5%) that specifically examined the impact of CDSSs/KMSs on health care provider use. These studies are summarized here, with details of the source and focus of the generalized knowledge provided in Table K-8 of Appendix K.

The types of generalized knowledge used in these 17 CDSSs/KMSs were primary research (5.9%), domain knowledge databases (5.9%), policy statements (11.2%), clinical practice guidelines (41.2%), structured care protocols (23.5%), and multiple types (17.6%). Generalized knowledge from systematic reviews, research evidence summaries, or locally developed knowledge was not employed in the CDSSs evaluated in these studies. The majority of CDSSs/KMSs incorporated knowledge that was targeted toward a particular condition or intervention (82.4%). For example, Bosworth et al. (2009)¹¹⁵ used evidence-based guidelines for management of hypertension as the source of generalized knowledge incorporated into a CDSS and found during the 2-year evaluation period that the CDSS intervention was displayed, providers interacted with the intervention 57 percent of the time ($n = 528$ of 929). Fortuna et al.¹¹⁹ targeted prescription of heavily marketed hypnotic medications with a CDSS that used knowledge from local pharmaceutical and therapeutics committee guidelines; however, during the 1-year evaluation period, recommendations regarding prescription of hypnotics were seen at least once by only 89 of 257 (35%) of providers.

CDSSs/KMSs in which the knowledge incorporated was broad in scope (20%)^{117,124,127} harnessed information from multiple databases to provide context-specific information. These knowledge sources included a commercially available drug database (MentoR),¹²⁷ commercially available information databases (Micromedex, Skolar MD),¹²⁴ and information from multiple databases (Micromedex, UpToDate, MDConsult MedlinePlus).¹¹⁷

Based on data reported in these studies, relatively few studies evaluated the relationship between use of CDSSs/KMSs and the resulting outcomes; therefore, we were unable to draw any conclusions regarding the type of generalized knowledge and health care provider use.

Discussion of KQ 4a

In the continuum of evidence-based knowledge, both structured care protocols and clinical guidelines represent a high degree of evidence synthesis. The defining feature of structured care protocols is incorporation of local knowledge and the (often) participatory nature of the development that involves local practitioners. For example, in the study by Litzleman et al. (1993),⁶⁰ faculty consensus on guidelines from multiple sources was used to define preventive care protocols that took into consideration local practices, reimbursement, and practice constraints. Litzleman et al., report improved compliance among intervention physicians with preventive care reminders for fecal occult blood testing, mammography, and cervical Papanicolaou (Pap) testing (46% intervention versus 38% control; P = 0.002).

The collaborative process of development and incorporation of local knowledge should, in theory, lead to CDSSs/KMSs that more accurately reflect the informational needs of clinicians. The impact of local adaptation and refinement of guidelines on clinical outcomes is a useful line of inquiry that should be explored further.

Results for KQ 4b

Clinician expertise with CDSSs/KMSs (defined as a measure related to evaluation of the degree of familiarity/expertise of the clinician with the CDSSs/KMSs) was reported in 53 studies (35.8%) out of our 148 included studies; however, these studies often reported indirect measures such as type and length of training on CDSSs.^{4,21,24,25,30,31,35-37,44,49,51-53,55,58,59,64-66,68,70,72,74,80,81,86-89,102,107,110,117-119,123,128,135,136,147,152,154,159,160,163,165,167-169,171,176,177,179}

Among the 53 studies that reported clinicians' expertise, none of the studies directly examined the impact of their expertise in using the CDSS/KMS or related it to eventual clinical outcomes.

Clinician expertise level was not reported in 59 of our 148 included studies (39.9%).^{20,23,29,32,33,42,43,45-48,54,56,57,67,69,73,76-78,82,83,85,90-92,94,98-101,103-106,109,113-116,120-122,124,125,127,129-131,143,146,148-151,153,155,156,158,166,169,172,175,178}

CDSS/KMS recommendations were delivered using a paper-based format in 36 studies (24.3%); in these studies, clinician expertise in using a CDSS was not relevant to the eventual outcome since the clinicians interacted only with paper-based outputs of CDSSs.^{4,21,24-27,30,31,35-37,40,44,49,51-53,55,58,59,61,64-66,68,70,72,74,86-89,102,107,110,117-}

^{119,123,128,135,136,147,152,154,159,160,163,165,167,168,170,171,176,177}

The reporting of clinician expertise in using CDSSs/KMSs was highly variable across studies. Clinician expertise ranged from highly trained and experienced users of the system^{59,177} to users who were new to the system^{123,171} or were provided some form of training on the system.¹³⁶

A particular distinction was between a CDSS/KMS implemented as an enhancement to an existing EHR system that had been in use for a certain length of time^{59,88} versus a CDSS/KMS deployed for the first time.⁷² For example, in the study by Linder et al. (2009),⁸⁸ the decision support functionality was implemented as an enhancement to an EHR that had been in use for at least 4 years. In this case, training on the CDSS functionality only included an introductory email to clinicians, one practice visit by an investigator, and periodic emails to encourage use of the enhancements. Linder et al. evaluated tobacco treatment reminders in a primary care setting and reported improvements in the primary outcome of interest: the proportion of documented smokers who contacted a smoking cessation counselor (3.9% in intervention practices versus 0.3% in control practices, $P = 0.001$, 12,207 patients).

Tamblyn et al. (2003)⁷² evaluated a CDSS that was introduced into practice for the first time and reported that clinicians' previous computer expertise influenced effectiveness of the CDSS. In this study, the potential of a CDSS to reduce inappropriate prescriptions to the elderly in a primary care setting was evaluated. Tamblyn et al. (2003) reported that the CDSS was effective in reducing number of new, potentially inappropriate medications (RR 0.82, 95% CI 0.69 to 0.98), with a more selective effect on discontinuation of inappropriate prescriptions. In particular, clinicians' previous computer expertise was found to influence the effectiveness of the CDSS. The rate of initiation of inappropriate prescriptions among experienced computer users was 30 percent lower in the CDSS group than in the control group (RR 0.70, 95% CI 0.55 to 0.89). The rate of initiation of inappropriate prescriptions among computer beginners was identical in the CDSS and control groups (RR 1.03, 95% CI 0.82 to 1.29). In addition, clinicians reported technical hurdles related to implementation of the new CDSS, with 22 percent of the clinicians reporting frequent software and hardware problems in the first few months of the study that affected the degree of use of the CDSS.

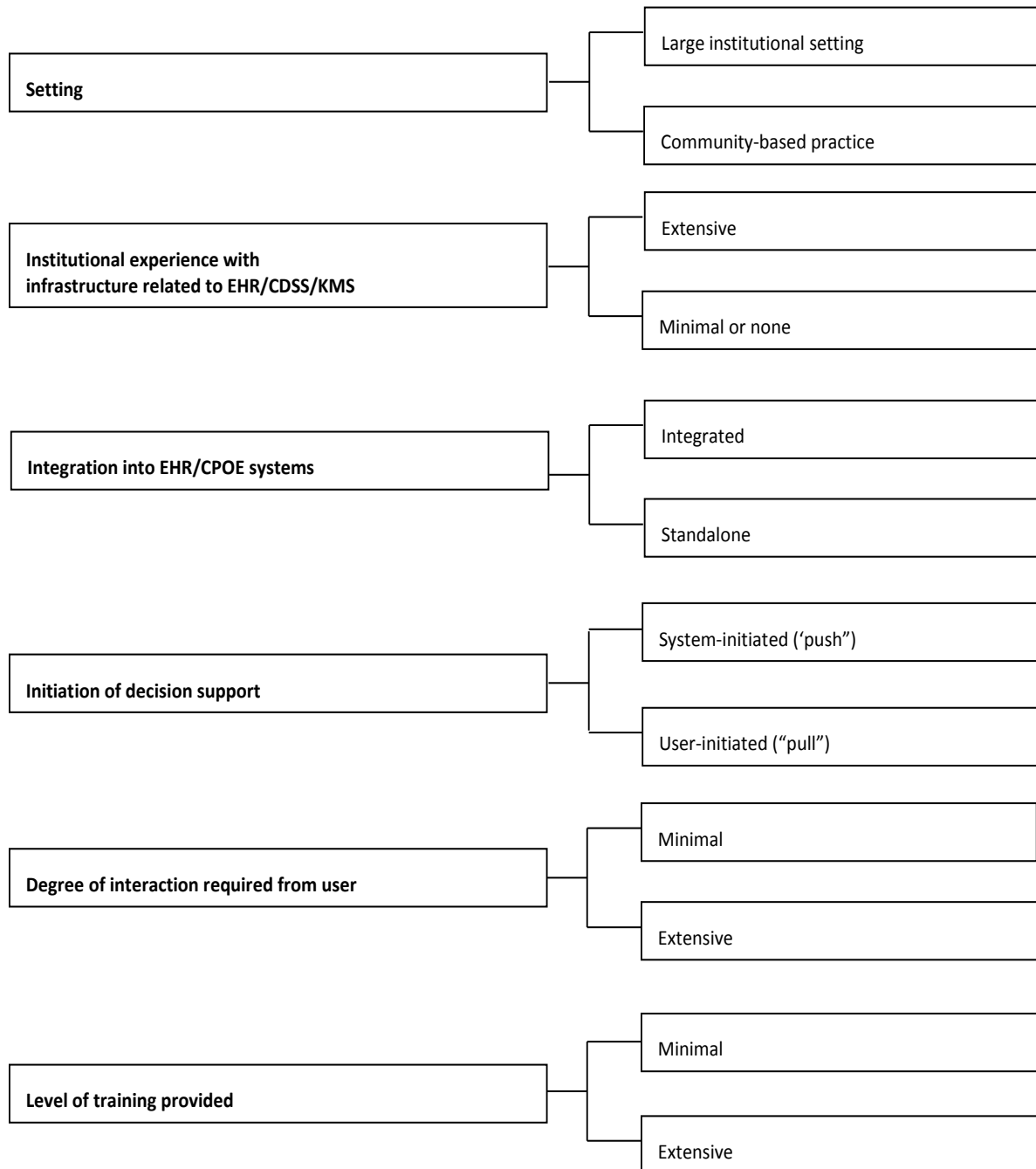
The degree of training provided on CDSSs/KMSs varied across studies, ranging from a 1-hour tutorial and assistance during the first month of use¹³⁶ to a half-day training session and site visits by study authors.¹⁶³ In addition, some studies required the use of a particular electronic medical record system as an inclusion criterion.^{107,147,168} In these studies, it was reasonable to assume that the CDSS/KMS was implemented as an additional functionality in a routinely used system.

Discussion of KQ 4b

A causal relationship between clinicians' expertise in using CDSSs/KMSs and successful implementation of CDSSs/KMSs as reflected in improvement in the quality of care (clinical outcomes and health care process measures) could not be established based on data from the studies reviewed. In the absence of directly relevant data, we examined the context in which clinicians' expertise operated as a variable with influence on the effectiveness of CDSSs/KMSs and potential impact on patient outcomes. CDSSs/KMSs evaluated as part of this review were diverse in the types of tasks performed as well as the settings in which they were employed; therefore, clinicians' expertise as a variable may not hold the same level of significance across systems and study settings. For example, in evaluating the role of clinicians' expertise, CDSSs/KMSs integrated into well-established EHR or CPOE systems are necessarily different from those being introduced into practice for the first time. CDSSs/KMSs built into existing EHR systems and implemented at large institutions with longstanding experience in using EHRs may present a far less steep learning curve compared to systems being introduced for the first

time. In particular, a CDSS/KMS implemented as an alert or as a reminder embedded in the EHR only represents an additional functionality in a routinely used and familiar EHR system. The key challenge to CDSS/KMS success in such cases may be drawing clinicians' attention to the functionality represented by the CDSS/KMS and monitoring clinician acceptance and usage of the CDSS/KMS. On the other hand, in case of a CDSS/KMS implemented in settings with no prior institutional experience in the use of computerized records, clinicians' acceptance and expertise may play a more important role. In particular, clinicians' expertise or lack thereof may be more significant when a CDSS/KMS is implemented in small, community-based practices with no institutional experience in using computerized records. System functionality, complexity, and design attributes have the potential to modify the influence of clinicians' expertise. In this context, a clear distinction may be made between systems in which information is presented automatically as part of the workflow without the need for additional input from the clinician and those who require the clinicians to seek out the information. Clinicians' expertise/familiarity with CDSSs/KMSs might be less significant when evaluating CDSS/KMS designs that do not require active information-seeking behaviors or additional steps in the workflow. Factors that potentially modify clinicians' expertise with CDSSs/KMSs are shown in Figure 11.

Figure 11. Contextual factors that may impact the role of clinician's expertise



Abbreviations: CDSS = clinical decision support system, CPOE = computerized physician order entry, EHR = electronic health record, KMS = knowledge management system

These include factors related to the environment in which CDSSs/KMSs are implemented (setting, institutional experience) as well as specific features related to the design of CDSSs/KMSs (degree of integration into existing computerized record systems, system-initiated or clinician-initiated provision of decision support, degree of interaction required from user and the level of training provided).^{5,9} These proposed factors do not constitute an exhaustive list but should be considered as possible candidate factors for evaluation. Future research could address how these and other contextual variables influence clinicians' expertise and acceptance of CDSSs/KMSs and impact clinical outcomes.

In summary, the role of clinicians' expertise with a CDSS/KMS and its effect on clinical outcomes can be examined only in the larger context of CDSS/KMS functionality and the setting in which it is implemented. It may very well be that clinicians' expertise is a necessary but not sufficient causal factor in determining the effectiveness of CDSSs and eventual patient outcomes. Examining the role of clinicians' expertise (and its evolution over time) should be part of the suite of user-system interaction factors reported in studies of CDS. In the vast majority of studies evaluated as part of this review, the objective of the CDSS/KMS was to enable changes in clinician behavior and improve the quality of care delivered. It stands to reason that system-user interaction features such as expertise, familiarity, acceptance, and degree of usage are important to the success or failure of the CDSS/KMS.^{6,187} Focusing greater scrutiny on user-related features can help us understand the specific conditions under which CDSS/KMS are effective and contribute to improvements in health care quality that are reflected in better patient outcomes.

Future Research

Studies of CDSSs/KMSs using RCTs should include a qualitative component, geared toward answering the question, What worked and what did not work in the implementation of CDSSs/KMSs? For example, in evaluation of CDSSs/KMSs geared toward improving guideline adherence, clinician attitudes toward specific guidelines being implemented and factors such as practical constraints affecting guideline adherence should be explored. This analytic approach will set the stage for designing CDSSs/KMSs that not only meet the specific informational needs of clinicians' but, more crucially, help us determine what improvements in practice can be addressed with CDSSs/KMSs and isolate these improvements from other determinants of clinical practice that lie outside the scope of CDSSs/KMSs.

The full suite of outcomes used to measure the impact of CDSSs/KMSs should include a robust evaluation of factors related to the clinician-system interaction. Ultimately, even the most sophisticated CDSSs/KMSs can influence clinical practice only when they are accepted, deemed to be useful by the end user, and effectively implemented in practice. We recommend additional studies that examine the influence of provider expertise on clinical outcomes as well as health care process measures.

Summary and Discussion

For this report, we conducted a systematic review of the indexed medical literature to determine what study designs have been used to evaluate the effectiveness of CDSSs/KMSs, to assess factors/features of CDSSs/KMSs that predict a successful clinical impact, to identify the best evidence concerning the impact of CDSSs/KMSs on a broad set of outcomes, and to identify the types of knowledge that can be integrated into CDSSs/KMSs. We also sought to identify gaps in the available evidence about the effectiveness of CDSSs/KMSs. We screened 15,176 abstracts and manuscripts dating back to 1976, from which we identified 311 comparative studies—of which 148 were RCTs. All of the RCTs were abstracted to evidence tables (Appendix D) that supplied the data for this report. Studies with similar outcomes and common endpoints were combined to conduct meta-analyses. This review investigated the continuum of information support for clinical care, including classic CDSSs as well as information retrieval systems and knowledge resources developed for access at the point of care.

Of the three study designs used to assess CDSSs/KMSs, the most common approach was RCTs, followed by quasi-experimental studies and observational studies. The most common outcomes assessed were health care process measures across all study designs followed by usability assessments and clinical outcomes. Over the past 5 years, the number of RCTs focusing on clinical outcomes in nonacademic settings using commercially developed CDSSs has increased; however, the majority of included studies still reported about locally developed systems in ambulatory care settings that provided clinical decision support for physicians on a single or limited set of conditions.

Using meta-analysis on studies that evaluated adherence to preventive care, ordering a clinical study, and prescribing a treatment as an outcome, we confirmed three previously reported features associated with successful CDSS implementations⁹ and identified six additional features. These nine features included **general system features**: integration with charting or order entry system to support workflow integration (new); **clinician-system interaction features**: automatic provision of decision support as part of clinician workflow (previous), no need for additional clinician data entry (new), and provision of decision support at the time and location of decisionmaking (previous); **communication content features**: provision of a recommendation, not just an assessment (previous), justification of decision support via provision of research evidence (new), and promotion of action rather than inaction (new); and **auxiliary features**: local user involvement in development process (new) and provision of decision support results to patients as well as providers (new). These features were present across the breadth of CDSS implementations in diverse venues (multiple countries, inpatient and ambulatory environments, academic and community settings) using both locally and commercially developed systems.

With regard to outcomes, we discovered strong evidence that CDSSs that include the nine success features favorably impact health care processes including prescribing treatments, facilitating preventive care services, and ordering clinical studies. This effect on health care processes spanned diverse venues and systems. In contrast to previous observations, where most reports of successful clinical decision support implementation were based on locally developed systems at four sites,³ this effect has now been observed at diverse community sites using commercially developed systems. We found, however, that evidence demonstrating positive effects of clinical decision support on clinical and economic outcomes remains limited. We also found limited evidence showing an impact of clinical decision support on clinical workload and efficiency.

The predominant source of knowledge used in CDSSs/KMSs was derived from structured care protocols and clinical practice guidelines that focused on a single or limited set of medical conditions. Local adoption of general knowledge sources was common. We found scant evidence exploring the relationship of clinicians' expertise and the successful implementation of clinical decision support. In spite of a favorable trend to fill a gap identified in a previous evidence report by adding more studies of commercial CDSSs/KMSs in community settings,³ the literature is still lacking for evidence concerning the breadth of content of CDSSs, the recipients of clinical decision support, the types of outcomes reported in CDSS evaluations, and the issues related to implementation and deployment of CDSSs to support wide-scale application as expected for the meaningful use of EHRs.

Most of the published RCTs on CDSSs focused on a single or limited set of conditions. Studies are needed to determine how clinical decision support can be provided for multiple health issues simultaneously. Such studies will need to address reconciliation of advice across diverse combinations of comorbid conditions, prioritization of recommendations, and avoidance of "alert fatigue." In a second issue related to CDSS/KMS content, we found a paucity of studies on KMSs (only three RCTs identified).^{117,124,171} Accordingly, studies need to be initiated to generate rigorous evidence to determine how information retrieval systems and point-of-care knowledge resources can most effectively be used to improve health care.

With regard to the recipients of clinical decision support, most studies concentrated on decision support delivered to physicians. As health care migrates to more team-oriented delivery models, future studies will need to investigate which care team members should receive clinical decision support advice to optimize effectiveness.

In the area of outcomes, relatively few studies reported clinical outcomes, and even fewer addressed the cost implications of clinical decision support.

Finally, with regard to deficiencies in the best literature, we discovered relatively few RCTs that rigorously evaluated issues related to CDSS/KMS implementation, workflow, and the delivery of care. In a similar vein, we found few studies that investigated how CDSSs/KMSs could be effectively ported to different settings. Most of the reports focused on the use of a CDSS at a single institution or closely related institutions. The portability issue will need to accommodate the discovery that user involvement in CDSS/KMS development is a feature associated with successful implementation.

To frame the context for the relevance of this report, we highlight the increasing political interest and financial investment of the U.S. government in resources for health information technology. The meaningful use of CDSSs/KMSs needs to be objectively informed regarding the role that CDSSs/KMSs can and should play in the reshaping of health care delivery. Stage 1 meaningful use guidelines¹ specify the implementation of a single clinical decision support rule. Ensuring successful CDSS/KMS implementation across the national landscape and preparing for the subsequent rounds of meaningful use standards is no longer just about getting the "right" information to the "right" person. Moving clinical decision support from isolated implementations at well-established institutions to broad penetration will require a better understanding of what the right information is and when and how it is delivered to the right person.

Ideally, the requirements for Stages 2 and 3 of meaningful use need to be more direct and based on demonstrated evidence of clinical effectiveness of CDSS/KMS tools. For example, a recent summary report has identified the lack of integration of health information technology into clinician workflow in a meaningful way as a potential contributor to the mixed success of clinical decision support.¹⁸⁸ It follows, therefore, that further understanding is needed about when to provide decision support that fits into clinician workflow and workload and how such support translates into provider acceptance, satisfaction, and improved quality of care. Another gap we identified from the included evidence that may have consequences for the meaningful use of clinical decision support is how to best present the knowledge to providers.

Limitations of This Review

Our systematic review has several limitations. First, we acknowledge a publication bias in that studies with positive outcomes are more likely than negative studies to be reported in the medical literature. Accordingly, the literature favors features that lead to CDSS success and may underreport features that result in CDSS implementation failures. In terms of reporting, this literature is also likely to contain a bias for the selective reporting of favorable outcomes at the exclusion of unfavorable outcomes. We explored the possibility of publication bias (Appendix I), and there was no consistent bias for most endpoints. The one exception was the clinical study adherence where there was a strong suggestion of publication bias. Thus these results should be viewed with caution.

A second limitation of the literature on clinical decision support is that the studies are extremely heterogeneous with regard to the systems, populations, settings, and outcomes. Consequently, it is difficult to derive general observations about CDSSs since each system and setting has unique characteristics that may be critical but not identified or transferable. We sought to minimize this limitation in our meta-analysis by including studies with a common endpoint within the outcome categories; still, it was difficult to isolate the effect of individual factors or features. A third limitation is that we chose to concentrate primarily on RCTs for the bulk of the evidence for this report and thus excluded findings from quasi-experimental and observational studies. While RCTs provide the best evidence on CDSS/KMS effectiveness, these RCTs may provide less information regarding issues related to CDSS/KMS implementation, impact on workflow, and factors affecting usability. A fourth limitation is related to the variable descriptions of intervention details provided in each publication. We abstracted specific data pertaining to the design and user interaction with each system that were commonly reported within informatics journal publications but which were less frequently described in clinically oriented publications. Conceivably, some studies did not report detailed system descriptions due to article length restrictions.

Conclusions

This systematic review has provided solid evidence that CDSSs can improve health care process measures in inpatient and ambulatory care settings with both commercially and locally developed systems in both academic and community environments in multiple countries for a single or limited set of conditions. Table 12 summarizes the key points for each key question and provides a grade for the strength of supporting evidence. In addition, nine factors/features of CDSSs/KMSs have been identified that correlate with a successful clinical decision support implementation. These features address how a CDSS/KMS is integrated with other systems, how clinicians should interact with a CDSS/KMS, how content should be communicated to users, how periodic performance feedback supports CDSSs/KMSs, and how intended users should be involved in CDSS/KMS development.

The evidence analyzed in this review builds upon an earlier review by Chaudhry et al. (2006)³ in that the benefits of CDSSs/KMSs have now been consistently demonstrated using commercially developed CDSSs/KMSs outside of four experienced academic centers with locally developed systems. In spite of these advances in the field, significant research is still required to promote the widespread use of CDSSs/KMSs and to augment the clinical effectiveness of CDSSs/KMS. This research should investigate (1) how to expand CDSS/KMS content to accommodate multiple comorbid conditions simultaneously, (2) which members of the care team should receive clinical decision support, (3) what impact CDSSs/KMSs have on clinical and economic outcomes, and (4) how CDSSs/KMSs can be most effectively integrated into workflow and deployed across multiple diverse settings. Further understanding of CDSSs/KMSs is increasingly important in order to optimally define their role in the context of meaningful use for EHRs.

Table 12. Summary of key findings

Key question	Strength of evidence	Conclusions
KQ 1: What evidence-based study designs have been used to determine the clinical effectiveness of electronic knowledge management and CDSSs?	Not applicable	<p>311 studies were reviewed, including 148 RCTs (47.5%), 121 quasi-experimental (38.9%), and 42 observational studies (13.5%).</p> <p>Clinical and health care process measures were frequently reported in all three study design types:</p> <p>Clinical outcomes (19.6% of RCTs, 35.5% of quasi-experimental, 40.5% of observational studies)</p> <p>Health care process measures (86.5.0% of RCTs, 75.2% of quasi-experimental, 69% of observational studies)</p> <p>When RCT studies are impractical to conduct, well-designed quasi-experimental and observational studies have been used to evaluate the clinical effectiveness of CDSSs/KMSs.</p>

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
KQ 2: What contextual factors/features influence the effectiveness or success of electronic knowledge management and CDSSs?	Moderate	<p>Using meta-analysis on studies that evaluated adherence to preventive care (25 studies), clinical study (20 studies), and treatment as an outcome (46 studies), we confirmed 3 previously reported features associated with successful CDSS/KMS implementation and identified 6 additional features.</p> <p>Our meta-analysis confirmed 3 previously reported factors/features were associated with successful CDSS/KMS implementation:</p> <p><i>Automatic provision of decision support as part of clinician workflow</i> (OR of 1.45, 95% CI of 1.28 to 1.64 for adherence to preventive care, n = 19; OR of 1.85, 95% CI of 1.52 to 2.25 for ordering of clinical studies, n = 15; OR of 1.59 95% CI of 1.33 to 1.90 for prescribing or ordering of therapy, n = 38). This set of studies included 44 good-quality, 26 fair-quality, and 4 poor-quality studies.</p> <p><i>Provision of decision support at time and location of decisionmaking</i> (OR of 1.35, 95% CI of 1.20 to 1.52 for adherence to preventive care, n = 22; OR of 1.78, 95% CI of 1.46 to 2.17 for ordering of clinical studies, n = 15; OR of 1.75, 95% CI of 1.47 to 2.08 for prescribing or ordering of therapy, n = 37). This set of studies included 41 good-quality, 28 fair-quality, and 6 poor-quality studies.</p> <p><i>Provision of a recommendation, not just an assessment</i> (OR of 1.50, 95% CI of 1.30 to 1.74 for adherence to preventive care, n = 18; OR of 2.01, 95% CI of 1.63 to 2.48 for ordering of clinical studies, n = 15; OR of 1.61, 95% CI of 1.34 to 1.93 for prescribing or ordering of therapy, n = 36). This set of studies included 43 good-quality, 22 fair-quality, and 5 poor-quality studies.</p>

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
KQ 2 (continued)		<ul style="list-style-type: none"> The meta-analysis also identified 6 additional factors/features that were correlated with the success of CDSSs: <ul style="list-style-type: none"> <i>Integration with charting or order entry system to support workflow integration</i> (OR of 1.47, 95% CI of 1.21 to 1.77 for adherence to preventive care, n = 13; OR of 1.56, 95% CI of 1.29 to 1.87 for ordering of clinical studies, n = 9; OR of 1.67, 95% CI of 1.39 to 2.00 for prescribing or ordering of therapy, n = 36). This set of studies included 39 good-quality, 19 fair-quality, and 3 poor-quality studies. <i>No need for additional clinician data entry</i> (OR of 1.43, 95% CI of 1.22 to 1.69 for adherence to preventive care, n = 16; OR of 1.58, 95% CI of 1.31 to 1.89 for ordering of clinical studies, n = 11; OR of 1.78, 95% CI of 1.44 to 2.19 for prescribing or ordering of therapy, n = 30). This set of studies included 38 good-quality, 19 fair-quality, and 1 poor-quality studies. <i>Promotion of action rather than inaction</i> (OR of 1.28, 95% CI of 1.09 to 1.50 for adherence to preventive care, n = 15; OR of 1.52, 95% CI of 1.23 to 1.87 for ordering of clinical studies, n = 9; OR of 1.71, 95% CI of 1.35 to 2.16 for prescribing or ordering of therapy, n = 22). This set of studies included 31 good-quality, 13 fair-quality, and 2 poor-quality studies. <i>Justification of decision support via provision of research evidence</i> (OR of 1.60, 95% CI of 1.04 to 2.46 for adherence to preventive care, n = 5; OR of 2.93, 95% CI of 1.40 to 6.12 for ordering of clinical studies, n = 5; OR of 1.59, 95% CI of 1.13 to 2.24 for prescribing or ordering of therapy, n = 15). This set of studies included 17 good-quality, 4 fair-quality, and 2 poor-quality studies. <i>Local user involvement in development process</i> (OR of 1.45, 95% CI of 1.23 to 1.73 for adherence to preventive care, n = 11; OR of 1.41, 95% CI of 1.18 to 1.70 for ordering of clinical studies, n = 10; OR of 1.90, 95% CI of 1.38 to 2.61 for prescribing or ordering of therapy, n = 20). This set of studies included 26 good-quality, 11 fair-quality, and 5 poor-quality studies. <i>Provision of decision support results to patients as well as providers</i> (OR of 1.18, 95% CI of 1.02 to 1.37 for adherence to preventive care, n = 5; OR of 1.41, 95% CI of 1.26 to 1.58 for ordering of clinical studies, n = 5; OR of 1.97, 95% CI of 1.20 to 3.21 for prescribing or ordering of therapy, n = 5). This set of studies included 7 good-quality, 5 fair-quality, and 3 poor-quality studies.
		<ul style="list-style-type: none"> Many studies included more than one feature/factor, and because the studies did not specifically evaluate whether the systems with and without an individual factor/feature differed in terms of their impact on the outcome of interest, it was difficult to determine the importance of individual factors/features.

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
KQ 3: What is the impact of introducing electronic knowledge management and CDSSs?		
3a. Changes in the organization of health care delivery	Insufficient	<ul style="list-style-type: none"> Of the eligible studies, none examined the impact of CDSSs/KMSs on changes in the organization of health care delivery.
3b. Changes in the workload and efficiency for the user		
Number of patients seen/unit time	Insufficient	<ul style="list-style-type: none"> Of the eligible studies, none examined the impact of CDSSs/KMSs on the number of patients seen/unit time.
Clinician workload	Insufficient	<ul style="list-style-type: none"> Of the eligible studies, none examined the impact of CDSSs/KMSs on clinician workload.
Efficiency	Low	<ul style="list-style-type: none"> 7 studies (4.7%) examined the impact of CDSSs/KMSs on efficiency (3 good-quality and 4 fair-quality studies). From these studies, there is limited evidence that CDSSs/KMSs demonstrated a trend toward improving efficiency.
3c. Changes in health care process measures and clinical outcomes		
<i>Health care process measures</i>		
Recommended preventive care service ordered/completed	High	<ul style="list-style-type: none"> 43 studies (29.1%) examined the impact of CDSSs/KMSs on ordering or completing recommended preventive care services. This set of studies included 20 good-quality, 16 fair-quality, and 7 poor-quality studies. A meta-analysis of 25 studies (58.1%) that provided sufficient data to calculate a common endpoint indicated that CDSSs increased preventive care service ordered/completed, with an odds ratio of 1.42 (95% CI 1.27 to 1.58). This set of studies included 13 good-quality, 10 fair-quality, and 2 poor-quality studies. There is strong evidence from studies conducted in the academic, VA, and community inpatient and ambulatory settings that locally and commercially developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response were effective at improving the appropriate ordering of preventive care procedures.

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
Recommended clinical study ordered/completed	Moderate	<ul style="list-style-type: none"> 29 studies (19.6%) examined the impact of CDSSs/KMSs on the ordering and completion of recommended clinical studies. This set of studies included 16 good-quality, 9 fair-quality, and 4 poor-quality studies. A meta-analysis of 20 studies (69%) that provided sufficient data to calculate a common endpoint indicated that CDSSs increased appropriate clinical studies ordered/completed, with an odds ratio of 1.72 (95% CI 1.47 to 2.00). This set of studies included 11 good-quality, 5 fair-quality, and 4 poor-quality studies. There is modest evidence from studies conducted in the academic and community inpatient and ambulatory settings that CDSSs integrated in CPOE or EHR systems and locally and commercially developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response were effective at improving the appropriate ordering of clinical studies.
Recommended treatment ordered/prescribed	High	<ul style="list-style-type: none"> 67 studies (45.3%) examined the impact of CDSSs/KMSs on the ordering or prescribing of therapy. This set of studies included 35 good-quality, 24 fair-quality, and 8 poor-quality studies. A meta-analysis of the 46 studies (68.7%) that provided sufficient data to calculate a common endpoint indicated that CDSSs increased treatment ordered/prescribed, with an odds ratio of 1.57 (95% CI 1.35 to 1.82). This set of studies included 28 good-quality, 15 fair-quality, and 3 poor-quality studies. There is strong evidence from the academic, community, and VA inpatient and ambulatory settings that locally and commercially developed CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response were effective at improving appropriate treatment ordering/prescribing.
Impact on user knowledge	Insufficient	<ul style="list-style-type: none"> 5 studies (3.4%) examined the impact of CDSSs/KMSs on user knowledge. This set of studies included 0 good-quality, 4 fair-quality, and 1 poor-quality studies.

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
<i>Clinical outcomes</i>		
Length of stay	Low	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on length of stay. All studies in this set were rated as good quality. A meta-analysis of 5 studies (83.3%) that provided sufficient data to calculate a common endpoint indicated a combined relative risk of 0.96 (95% CI 0.88 to 1.05). Although all of the studies were high-quality and 4 were evaluated with > 2000 patients, only 1 study was evaluated for ≥ 1 year. There is limited evidence that CDSSs that automatically delivered system-initiated (push) recommendations to providers were effective at reducing length of stay or demonstrated a trend toward reducing length of stay.
Morbidity	Moderate	<ul style="list-style-type: none"> 22 studies (14.9%) examined the impact of CDSSs/KMSs on morbidity. This set of studies included 13 good-quality, 7 fair-quality, and 2 poor-quality studies. A meta-analysis of 16 studies (72.7%) that provided sufficient data to calculate a common endpoint indicated a combined relative risk of 0.88 (95% CI 0.80 to 0.96). This set of studies included 11 good-quality, 3 fair-quality, and 2 poor-quality studies. There is modest evidence from the academic and community inpatient and ambulatory settings that locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care were effective or demonstrated a trend toward reducing patient morbidity.
Mortality	Low	<ul style="list-style-type: none"> 7 studies (4.7%) examined the impact of CDSSs/KMSs on mortality. This set of studies included 6 good quality and 1 fair-quality studies. A meta-analysis of 6 studies (85.7%) that provided sufficient data to calculate a common endpoint indicated a combined odds ratio of 0.79 (95% CI 0.54 to 1.15). This set of studies included all good-quality studies. Although the majority of the studies were high-quality, less than half of the studies were evaluated for ≥ 1 year or with > 2000 patients. There is limited evidence that CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers were effective at reducing patient mortality or demonstrated a trend toward reducing patient mortality.

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
Health-related quality of life	Low	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on health-related quality of life. This set of studies included 3 good-quality, 2 fair-quality, and 1 poor-quality studies. The majority of these studies were evaluated for ≥ 1 year and included a sample size between 500 and 1000. There is limited evidence from the ambulatory setting that locally developed CDSSs that automatically delivered system-initiated (push) recommendations to providers demonstrated a trend toward higher quality-of-life scores.
Adverse events	Low	<ul style="list-style-type: none"> 5 studies (3.4%) examined the impact of CDSSs/KMSs on adverse events. This set of studies included 3 good-quality, 1 fair-quality, and 1 poor-quality studies. A meta-analysis of the 5 studies (100%) reported a combined relative risk of 1.01 (95% CI 0.90 to 1.14). Although the majority of the studies were high quality, most were evaluated for < 1 year and did not include a sample size > 2000 patients. There is limited evidence from the academic setting that CDSSs that delivered recommendations to providers synchronously at the point of care demonstrated an effect on reducing or preventing adverse events.
<i>Economic outcomes</i>		
Cost	Moderate	<ul style="list-style-type: none"> 22 studies (14.9%) examined the impact of CDSSs/KMSs on cost. This set of studies included 10 good-quality, 7 fair-quality, and 5 poor-quality studies. The majority of the studies that demonstrated a trend toward lower costs and greater cost savings were evaluated for < 1 year but were evaluated with ≥ 2000 patients. There is modest evidence from the academic and community inpatient and ambulatory settings that locally and commercially developed CDSSs integrated in CPOE or EHR systems that automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care demonstrated a trend toward lower treatment costs, total costs, and greater cost-savings than did the control groups and other non-CDSS intervention groups.
Cost-effectiveness	Insufficient	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on cost-effectiveness. This set of studies included 1 good-quality, 5 fair-quality, and 0 poor-quality studies. There is conflicting evidence from the ambulatory setting regarding the cost-effectiveness of CDSSs that delivered recommendations to providers synchronously at the point of care. Some studies demonstrated a trend toward cost-effectiveness; however, one of the

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
		included key articles reported a negative impact of CDSSs on cost-effectiveness, and therefore our confidence in the impact is additionally lessened.
<i>Use and implementation outcomes</i>		
Health care provider acceptance	Low	<ul style="list-style-type: none"> 24 studies (16.2%) examined the impact of CDSSs/KMSs on health care provider acceptance. This set of studies included 9 good-quality, 11 fair-quality, and 4 poor-quality studies. Studies that reported on health care provider acceptance suggested that high levels of acceptance (acceptance rate > 75%) of recommendations from CDSSs are the exception rather than the rule. Many successful CDSS studies did not report acceptance.
Health care provider satisfaction	Moderate	<ul style="list-style-type: none"> 19 studies (12.8%) examined the impact of CDSSs/KMSs on health care provider satisfaction. This set of studies included 9 good-quality, 7 fair-quality, and 3 poor-quality studies. The majority of these studies were evaluated for < 1 year and only 2 included a sample size > 2000 patients. CDSSs that fostered high satisfaction among providers were implemented within the academic, community, and VA ambulatory settings; integrated in CPOE or EHR systems; locally and commercially developed; and automatically delivered system-initiated (push) recommendations to providers synchronously at the point of care and did not require a mandatory clinician response.
Health care provider use	Low	<ul style="list-style-type: none"> 17 studies (11.5%) examined the impact of CDSSs/KMSs on health care provider use. This set of studies included 5 good-quality, 10 fair-quality, and 2 poor-quality studies. The majority of the included studies documented low usage (< 50% of time or patient visits), or less than half of clinicians used the CDSS or received alerts to guide therapeutic action; only one study documented usage over 80%. Among studies evaluating clinical or economic outcomes, none of these studies demonstrated provider use of CDSSs > 80%.
Implementation	Insufficient	<ul style="list-style-type: none"> 5 studies (3.4%) examined the impact of CDSSs/KMSs on implementation in practice. This set of studies included 0 good-quality, 3 fair-quality, and 2 poor-quality studies There is insufficient evidence for how CDSSs/KMSs impacted implementation in practice, and no high-quality studies specifically examined this outcome.

Table 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
<i>Relationship-centered outcomes</i>		
Patient satisfaction	Insufficient	<ul style="list-style-type: none"> 6 studies (4.1%) examined the impact of CDSSs/KMSs on patient satisfaction. This set of studies included 4 good-quality, 1 fair-quality, and 1 poor-quality studies. Although the majority of the studies were high quality and most reported that intervention patients were more satisfied with the care received or overall visit, it was difficult to assess the overall level of the evidence since each study used different metrics to evaluate patient satisfaction. There is limited evidence that clinician use of CDSSs had a positive effect on patient satisfaction.
KQ 4: What generalizable knowledge can be integrated into electronic knowledge management and CDSSs to improve health care quality?		
4a. Knowledge from published evidence about electronic knowledge management and CDSSs to improve health care quality based on different types of measures (health care process, relationship-centered, clinical, economic)	Not applicable	<ul style="list-style-type: none"> The most common source of knowledge incorporated into CDSSs/KMSs was derived from structured care protocols (61 studies, 41.2%) and clinical practice guidelines (42 studies, 28.4%) that focused on a single or limited set of medical conditions. <p>This set of studies included 56 good-quality, 33 fair-quality, and 15 poor-quality studies.</p>
4b. How a clinician's expertise/proficiency/informatics competency using the electronic knowledge management and CDSS affects patient outcomes (one type of measure)	Not applicable	<ul style="list-style-type: none"> 53 studies (35.8%) reported data on clinician expertise in using CDSSs/KMSs although the definition and reporting of this expertise was variable and the relationship between this expertise and patient outcomes was sparse. Clinician expertise was not reported in 59 of the included studies (39.9%). In 36 studies (24.3%), CDSS/KMS recommendations were delivered using a paper-based format, so clinician expertise in using the CDSS/KMS was not relevant.

Future Research

In the previous chapter, we identified several areas in which rigorous evidence related to CDSSs /KMSs was lacking. In this chapter we propose activities through which these identified gaps could be filled by future research studies that investigate issues related to CDSS/KMS breadth of content, content delivery, decision support recipients, outcomes, and implementation. First, in the area of content, CDSSs/KMSs need to mature to the next generation, in which the breadth of comorbid conditions for a given patient are routinely addressed. Such studies will need to explore how advice about multiple care issues and disparate CDSSs/KMSs can be reconciled and how recommendations should be prioritized to avoid alert fatigue. Additionally, further investigation is needed to better understand (1) how local adoption of general knowledge into CDSSs/KMSs affects outcomes and provider acceptance, (2) whether specific types of general knowledge are better suited for implementation in CDSSs/KMSs, and (3) how differences in types of general knowledge contained in locally developed and commercially developed CDSSs/KMSs improve health care quality.

Along related lines of inquiry, studies are also needed to determine how CDSS/KMS content can be delivered most effectively for each CDSS/KMS niche. Such studies can determine if interruptive (pop-up alerts and reminders) or noninterruptive (order sets, smart forms, dashboards) are preferable; or how users should interact with the content from a specific type of CDSS (push versus pull, mandatory versus voluntary versus no user response, explanation versus no explanation for noncompliance, etc.).

Future studies will also need to explore who the optimal recipients of clinical decision support advice should be. With the growth of team-based care delivery models, studies are needed to ascertain who on the team, other than physicians, should receive which type of advice, how the delivery of advice can be orchestrated to facilitate team-based care coordination, and how the delivery of advice can be best integrated into team-based care.

More studies are needed to demonstrate how CDSSs/KMSs impact hard clinical outcomes to make real differences in health and wellness and not just improve health care process measures. Additionally, the costs of CDSSs/KMSs need to be investigated, and the economic attractiveness of clinical decision support needs to be determined. The case needs to be made for CDSS/KMS cost-effectiveness and subsequent return on investment in order to promote and expand CDSS/KMS utilization. Future studies also need to explore the unintended consequences of clinical decision support, particularly as multiple comorbid conditions are included and recommendations are delivered to multiple members of a care delivery team. As outcomes are measured with disparate CDSSs/KMSs in diverse environments, the need to standardize metrics and models for workload, efficiency, costs, health care process measures, and clinical outcomes across systems must be addressed. Research is needed to determine what metrics best assess the effectiveness of clinical decision support and how these metrics can be standardized. Standardization of these outcomes and metrics will also facilitate the evaluation of CDSSs/KMSs.

Finally, in the area of future investigation, studies evaluating the impact of KMSs are needed across the board. The KMS field is in its infancy, and such studies need to demonstrate when and how knowledge retrieval systems and point-of-care knowledge references are effective and

useful. For both CDSSs and KMSs, additional research is needed to determine the best study designs to evaluate the effectiveness of these interventions.

With regard to promoting extensive use of clinical decision support, the following important needs must be addressed. First, there is a need for consistent underlying frameworks for describing CDSSs/KMSs such as the “CDS Five Rights”¹⁸⁹ to aid in the aggregation and synthesis of results. Second, models for porting CDSSs/KMSs across settings will need to be developed and evaluated. Studies will need to validate the concept of CDSS knowledge sharing across applications and institutions as proposed in recent position papers.^{190,191} Can centralized knowledge repositories be effective in meeting the clinical decision support needs for region or the nation as a whole? At the level of individual systems, it will be useful to identify which CDSS/KMS features genuinely make a difference in effectiveness and user satisfaction. Third, from the analysis conducted through this report, we have identified a cluster of features associated with a favorable impact of a CDSS/KMS; however, the many features are interrelated, and the available studies do not allow us to isolate individual features or even feature groups. As CDSSs/KMSs become more ubiquitous, studies can be performed that assess them with and without selected features in order to determine with greater clarity the relative importance of individual features.

Fourth, in addition to the features of the CDSS/KMS itself, characteristics of the environment and workflow into which a CDSS/KMS is deployed, and characteristics of the intended users, needed to be identified and investigated so that the impact of these characteristics on the success of the CDSS/KMS can be determined. Fifth, well-described RCTs are most needed to investigate the impact of those characteristics; however, exploration into the strengths and limitations of the evidence provided by quasi-experimental and observational studies is also warranted. Once the system, environmental, workflow, and user characteristics are delineated with regard to their influence on CDSS/KMS effectiveness, the system, environment, workflow, and users can be proactively adapted to optimize CDSS/KMS integration. Lastly, as CDSSs/KMSs continue to play a critical role in health care reform, future research is needed to understand (1) how CDSSs/KMSs can aid in the transformation of care delivery models such as accountable care organizations and patient-centered medical homes, (2) how to integrate CDSSs/KMSs with workflow tools such as medical registries and provider-provider messaging capabilities, and (3) how to integrate CDSSs/KMSs with workflow-oriented quality improvement programs.

References

1. Medicare and Medicaid programs; electronic health record incentive program. Final rule. Fed Regist 2010;75(144):44313-588.
2. Eichner J, Das M. Challenges and Barriers to Clinical Decision Support (CDS) Design and Implementation Experienced in the Agency for Healthcare Research and Quality CDS Demonstrations. Prepared for: Agency for Healthcare Research and Quality. Contract Number: 290-04-0016. AHRQ Publication No. 10-0064-EF. March 2010.
3. Chaudhry B, Wang J, Wu SY, et al. Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med 2006;144(10):742-752.
4. Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. BMJ 2002;325(7370):941.
5. Garg AX, Adhikari NK, McDonald H, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. JAMA 2005;293(10):1223-38.
6. Sim I, Gorman P, Greenes RA, et al. Clinical decision support systems for the practice of evidence-based medicine. J Am Med Inform Assoc 2001;8(6):527-34.
7. Bates DW, Evans RS, Murff H, et al. Detecting adverse events using information technology. J Am Med Inform Assoc 2003;10(2):115-28.
8. Bates DW, Gawande AA, Bates DW, et al. Improving safety with information technology. N Engl J Med 2003;348(25):2526-34.
9. Kawamoto K, Houlihan CA, Balas EA, et al. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. BMJ 2005;330(7494):765.
10. Bryan C, Boren SA. The use and effectiveness of electronic clinical decision support tools in the ambulatory/primary care setting: a systematic review of the literature. Inform Prim Care 2008;16(2):79-91.
11. Grimshaw J, Freemantle N, Wallace S, et al. Developing and implementing clinical practice guidelines. Qual Health Care 1995;4(1):55-64.
12. Hunt DL, Haynes RB, Hanna SE, et al. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. JAMA 1998;280(15):1339-46.
13. Sintchenko V, Magrabi F, Tipper S. Are we measuring the right end-points? Variables that affect the impact of computerised decision support on patient outcomes: a systematic review. Med Inform Internet Med 2007;32(3):225-40.
14. Shojania KG, Jennings A, Mayhew A, et al. Effect of point-of-care computer reminders on physician behaviour: a systematic review. Can Med Assoc J 2010;182(5):E216-E225.
15. Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. Arch Intern Med 2003;163(12):1409-16.
16. Agency for Healthcare Research and Quality. Methods Guide for Effectiveness and Comparative Effectiveness Reviews. Rockville, MD: Agency for Healthcare Research and Quality. Available at: <http://www.effectivehealthcare.ahrq.gov/index.cfm/search-for-guides-reviews-and-reports/?pageaction=displayproduct&productid=318>. Accessed September 20, 2010.
17. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7(3):177-188.
18. Aronsky D, Chan KJ, Haug PJ. Evaluation of a computerized diagnostic decision support system for patients with pneumonia: study design considerations. J Am Med Inform Assoc 2001;8(5):473-85.

19. Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly* 1989;13(3):319-340.
20. Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107(22):2799-804.
21. Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352(10):969-77.
22. McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Ann Intern Med* 1984;100(1):130-8.
23. Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58(6):1238-45.
24. Roumie CL, Elasy TA, Greevy R, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. *Ann Intern Med* 2006;145(3):165-75.
25. Terrell KM, Perkins AJ, Dexter PR, et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57(8):1388-94.
26. Khan S, Maclean CD, Littenberg B. The effect of the Vermont Diabetes Information System on inpatient and emergency room use: results from a randomized trial. *Health Outcomes Res Med* 2010;1(1):e61-e66.
27. Maclean CD, Gagnon M, Callas P, et al. The vermont diabetes information system: a cluster randomized trial of a population based decision support system. *J Gen Intern Med* 2009;24(12):1303-10.
28. Kleinbaum D, Kupper L, Morgenstern H. *Epidemiologic Research*. Belmont, CA: Lifetime Learning Publications; 1982.
29. Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4(5):364-75.
30. McGregor JC, Weekes E, Forrest GN, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(4):378-84.
31. Roukema J, Steyerberg EW, van der Lei J, et al. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. *J Am Med Inform Assoc* 2008;15(1):107-13.
32. McCowan C, Neville RG, Ricketts IW, et al. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26(3):191-201.
33. Cavalcanti AB, Silva E, Pereira AJ, et al. A randomized controlled trial comparing a computer-assisted insulin infusion protocol with a strict and a conventional protocol for glucose control in critically ill patients. *J Crit Care* 2009;24(3):371-8.
34. Kline JA, Zeitouni RA, Hernandez-Nino J, et al. Randomized trial of computerized quantitative pretest probability in low-risk chest pain patients: effect on safety and resource use. *Ann Emerg Med* 2009;53(6):727-35 e1.
35. Zanetti G, Flanagan HL, Jr., Cohn LH, et al. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24(1):13-6.
36. Graumlich JF, Novotny NL, Nace GS, et al. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2009;4(6):356-63.
37. Graumlich JF, Novotny NL, Nace GS, et al. Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial. *J Hosp Med* 2009;4(7):E11-9.

38. Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115(22):2829-34.
39. Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40(2):477-97.
40. Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18(12):967-76.
41. Gilutz H, Novack L, Shvartzman P, et al. Computerized community cholesterol control (4C): meeting the challenge of secondary prevention. *Isr Med Assoc J* 2009;11(1):23-9.
42. Holt TA, Thorogood M, Griffiths F, et al. Protocol for the 'e-Nudge trial': a randomised controlled trial of electronic feedback to reduce the cardiovascular risk of individuals in general practice [ISRCTN64828380]. *Trials* 2006;7:11.
43. Holt TA, Thorogood M, Griffiths F, et al. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60(573):e137-43.
44. Kuperman GJ, Teich JM, Tanasijevic MJ, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6(6):512-22.
45. Fihn SD, McDonell MB, Vermes D, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. *National Consortium of Anticoagulation Clinics. J Gen Intern Med* 1994;9(3):131-9.
46. Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56(12):2225-33.
47. Apkon M, Mattera JA, Lin Z, et al. A randomized outpatient trial of a decision-support information technology tool. *Arch Intern Med* 2005;165(20):2388-94.
48. Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106(2):144-50.
49. Bell LM, Grundmeier R, Localio R, et al. Electronic Health Record-Based Decision Support to Improve Asthma Care: A Cluster-Randomized Trial. *Pediatrics* 2010;125(4):E770-E777.
50. Demakis JG, Beauchamp C, Cull WL, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. *JAMA* 2000;284(11):1411-6.
51. Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345(13):965-70.
52. Feldstein A, Elmer PJ, Smith DH, et al. Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. *J Am Geriatr Soc* 2006;54(3):450-7.
53. Field TS, Rochon P, Lee M, et al. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16(4):480-5.
54. Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26(5):1497-500.
55. Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33(1-2):87-90.
56. Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. *PLoS Med* 2006;3(6):e216.

57. Fretheim A, Oxman AD, Havelrud K, et al. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. *PLoS Med* 2006;3(6):e134.
58. Gill JM, Chen YX, Glutting JJ, et al. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12(5):221-6.
59. Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107(Pt 1):135-9.
60. Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med* 1993;8(6):311-7.
61. Mc Donald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med* 1976;84(2):162-7.
62. McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. *Med Care* 1989;27(3):297-305.
63. McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. *CMAJ* 1986;135(9):991-7.
64. Rood E, Bosman RJ, van der Spoel JJ, et al. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. *J Am Med Inform Assoc* 2005;12(2):172-80.
65. Raebel MA, Chester EA, Newsom EE, et al. Randomized trial to improve laboratory safety monitoring of ongoing drug therapy in ambulatory patients. *Pharmacotherapy* 2006;26(5):619-26.
66. Raebel MA, Lyons EE, Chester EA, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. *Arch Intern Med* 2005;165(20):2395-401.
67. Roy PM, Durieux P, Gillaizeau F, et al. A computerized handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151(10):677-86.
68. Sequist TD, Zaslavsky AM, Marshall R, et al. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169(4):364-71.
69. Schriefer SP, Landis SE, Turbow DJ, et al. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41(7):502-7.
70. Sundaram V, Lazzeroni LC, Douglass LR, et al. A randomized trial of computer-based reminders and audit and feedback to improve HIV screening in a primary care setting. *Int J STD AIDS* 2009;20(8):527-33.
71. Taylor V, Thompson B, Lessler D, et al. A clinic-based mammography intervention targeting inner-city women. *J Gen Intern Med* 1999;14(2):104-11.
72. Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169(6):549-56.
73. Tamblyn R, Reidel K, Huang A, et al. Increasing the Detection and Response to Adherence Problems with Cardiovascular Medication in Primary Care through Computerized Drug Management Systems: A Randomized Controlled Trial. *Med Decis Making* 2009.
74. van Wyk JT, van Wijk MA, Sturkenboom MC, et al. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117(3):371-8.
75. McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Comput* 1992;9(5):304-12.
76. Chambers CV, Balaban DJ, Carlson BL, et al. Microcomputer-generated reminders. Improving the compliance of primary care physicians with mammography screening guidelines. *J Fam Pract* 1989;29(3):273-80.

77. Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18(4):223-9.
78. Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37(7):445-50.
79. Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. *J Gen Intern Med* 1997;12(11):672-8.
80. Bourgeois FC, Linder J, Johnson SA, et al. Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clin Pediatr (Phila)* 2010;49(10):976-83.
81. Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126(2):239-46.
82. Strom BL, Schinnar R, Abera F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med* 2010;170(17):1578-83.
83. Terrell KM, Perkins AJ, Hui SL, et al. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56(6):623-9.
84. Burack RC, Gimotty PA, Simon M, et al. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. *Prev Med* 2003;36(5):547-54.
85. Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. *J Am Med Inform Assoc* 2000;7(2):196-203.
86. Cobos A, Vilaseca J, Asenjo C, et al. Cost effectiveness of a clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Disease Management & Health Outcomes* 2005;13(6):421-432.
87. Lee NJ, Chen ES, Currie LM, et al. The effect of a mobile clinical decision support system on the diagnosis of obesity and overweight in acute and primary care encounters. *ANS Adv Nurs Sci* 2009;32(3):211-21.
88. Linder JA, Rigotti NA, Schneider LI, et al. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169(8):781-7.
89. Price M. Can hand-held computers improve adherence to guidelines? A (Palm) Pilot study of family doctors in British Columbia. *Can Fam Physician* 2005;51:1506-7.
90. Vissers MC, Biert J, van der Linden CJ, et al. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. *Comput Methods Programs Biomed* 1996;49(2):177-84.
91. Vissers MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. *Comput Methods Programs Biomed* 1995;48(1-2):53-8.
92. Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med* 2009;169(7):678-86.
93. Burack RC, Gimotty PA, George J, et al. How reminders given to patients and physicians affected pap smear use in a health maintenance organization: results of a randomized controlled trial. *Cancer* 1998;82(12):2391-400.

94. Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA* 2004;292(19):2366-71.
95. McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *J Fam Pract* 1989;28(4):420-4.
96. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156(14):1551-6.
97. Unrod M, Smith M, Spring B, et al. Randomized controlled trial of a computer-based, tailored intervention to increase smoking cessation counseling by primary care physicians. *J Gen Intern Med* 2007;22(4):478-84.
98. Dykes PC, Carroll DL, Hurley A, et al. Fall Prevention in Acute Care Hospitals A Randomized Trial. *Jama-Journal of the American Medical Association* 2010;304(17):1912-1918.
99. Flottorp S, Oxman AD, Havelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325(7360):367.
100. Greiver M, Drummond N, White D, et al. Angina on the Palm: randomized controlled pilot trial of Palm PDA software for referrals for cardiac testing. *Can Fam Physician* 2005;51:382-3.
101. Lo HG, Matheny ME, Seger DL, et al. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16(1):66-71.
102. Palen TE, Raebel M, Lyons E, et al. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. *Am J Manag Care* 2006;12(7):389-95.
103. Wilson BJ, Torrance N, Mollison J, et al. Cluster randomized trial of a multifaceted primary care decision-support intervention for inherited breast cancer risk. *Fam Pract* 2006;23(5):537-44.
104. Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2(5):e25.
105. Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23(4):429-41.
106. Locatelli F, Covic A, Macdougall IC, et al. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22(5):662-74.
107. Montgomery AA, Fahey T, Peters TJ, et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000;320(7236):686-90.
108. Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24(3):324-37.
109. Raebel MA, Charles J, Dugan J, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. *J Am Geriatr Soc* 2007;55(7):977-85.
110. Smith SA, Shah ND, Bryant SC, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83(7):747-57.
111. Subramanian U, Fihn SD, Weinberger M, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. *Am J Med* 2004;116(6):375-84.

112. Weir CJ, Lees KR, MacWalter RS, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM* 2003;96(2):143-53.
113. Brier ME, Gaweda AE, Dailey A, et al. Randomized trial of model predictive control for improved anemia management. *Clin J Am Soc Nephrol* 2010;5(5):814-20.
114. Strom BL, Schinnar R, Bilker W, et al. Randomized clinical trial of a customized electronic alert requiring an affirmative response compared to a control group receiving a commercial passive CPOE alert: NSAID--warfarin co-prescribing as a test case. *J Am Med Inform Assoc* 2010;17(4):411-5.
115. Bosworth HB, Olsen MK, Dudley T, et al. Patient education and provider decision support to control blood pressure in primary care: a cluster randomized trial. *Am Heart J* 2009;157(3):450-6.
116. Bosworth HB, Olsen MK, Goldstein MK, et al. The veterans' study to improve the control of hypertension (V-STITCH): design and methodology. *Contemp Clin Trials* 2005;26(2):155-68.
117. Del Fiol G, Haug PJ, Cimino JJ, et al. Effectiveness of topic-specific infobuttons: a randomized controlled trial. *J Am Med Inform Assoc* 2008;15(6):752-9.
118. Emery J, Morris H, Goodchild R, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. *Br J Cancer* 2007;97(4):486-93.
119. Fortuna RJ, Zhang F, Ross-Degnan D, et al. Reducing the prescribing of heavily marketed medications: a randomized controlled trial. *J Gen Intern Med* 2009;24(8):897-903.
120. Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. *Scand J Prim Health Care* 1999;17(1):35-40.
121. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of hypertension in general practice. *Blood Press* 1998;7(5-6):270-6.
122. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. *Int J Technol Assess Health Care* 2000;16(1):210-27.
123. Hobbs FD, Delaney BC, Carson A, et al. A prospective controlled trial of computerized decision support for lipid management in primary care. *Fam Pract* 1996;13(2):133-7.
124. Maviglia SM, Yoon CS, Bates DW, et al. KnowledgeLink: impact of context-sensitive information retrieval on clinicians' information needs. *J Am Med Inform Assoc* 2006;13(1):67-73.
125. Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA* 2005;294(18):2305-14.
126. Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12(4):431-7.
127. Tamblyn R, Huang A, Taylor L, et al. A randomized trial of the effectiveness of on-demand versus computer-triggered drug decision support in primary care. *J Am Med Inform Assoc* 2008;15(4):430-8.
128. van Wijk MA, van der Lei J, Mosseveld M, et al. Assessment of decision support for blood test ordering in primary care: a randomized trial. *Ann Intern Med* 2001;134(4):274-81.
129. Cleveringa FG, Gorter KJ, van den Donk M, et al. Combined task delegation, computerized decision support, and feedback improve cardiovascular risk for type 2 diabetic patients: a cluster randomized trial in primary care. *Diabetes Care* 2008;31(12):2273-5.

130. Cleveringa FG, Welsing PM, van den Donk M, et al. Cost-effectiveness of the diabetes care protocol, a multifaceted computerized decision support diabetes management intervention that reduces cardiovascular risk. *Diabetes Care* 2010;33(2):258-63.
131. Hamilton E, Platt R, Gauthier R, et al. The effect of computer-assisted evaluation of labor on cesarean rates. *J Healthc Qual* 2004;26(1):37-44.
132. Thomas HV, Lewis G, Watson M, et al. Computerised patient-specific guidelines for management of common mental disorders in primary care: a randomised controlled trial. *Br J Gen Pract* 2004;54(508):832-7.
133. Burack RC, Gimotty PA. Promoting screening mammography in inner-city settings. The sustained effectiveness of computerized reminders in a randomized controlled trial. *Med Care* 1997;35(9):921-31.
134. Burack RC, Gimotty PA, George J, et al. Promoting screening mammography in inner-city settings: a randomized controlled trial of computerized reminders as a component of a program to facilitate mammography. *Med Care* 1994;32(6):609-24.
135. Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124(1):159-69.
136. Flanagan JR, Doebbeling BN, Dawson J, et al. Randomized study of online vaccine reminders in adult primary care. *Proc Amia Symp* 1999:755-9.
137. Fordham D, McPhee SJ, Bird JA, et al. The Cancer Prevention Reminder System. *MD Comput* 1990;7(5):289-95.
138. Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. *Proc Annu Symp Comput Appl Med Care* 1994:787-91.
139. McPhee SJ, Bird JA, Jenkins CN, et al. Promoting cancer screening. A randomized, controlled trial of three interventions. *Arch Intern Med* 1989;149(8):1866-72.
140. Ornstein SM, Garr DR, Jenkins RG, et al. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. *J Fam Pract* 1991;32(1):82-90.
141. Peterson KA, Radosevich DM, O'Connor PJ, et al. Improving Diabetes Care in Practice: findings from the TRANSLATE trial. *Diabetes Care* 2008;31(12):2238-43.
142. Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care* 1986;24(8):659-66.
143. Holbrook A, Thabane L, Keshavjee K, et al. Individualized electronic decision support and reminders to improve diabetes care in the community: COMPETE II randomized trial. *CMAJ* 2009;181(1-2):37-44.
144. Rosser WW, Hutchison BG, McDowell I, et al. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992;146(6):911-7.
145. Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. *CMAJ* 1991;145(7):807-14.
146. Reeve JF, Tenni PC, Peterson GM. An electronic prompt in dispensing software to promote clinical interventions by community pharmacists: a randomized controlled trial. *Br J Clin Pharmacol* 2008;65(3):377-85.
147. Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20(10):916-21.
148. Harpole LH, Khorasani R, Fiskio J, et al. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4(6):511-21.
149. Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15(4):424-9.

150. Palen TE, Price DW, Snyder AJ, et al. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16(11):e267-75.
151. Tierney WM, McDonald CJ, Martin DK, et al. Computerized display of past test results. Effect on outpatient testing. *Ann Intern Med* 1987;107(4):569-74.
152. Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332(7543):692-6.
153. Stiell IG, Clement CM, Grimshaw J, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.
154. Feldstein AC, Smith DH, Perrin N, et al. Improved therapeutic monitoring with several interventions: a randomized trial. *Arch Intern Med* 2006;166(17):1848-54.
155. Christakis DA, Zimmerman FJ, Wright JA, et al. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics* 2001;107(2):E15.
156. Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129(Pt 2):1037-40.
157. Phillips LS, Ziemer DC, Doyle JP, et al. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. *Diabetes Care* 2005;28(10):2352-60.
158. Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion (Paris)* 2007;47(2):228-39.
159. Shojania KG, Yokoe D, Platt R, et al. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5(6):554-62.
160. Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-968.
161. White KS, Lindsay A, Pryor TA, et al. Application of a computerized medical decision-making process to the problem of digoxin intoxication. *J Am Coll Cardiol* 1984;4(3):571-6.
162. Ziemer DC, Doyle JP, Barnes CS, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting: Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. *Arch Intern Med* 2006;166(5):507-13.
163. Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *Arch Intern Med* 2000;160(15):2343-8.
164. Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.
165. Manotti C, Moia M, Palareti G, et al. Effect of computer-aided management on the quality of treatment in anticoagulated patients: a prospective, randomized, multicenter trial of APROAT (Automated PProgram for Oral Anticoagulant Treatment). *Haematologica* 2001;86(10):1060-70.
166. Marco F, Sedano C, Bermudez A, et al. A prospective controlled study of a computer-assisted acenocoumarol dosage program. *Pathophysiol Haemost Thromb* 2003;33(2):59-63.
167. Martens JD, van der Aa A, Panis B, et al. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. *Stud Health Technol Inform* 2006;124:617-23.

168. Martens JD, van der Weijden T, Severens JL, et al. The effect of computer reminders on GPs' prescribing behaviour: a cluster-randomised trial. *Int J Med Inform* 2007;76 Suppl 3:S403-16.
169. Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997;314(7089):1252-6.
170. Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. *Clin Lab Haematol* 1997;19(3):203-7.
171. Alper BS, White DS, Ge B. Physicians answer more clinical questions and change clinical decisions more often with synthesized evidence: a randomized trial in primary care. *Ann Fam Med* 2005;3(6):507-13.
172. Etchells E, Adhikari NK, Cheung C, et al. Real-time clinical alerting: effect of an automated paging system on response time to critical laboratory values--a randomised controlled trial. *Qual Saf Health Care* 2010;19(2):99-102.
173. Bird JA, McPhee SJ, Jenkins C, et al. Three strategies to promote cancer screening. How feasible is wide-scale implementation? *Med Care* 1990;28(11):1005-12.
174. Frame PS, Zimmer JG, Werth PL, et al. Computer-based vs manual health maintenance tracking. A controlled trial. *Arch Fam Med* 1994;3(7):581-8.
175. Tierney WM, McDonald CJ, Hui SL, et al. Computer predictions of abnormal test results. Effects on outpatient testing. *JAMA* 1988;259(8):1194-8.
176. Smith DH, Feldstein AC, Perrin NA, et al. Improving laboratory monitoring of medications: an economic analysis alongside a clinical trial. *Am J Manag Care* 2009;15(5):281-9.
177. Judge J, Field TS, DeFlorio M, et al. Prescribers' responses to alerts during medication ordering in the long term care setting. *J Am Med Inform Assoc* 2006;13(4):385-90.
178. Rollman BL, Hanusa BH, Gilbert T, et al. The electronic medical record. A randomized trial of its impact on primary care physicians' initial management of major depression [corrected]. *Arch Intern Med* 2001;161(2):189-97.
179. McLaughlin D, Hayes JR, Kelleher K. Office-Based Interventions for Recognizing Abnormal Pediatric Blood Pressures. *Clin Pediatr (Phila)* 2010;49(4):355-362.
180. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, D.C.: National Academy Press; 2001.
181. Balas EA, SA B. Managing Clinical Knowledge for Health Care Improvement. *Yearbook of Medical Informatics 2000: Patient-centered Systems 2000*:65-70.
182. Haynes B. Of studies, syntheses, synopses, summaries, and systems: the "5S" evolution of information services for evidence-based healthcare decisions. *Evid Based Nurs* 2007;10(1):6-7.
183. Dicenso A, Bayley L, Haynes RB. Accessing pre-appraised evidence: fine-tuning the 5S model into a 6S model. *Evid Based Nurs* 2009;12(4):99-101.
184. Stetler CB. Role of the organization in translating research into evidence-based practice. *Outcomes Manag* 2003;7(3):97-103; quiz 104-5.
185. Stetler CB, Corrigan B, Sander-Buscemi K, et al. Integration of evidence into practice and the change process: fall prevention program as a model. *Outcomes Manag Nurs Pract* 1999;3(3):102-11.
186. McCormack B, Kitson A, Harvey G, et al. Getting evidence into practice: the meaning of 'context'. *J Adv Nurs* 2002;38(1):94-104.
187. Kaplan B. Evaluating informatics applications--some alternative approaches: theory, social interactionism, and call for methodological pluralism. *Int J Med Inform* 2001;64(1):39-56.

188. Carayon P, Karsh B-T, Cartmill RS. Incorporating Health Information Technology Into Workflow Redesign-- Summary Report. (Prepared by the Center for Quality and Productivity Improvement, University of Wisconsin--Madison, under Contract No. HHSA 290-2008-10036C). AHRQ Publication No. 10-0098-EF. Rockville, MD: Agency for Healthcare Research and Quality. October 2010.
189. Osheroff JA, Healthcare Information and Management Systems Society. *Improving outcomes with clinical decision support : an implementer's guide*. 2nd ed Chicago, IL: HIMSS; 2005.
190. Kawamoto K, Lobach DF. Proposal for fulfilling strategic objectives of the U.S. Roadmap for national action on clinical decision support through a service-oriented architecture leveraging HL7 services. *J Am Med Inform Assoc* 2007;14(2):146-55.
191. Sittig DF, Wright A, Osheroff JA, et al. Grand challenges in clinical decision support. *J Biomed Inform* 2008;41(2):387-92.

Abbreviations

AHRQ	Agency for Healthcare Research and Quality
CDSS	clinical decision support system
CHF	congestive heart failure
CI	confidence interval
COPD	chronic obstructive pulmonary disease
CPOE	computerized physician/provider order entry
DVT	deep vein thrombosis
EHR	electronic health record
HIV	human immunodeficiency virus
HRQOL	health-related quality of life
ICU	intensive care unit
KMS	knowledge management system
mg/dL	milligrams per deciliter
ml	milliliter or milliliters
N or n	number
NA	not applicable
NR	not reported
OR	odds ratio
p	probability
PE	pulmonary embolism
RCT	randomized controlled trial
RR	risk ratio
SD	standard deviation
SE	standard error
VA	Veterans Affairs

Appendix A: List of Included Studies in Alphabetical Order

Adams ID, Chan M, Clifford PC, et al. Computer aided diagnosis of acute abdominal pain: a multicentre study. *Br Med J (Clin Res Ed)* 1986;293(6550):800-4.

Agostini JV, Zhang Y, Inouye SK. Use of a computer-based reminder to improve sedative-hypnotic prescribing in older hospitalized patients. *J Am Geriatr Soc* 2007;55(1):43-8.

Alper BS, White DS, Ge B. Physicians answer more clinical questions and change clinical decisions more often with synthesized evidence: a randomized trial in primary care. *Ann Fam Med* 2005;3(6):507-13.

Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107(22):2799-804.

Anton C, Nightingale PG, Adu D, et al. Improving prescribing using a rule based prescribing system. *Qual Saf Health Care* 2004;13(3):186-90.

Apkon M, Mattera JA, Lin Z, et al. A randomized outpatient trial of a decision-support information technology tool. *Arch Intern Med* 2005;165(20):2388-94.

Bansal P, Aronsky D, Talbert D, et al. A computer based intervention on the appropriate use of arterial blood gas. *Proc Amia Symp* 2001:32-6.

Baroletti S, Munz K, Sonis J, et al. Electronic alerts for hospitalized high-VTE risk patients not receiving prophylaxis: a cohort study. *J Thromb Thrombolysis* 2008;25(2):146-50.

Bassa A, del Val M, Cobos A, et al. Impact of a clinical decision support system on the management of patients with hypercholesterolemia in the primary healthcare setting. *Disease Management & Health Outcomes* 2005;13(1):65-72.

Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106(2):144-50.

Bell LM, Grundmeier R, Localio R, et al. Electronic Health Record-Based Decision Support to Improve Asthma Care: A Cluster-Randomized Trial. *Pediatrics* 2010;125(4):E770-E777.

Bernstein SL, Whitaker D, Winograd J, et al. An electronic chart prompt to decrease proprietary antibiotic prescription to self-pay patients. *Acad Emerg Med* 2005;12(3):225-31.

Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med* 2009;169(7):678-86.

Bertsche T, Askoxylakis V, Hahl G, et al. Multidisciplinary pain management based on a computerized clinical decision support system in cancer pain patients. *Pain* 2009;147(1-3):20-28.

Bertsche T, Pfaff J, Schiller P, et al. Prevention of adverse drug reactions in intensive care patients by personal intervention based on an electronic clinical decision support system. *Intensive Care Med* 2010;36(4):665-672.

Bertsche T, Pfaff J, Schiller P, et al. Prevention of adverse drug reactions in intensive care patients by personal intervention based on an electronic clinical decision support system. *Intensive Care Med* 2010;36(4):665-72.

Bird JA, McPhee SJ, Jenkins C, et al. Three strategies to promote cancer screening. How feasible is wide-scale implementation? *Med Care* 1990;28(11):1005-12.

Blackmore CC, Robert SM, Gary SK. Effectiveness of Clinical Decision Support in Controlling Inappropriate Imaging. *Journal of the American College of Radiology : JACR* 2011;8(1):19-25.

Bogucki B, Jacobs BR, Hingle J. Computerized reminders reduce the use of medications during shortages. *J Am Med Inform Assoc* 2004;11(4):278-80.

- Bosworth HB, Olsen MK, Dudley T, et al. Patient education and provider decision support to control blood pressure in primary care: a cluster randomized trial. *Am Heart J* 2009;157(3):450-6.
- Bosworth HB, Olsen MK, Goldstein MK, et al. The veterans' study to improve the control of hypertension (V-STITCH): design and methodology. *Contemp Clin Trials* 2005;26(2):155-68.
- Bouaud J, Seroussi B, Antoine EC, et al. A before-after study using OncoDoc, a guideline-based decision support-system on breast cancer management: impact upon physician prescribing behaviour. *Stud Health Technol Inform* 2001;84(Pt 1):420-4.
- Bourgeois FC, Linder J, Johnson SA, et al. Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clin Pediatr (Phila)* 2010;49(10):976-83.
- Brier ME, Gaweda AE, Dailey A, et al. Randomized trial of model predictive control for improved anemia management. *Clin J Am Soc Nephrol* 2010;5(5):814-20.
- Buising KL, Thursky KA, Black JF, et al. Improving antibiotic prescribing for adults with community acquired pneumonia: Does a computerised decision support system achieve more than academic detailing alone?--A time series analysis. *BMC Med Inform Decis Mak* 2008;8:35.
- Buller-Close K, Schrager DL, Baraff LJ. Heterogeneous effect of an Emergency Department Expert Charting System. *Ann Emerg Med* 2003;41(5):644-52.
- Burack RC, Gimotty PA. Promoting screening mammography in inner-city settings. The sustained effectiveness of computerized reminders in a randomized controlled trial. *Med Care* 1997;35(9):921-31.
- Burack RC, Gimotty PA, George J, et al. How reminders given to patients and physicians affected pap smear use in a health maintenance organization: results of a randomized controlled trial. *Cancer* 1998;82(12):2391-400.
- Burack RC, Gimotty PA, George J, et al. Promoting screening mammography in inner-city settings: a randomized controlled trial of computerized reminders as a component of a program to facilitate mammography. *Med Care* 1994;32(6):609-24.
- Burack RC, Gimotty PA, Simon M, et al. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. *Prev Med* 2003;36(5):547-54.
- Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. *J Am Med Inform Assoc* 2000;7(2):196-203.
- Carton M, Auvert B, Guerini H, et al. Assessment of radiological referral practice and effect of computer-based guidelines on radiological requests in two emergency departments. *Clin Radiol* 2002;57(2):123-8.
- Cavalcanti AB, Silva E, Pereira AJ, et al. A randomized controlled trial comparing a computer-assisted insulin infusion protocol with a strict and a conventional protocol for glucose control in critically ill patients. *J Crit Care* 2009;24(3):371-8.
- Chambers CV, Balaban DJ, Carlson BL, et al. Microcomputer-generated reminders. Improving the compliance of primary care physicians with mammography screening guidelines. *J Fam Pract* 1989;29(3):273-80.
- Chen P, Tanasijevic MJ, Schoenenberger RA, et al. A computer-based intervention for improving the appropriateness of antiepileptic drug level monitoring. *Am J Clin Pathol* 2003;119(3):432-8.
- Cho S, Jeong J, Park H, et al. Effectiveness of A Computer-Assisted Asthma Management Program on Physician Adherence to Guidelines. *J Asthma* 2010;4-8.
- Christakis DA, Zimmerman FJ, Wright JA, et al. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics* 2001;107(2):E15.
- Cleveringa FG, Gorter KJ, van den Donk M, et al. Task delegation and computerized decision support reduce coronary heart disease risk factors in type 2 diabetes patients in primary care. *Diabetes Technol Ther* 2007;9(5):473-81.
- Cleveringa FG, Gorter KJ, van den Donk M, et al. Combined task delegation, computerized decision support, and feedback improve cardiovascular risk for type 2 diabetic patients: a cluster randomized trial in primary care. *Diabetes Care* 2008;31(12):2273-5.

Cleveringa FG, Welsing PM, van den Donk M, et al. Cost-effectiveness of the diabetes care protocol, a multifaceted computerized decision support diabetes management intervention that reduces cardiovascular risk. *Diabetes Care* 2010;33(2):258-63.

Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126(2):239-46.

Cobos A, Vilaseca J, Asenjo C, et al. Cost effectiveness of a clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Disease Management & Health Outcomes* 2005;13(6):421-432.

Cote GA, Rice JP, Bulsiewicz W, et al. Use of physician education and computer alert to improve targeted use of gastroprotection among NSAID users. *Am J Gastroenterol* 2008;103(5):1097-103.

Coyle CM, Currie BP. Improving the rates of inpatient pneumococcal vaccination: impact of standing orders versus computerized reminders to physicians. *Infect Control Hosp Epidemiol* 2004;25(11):904-7.

Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2(5):e25.

Day F, Hoang LP, Ouk S, et al. The impact of a guideline-driven computer charting system on the emergency care of patients with acute low back pain. *Proc Annu Symp Comput Appl Med Care* 1995:576-80.

de Dombal FT, Dallos V, McAdam WA. Can computer aided teaching packages improve clinical care in patients with acute abdominal pain? *BMJ* 1991;302(6791):1495-7.

de Jong JD, Groenewegen PP, Spreeuwenberg P, et al. Do decision support systems influence variation in prescription? *BMC Health Serv Res* 2009;9:20.

DeJesus R, Angstman K, Rebecca Kesman M, et al. Use of a clinical decision support system to increase osteoporosis screeningjep_1528. 2010.

Del Fiol G, Haug PJ, Cimino JJ, et al. Effectiveness of topic-specific infobuttons: a randomized controlled trial. *J Am Med Inform Assoc* 2008;15(6):752-9.

Demakis JG, Beauchamp C, Cull WL, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. *JAMA* 2000;284(11):1411-6.

Devine EB, Hansen RN, Wilson-Norton JL, et al. The impact of computerized provider order entry on medication errors in a multispecialty group practice. *J Am Med Inform Assoc* 2010;17(1):78-84.

Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345(13):965-70.

Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA* 2004;292(19):2366-71.

Dorr DA, Wilcox A, Donnelly SM, et al. Impact of generalist care managers on patients with diabetes. *Health Serv Res* 2005;40(5 Pt 1):1400-21.

Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332(7543):692-6.

Durieux P, Nizard R, Ravaud P, et al. A clinical decision support system for prevention of venous thromboembolism: effect on physician behavior. *JAMA* 2000;283(21):2816-21.

Dykes PC, Carroll DL, Hurley A, et al. Fall Prevention in Acute Care Hospitals A Randomized Trial. *Jama-Journal of the American Medical Association* 2010;304(17):1912-1918.

Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002;325(7370):941.

Emery J, Morris H, Goodchild R, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. *Br J Cancer* 2007;97(4):486-93.

- Eslami S, Abu-Hanna A, de Keizer NF, et al. Implementing glucose control in intensive care: a multicenter trial using statistical process control. *Intensive Care Med* 2010;36(9):1556-65.
- Etchells E, Adhikari NK, Cheung C, et al. Real-time clinical alerting: effect of an automated paging system on response time to critical laboratory values--a randomised controlled trial. *Qual Saf Health Care* 2010;19(2):99-102.
- Evans RS, Classen DC, Pestotnik SL, et al. Improving empiric antibiotic selection using computer decision support. *Arch Intern Med* 1994;154(8):878-84.
- Evans RS, Pestotnik SL, Classen DC, et al. Evaluation of a computer-assisted antibiotic-dose monitor. *Ann Pharmacother* 1999;33(10):1026-31.
- Evans RS, Pestotnik SL, Classen DC, et al. A computer-assisted management program for antibiotics and other anti-infective agents. *N Engl J Med* 1998;338(4):232-8.
- Evans RS, Pestotnik SL, Classen DC, et al. Preventing adverse drug events in hospitalized patients. *Ann Pharmacother* 1994;28(4):523-7.
- Feldstein A, Elmer PJ, Smith DH, et al. Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. *J Am Geriatr Soc* 2006;54(3):450-7.
- Feldstein AC, Perrin NA, Unitan R, et al. Effect of a Patient Panel-Support Tool on Care Delivery. *Am J Manag Care* 2010;16(10):E256-E266.
- Feldstein AC, Smith DH, Perrin N, et al. Improved therapeutic monitoring with several interventions: a randomized trial. *Arch Intern Med* 2006;166(17):1848-54.
- Feldstein AC, Smith DH, Perrin N, et al. Reducing warfarin medication interactions: an interrupted time series evaluation. *Arch Intern Med* 2006;166(9):1009-15.
- Field TS, Rochon P, Lee M, et al. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16(4):480-5.
- Fifield J, McQuillan J, Martin-Peele M, et al. Improving pediatric asthma control among minority children participating in medicaid: providing practice redesign support to deliver a chronic care model. *J Asthma* 2010;47(7):718-27.
- Fihn SD, McDonnell MB, Vermes D, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. *J Gen Intern Med* 1994;9(3):131-9.
- Fiks AG, Grundmeier RW, Biggs LM, et al. Impact of clinical alerts within an electronic health record on routine childhood immunization in an urban pediatric population. *Pediatrics* 2007;120(4):707-14.
- Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124(1):159-69.
- Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26(5):1497-500.
- Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *Arch Intern Med* 2000;160(15):2343-8.
- Fiumara K, Piovella C, Hurwitz S, et al. Multi-screen electronic alerts to augment venous thromboembolism prophylaxis. *Thromb Haemost* 2010;103(2):312-317.
- Flanagan JR, Doebbeling BN, Dawson J, et al. Randomized study of online vaccine reminders in adult primary care. *Proc Amia Symp* 1999:755-9.
- Flottorp S, Oxman AD, Havelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325(7360):367.
- Fonquernie L, Lacombe K, Vincensini JP, et al. How to improve the quality of a disease management program for HIV-infected patients using a computerized data system. The Saint-Antoine Orchestra program. *AIDS Care* 2010;22(5):588-596.

Fordham D, McPhee SJ, Bird JA, et al. The Cancer Prevention Reminder System. *MD Comput* 1990;7(5):289-95.

Fort A, Narsinghani U, Bowyer F. Evaluating the safety and efficacy of Glucommander, a computer-based insulin infusion method, in management of diabetic ketoacidosis in children, and comparing its clinical performance with manually titrated insulin infusion. *J Pediatr Endocrinol Metab* 2009;22(2):119-25.

Fortuna RJ, Zhang F, Ross-Degnan D, et al. Reducing the prescribing of heavily marketed medications: a randomized controlled trial. *J Gen Intern Med* 2009;24(8):897-903.

Fox CH, Swanson A, Kahn LS, et al. Improving chronic kidney disease care in primary care practices: an upstate New York practice-based research network (UNYNET) study. *J Am Board Fam Med* 2008;21(6):522-30.

Frame PS, Zimmer JG, Werth PL, et al. Computer-based vs manual health maintenance tracking. A controlled trial. *Arch Fam Med* 1994;3(7):581-8.

Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33(1-2):87-90.

Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. *PLoS Med* 2006;3(6):e216.

Fretheim A, Oxman AD, Havelsrud K, et al. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. *PLoS Med* 2006;3(6):e134.

Galanter WL, Didomenico RJ, Polikaitis A. A trial of automated decision support alerts for contraindicated medications using computerized physician order entry. *J Am Med Inform Assoc* 2005;12(3):269-74.

Galanter WL, Polikaitis A, DiDomenico RJ. A trial of automated safety alerts for inpatient digoxin use with computerized physician order entry. *J Am Med Inform Assoc* 2004;11(4):270-7.

Gerard MN, Tick WE, Das K, et al. Use of Clinical Decision Support to Increase Influenza Vaccination: Multi-year Evolution of the System. *J Am Med Inform Assoc* 2008;15(6):776-779.

Gill JM, Chen YX, Glutting JJ, et al. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12(5):221-6.

Gill JM, Ewen E, Nsereko M. Impact of an electronic medical record on quality of care in a primary care office. *Del Med J* 2001;73(5):187-94.

Gilutz H, Novack L, Shvartzman P, et al. Computerized community cholesterol control (4C): meeting the challenge of secondary prevention. *Isr Med Assoc J* 2009;11(1):23-9.

Goergen SK, Fong C, Dalziel K, et al. Can an evidence-based guideline reduce unnecessary imaging of road trauma patients with cervical spine injury in the emergency department? *Australas Radiol* 2006;50(6):563-9.

Goethe JW, Schwartz HI, Szarek BL. Physician compliance with practice guidelines. *Conn Med* 1997;61(9):553-8.

Goldberg HI, Neighbor WE, Cheadle AD, et al. A controlled time-series trial of clinical reminders: using computerized firm systems to make quality improvement research a routine part of mainstream practice. *Health Serv Res* 2000;34(7):1519-34.

Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.

Gouin-Thibault I, Levy C, Pautas E, et al. Improving anticoagulation control in hospitalized elderly patients on warfarin. *J Am Geriatr Soc* 2010;58(2):242-7.

Graumlich JF, Novotny NL, Nace GS, et al. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2009;4(6):356-63.

Graumlich JF, Novotny NL, Nace GS, et al. Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial. *J Hosp Med* 2009;4(7):E11-9.

Greiver M, Drummond N, White D, et al. Angina on the Palm: randomized controlled pilot trial of Palm PDA software for referrals for cardiac testing. *Can Fam Physician* 2005;51:382-3.

- Griffey RT, Wittels K, Gilboy N, et al. Use of a computerized forcing function improves performance in ordering restraints. *Ann Emerg Med* 2009;53(4):469-76.
- Guerra YS, Das K, Antonopoulos P, et al. Computerized physician order entry- based hyperglycemia inpatient protocol and glycemic outcomes: The CPOE-HIP study. *Endocr Pract* 2010;16(3):389-97.
- Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56(12):2225-33.
- Halkin H, Katzir I, Kurman I, et al. Preventing drug interactions by online prescription screening in community pharmacies and medical practices. *Clin Pharmacol Ther* 2001;69(4):260-5.
- Hamilton E, Platt R, Gauthier R, et al. The effect of computer-assisted evaluation of labor on cesarean rates. *J Healthc Qual* 2004;26(1):37-44.
- Harpole LH, Khorasani R, Fiskio J, et al. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4(6):511-21.
- Harris RP, O'Malley MS, Fletcher SW, et al. Prompting physicians for preventive procedures: a five-year study of manual and computer reminders. *Am J Prev Med* 1990;6(3):145-52.
- Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115(22):2829-34.
- Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. *Scand J Prim Health Care* 1999;17(1):35-40.
- Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of hypertension in general practice. *Blood Press* 1998;7(5-6):270-6.
- Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. *Int J Technol Assess Health Care* 2000;16(1):210-27.
- Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23(4):429-41.
- Hobbs FD, Delaney BC, Carson A, et al. A prospective controlled trial of computerized decision support for lipid management in primary care. *Fam Pract* 1996;13(2):133-7.
- Hoch I, Heymann AD, Kurman I, et al. Countrywide computer alerts to community physicians improve potassium testing in patients receiving diuretics. *J Am Med Inform Assoc* 2003;10(6):541-6.
- Hoekstra M, Vogelzang M, Drost JT, et al. Implementation and evaluation of a nurse-centered computerized potassium regulation protocol in the intensive care unit--a before and after analysis. *BMC Med Inform Decis Mak* 2010;10:5.
- Hoekstra M, Vogelzang M, Drost JT, et al. Implementation and evaluation of a nurse-centered computerized potassium regulation protocol in the intensive care unit - a before and after analysis. *Bmc Medical Informatics and Decision Making* 2010;10.
- Holbrook A, Thabane L, Keshavjee K, et al. Individualized electronic decision support and reminders to improve diabetes care in the community: COMPETE II randomized trial. *CMAJ* 2009;181(1-2):37-44.
- Holdsworth MT, Fichtl RE, Raisch DW, et al. Impact of computerized prescriber order entry on the incidence of adverse drug events in pediatric inpatients. *Pediatrics* 2007;120(5):1058-66.
- Holt TA, Thorogood M, Griffiths F, et al. Protocol for the 'e-Nudge trial': a randomised controlled trial of electronic feedback to reduce the cardiovascular risk of individuals in general practice [ISRCTN64828380]. *Trials* 2006;7:11.

Holt TA, Thorogood M, Griffiths F, et al. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60(573):e137-43.

Hoogendam A, Stalenhoef AF, Robbe PF, et al. Answers to questions posed during daily patient care are more likely to be answered by UpToDate than PubMed. *J Med Internet Res* 2008;10(4):e29.

Hulgan T, Rosenbloom ST, Hargrove F, et al. Oral quinolones in hospitalized patients: an evaluation of a computerized decision support intervention. *J Intern Med* 2004;256(4):349-57.

Hutchison BG. Effect of computer-generated nurse/physician reminders on influenza immunization among seniors. *Fam Med* 1989;21(6):433-7.

Hwang HG, Chang IC, Hung WF, et al. The design and evaluation of clinical decision support systems in the area of pharmacokinetics. *Med Inform Internet Med* 2004;29(3-4):239-51.

Janssen B, Ludwig S, Eustermann H, et al. Improving outpatient treatment in schizophrenia: Effects of computerized guideline implementation—Results of a multicenter-study within the German Research Network on Schizophrenia. *Eur Arch Psychiatry Clin Neurosci* 2010;260(1):51-57.

Jellinek SP, Cohen V, Likourezos A, et al. Analyzing a health-system's use of unfractionated heparin to ensure optimal anticoagulation. *J Pharm Technol* 2005;21(2):69-78.

Judge J, Field TS, DeFlorio M, et al. Prescribers' responses to alerts during medication ordering in the long term care setting. *J Am Med Inform Assoc* 2006;13(4):385-90.

Kac G, Grohs P, Durieux P, et al. Impact of electronic alerts on isolation precautions for patients with multidrug-resistant bacteria. *Arch Intern Med* 2007;167(19):2086-2090.

Kaushal R, Kern LM, Barron Y, et al. Electronic prescribing improves medication safety in community-based office practices. *J Gen Intern Med* 2010;25(6):530-6.

Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20(10):916-21.

Khan S, Maclean CD, Littenberg B. The effect of the Vermont Diabetes Information System on inpatient and emergency room use: results from a randomized trial. *Health Outcomes Res Med* 2010;1(1):e61-e66.

Kho A, Dexter P, Warvel J, et al. Computerized reminders to improve isolation rates of patients with drug-resistant infections: design and preliminary results. *AMIA Annu Symp Proc* 2005:390-4.

Khoury AT, Wan GJ, Niedermaier ON, et al. Improved cholesterol management in coronary heart disease patients enrolled in an HMO. *J Healthc Qual* 2001;23(2):29-33.

Kirk RC, Li-Meng Goh D, Packia J, et al. Computer calculated dose in paediatric prescribing. *Drug Saf* 2005;28(9):817-24.

Kitahata MM, Dillingham PW, Chaiyakunapruk N, et al. Electronic human immunodeficiency virus (HIV) clinical reminder system improves adherence to practice guidelines among the University of Washington HIV Study Cohort. *Clin Infect Dis* 2003;36(6):803-11.

Kline JA, Zeitouni RA, Hernandez-Nino J, et al. Randomized trial of computerized quantitative pretest probability in low-risk chest pain patients: effect on safety and resource use. *Ann Emerg Med* 2009;53(6):727-35 e1.

Kofoed K, Zalounina A, Andersen O, et al. Performance of the TREAT decision support system in an environment with a low prevalence of resistant pathogens. *J Antimicrob Chemother* 2009;63(2):400-4.

Kooij FO, Klok T, Hollmann MW, et al. Decision support increases guideline adherence for prescribing postoperative nausea and vomiting prophylaxis. *Anesth Analg* 2008;106(3):893-8, table of contents.

Kralj B, Iverson D, Hotz K, et al. The impact of computerized clinical reminders on physician prescribing behavior: evidence from community oncology practice. *Am J Med Qual* 2003;18(5):197-203.

Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107(Pt 1):135-9.

- Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352(10):969-77.
- Kuperman GJ, Teich JM, Tanasijevic MJ, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6(6):512-22.
- Kurian BT, Trivedi MH, Grannemann BD, et al. A computerized decision support system for depression in primary care. *Prim Care Companion J Clin Psychiatry* 2009;11(4):140-6.
- Kwok R, Dinh M, Dinh D, et al. Improving adherence to asthma clinical guidelines and discharge documentation from emergency departments: implementation of a dynamic and integrated electronic decision support system. *Emerg Med Australas* 2009;21(1):31-7.
- Larsen RA, Evans RS, Burke JP, et al. Improved perioperative antibiotic use and reduced surgical wound infections through use of computer decision analysis. *Infect Control Hosp Epidemiol* 1989;10(7):316-20.
- Larson MF, Ko CW, Dominitz JA. Effectiveness of a provider reminder on fecal occult blood test follow-up. *Dig Dis Sci* 2009;54(9):1991-6.
- Lecumberri R, Marques M, Diaz-Navarraz MT, et al. Maintained effectiveness of an electronic alert system to prevent venous thromboembolism among hospitalized patients. *Thromb Haemost* 2008;100(4):699-704.
- Ledwich LJ, Harrington TM, Ayoub WT, et al. Improved influenza and pneumococcal vaccination in rheumatology patients taking immunosuppressants using an electronic health record best practice alert. *Arthritis Rheum* 2009;61(11):1505-10.
- Lee NJ, Chen ES, Currie LM, et al. The effect of a mobile clinical decision support system on the diagnosis of obesity and overweight in acute and primary care encounters. *ANS Adv Nurs Sci* 2009;32(3):211-21.
- Linder JA, Rigotti NA, Schneider LI, et al. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169(8):781-7.
- Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med* 1993;8(6):311-7.
- Liu SA, Chiu YT, Lin WD, et al. Using information technology to reduce the inappropriate use of surgical prophylactic antibiotic. *Eur Arch Otorhinolaryngol* 2008;265(9):1109-1112.
- Lo HG, Matheny ME, Seger DL, et al. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16(1):66-71.
- Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. *Proc Annu Symp Comput Appl Med Care* 1994:787-91.
- Locatelli F, Covic A, Macdougall IC, et al. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22(5):662-74.
- Maclean CD, Gagnon M, Callas P, et al. The vermont diabetes information system: a cluster randomized trial of a population based decision support system. *J Gen Intern Med* 2009;24(12):1303-10.
- Major K, Shabot MM, Cunneen S. Wireless clinical alerts and patient outcomes in the surgical intensive care unit. *Am Surg* 2002;68(12):1057-60.
- Manotti C, Moia M, Palareti G, et al. Effect of computer-aided management on the quality of treatment in anticoagulated patients: a prospective, randomized, multicenter trial of APROAT (Automated PProgram for Oral Anticoagulant Treatment). *Haematologica* 2001;86(10):1060-70.
- Marco F, Sedano C, Bermudez A, et al. A prospective controlled study of a computer-assisted acenocoumarol dosage program. *Pathophysiol Haemost Thromb* 2003;33(2):59-63.
- Margolis A, Flores F, Kierszenbaum M, et al. Warfarin 2.0--a computer program for warfarin management. Design and clinical use. *Proc Annu Symp Comput Appl Med Care* 1994:846-50.
- Martens JD, van der Aa A, Panis B, et al. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. *Stud Health Technol Inform* 2006;124:617-23.

Martens JD, van der Weijden T, Severens JL, et al. The effect of computer reminders on GPs' prescribing behaviour: a cluster-randomised trial. *Int J Med Inform* 2007;76 Suppl 3:S403-16.

Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15(4):424-9.

Mattison ML, Afonso KA, Ngo LH, et al. Preventing potentially inappropriate medication use in hospitalized older patients with a computerized provider order entry warning system. *Arch Intern Med* 2010;170(15):1331-6.

Maviglia SM, Yoon CS, Bates DW, et al. KnowledgeLink: impact of context-sensitive information retrieval on clinicians' information needs. *J Am Med Inform Assoc* 2006;13(1):67-73.

McDonald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med* 1976;84(2):162-7.

McCluggage L, Lee K, Potter T, et al. Implementation and evaluation of vancomycin nomogram guidelines in a computerized prescriber-order-entry system. *Am J Health Syst Pharm* 2010;67(1):70-5.

McCowan C, Neville RG, Ricketts IW, et al. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26(3):191-201.

McCoy AB, Waitman LR, Gadd CS, et al. A computerized provider order entry intervention for medication safety during acute kidney injury: a quality improvement report. *Am J Kidney Dis* 2010;56(5):832-41.

McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Ann Intern Med* 1984;100(1):130-8.

McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Comput* 1992;9(5):304-12.

McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. *CMAJ* 1986;135(9):991-7.

McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *J Fam Pract* 1989;28(4):420-4.

McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. *Med Care* 1989;27(3):297-305.

McGregor JC, Weekes E, Forrest GN, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(4):378-84.

McLaughlin D, Hayes JR, Kelleher K. Office-Based Interventions for Recognizing Abnormal Pediatric Blood Pressures. *Clin Pediatr (Phila)* 2010;49(4):355-362.

McMullin ST, Lonergan TP, Rynearson CS. Twelve-month drug cost savings related to use of an electronic prescribing system with integrated decision support in primary care. *J Manag Care Pharm* 2005;11(4):322-32.

McMullin ST, Lonergan TP, Rynearson CS, et al. Impact of an evidence-based computerized decision support system on primary care prescription costs. *Ann Fam Med* 2004;2(5):494-8.

McPhee SJ, Bird JA, Jenkins CN, et al. Promoting cancer screening. A randomized, controlled trial of three interventions. *Arch Intern Med* 1989;149(8):1866-72.

Meynaar IA, Dawson L, Tangkau PL, et al. Introduction and evaluation of a computerised insulin protocol. *Intensive Care Med* 2007;33(4):591-6.

Miskulin DC, Weiner DE, Tighiouart H, et al. Computerized decision support for EPO dosing in hemodialysis patients. *Am J Kidney Dis* 2009;54(6):1081-8.

Montgomery AA, Fahey T, Peters TJ, et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000;320(7236):686-90.

Morrison RS, Meier DE, Fischberg D, et al. Improving the management of pain in hospitalized adults. *Arch Intern Med* 2006;166(9):1033-9.

- Mosen D, Elliott CG, Egger MJ, et al. The effect of a computerized reminder system on the prevention of postoperative venous thromboembolism. *Chest* 2004;125(5):1635-41.
- Motykie GD, Mokhtee D, Zebala LP, et al. The use of a Bayesian forecasting model in the management of warfarin therapy after total hip arthroplasty. *J Arthroplasty* 1999;14(8):988-93.
- Mudge A, Denaro C, Scott I, et al. The paradox of readmission: effect of a quality improvement program in hospitalized patients with heart failure. *J Hosp Med* 2010;5(3):148-53.
- Mullett CJ, Evans RS, Christenson JC, et al. Development and impact of a computerized pediatric antiinfective decision support program. *Pediatrics* 2001;108(4):E75.
- Murray LS, Teasdale GM, Murray GD, et al. Does prediction of outcome alter patient management? *Lancet* 1993;341(8859):1478-1491.
- Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24(3):324-37.
- Nease DE, Jr., Ruffin MT, Klinkman MS, et al. Impact of a generalizable reminder system on colorectal cancer screening in diverse primary care practices: a report from the prompting and reminding at encounters for prevention project. *Med Care* 2008;46(9 Suppl 1):S68-73.
- Nelson NC, Evans RS, Samois MH, et al. Detection and prevention of medication errors using real-time bedside nurse charting. *J Am Med Inform Assoc* 2005;12(4):390-397.
- Nendaz MR, Chopard P, Lovis C, et al. Adequacy of venous thromboprophylaxis in acutely ill medical patients (IMPART): multisite comparison of different clinical decision support systems. *J Thromb Haemost* 2010;8(6):1230-4.
- Nies J, Colombet I, Zapletal E, et al. Effects of automated alerts on unnecessarily repeated serology tests in a cardiovascular surgery department: a time series analysis. *Bmc Health Services Research* 2010;10.
- Novis SJ, Havelka GE, Ostrowski D, et al. Prevention of thromboembolic events in surgical patients through the creation and implementation of a computerized risk assessment program. *J Vasc Surg* 2010;51(3):648-54.
- O'Connor PJ, Crain AL, Rush WA, et al. Impact of an electronic medical record on diabetes quality of care. *Ann Fam Med* 2005;3(4):300-6.
- Okon TR, Lutz PS, Liang H. Improved pain resolution in hospitalized patients through targeting of pain mismanagement as medical error. *J Pain Symptom Manage* 2009;37(6):1039-49.
- Onundarson PT, Einarsdottir KA, Gudmundsdottir BR. Warfarin anticoagulation intensity in specialist-based and in computer-assisted dosing practice. *Int J Lab Hematol* 2008;30(5):382-9.
- Ornstein SM, Garr DR, Jenkins RG, et al. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. *J Fam Pract* 1991;32(1):82-90.
- Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156(14):1551-6.
- Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4(5):364-75.
- Ozdas A, Speroff T, Waitman LR, et al. Integrating "best of care" protocols into clinicians' workflow via care provider order entry: impact on quality-of-care indicators for acute myocardial infarction. *J Am Med Inform Assoc* 2006;13(2):188-96.
- Padberg FT, Jr., Hauck K, Mercer RG, et al. Screening for abdominal aortic aneurysm with electronic clinical reminders. *Am J Surg* 2009;198(5):670-4.
- Palen TE, Price DW, Snyder AJ, et al. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16(11):e267-75.
- Palen TE, Raebel M, Lyons E, et al. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. *Am J Manag Care* 2006;12(7):389-95.

- Papaoiannou A, Kennedy CC, Campbell G, et al. A team-based approach to warfarin management in long term care: a feasibility study of the MEDeINR electronic decision support system. *BMC Geriatr* 2010;10:38.
- Patel PV, Gilski D, Morrison J. Improving outcomes in high-risk populations using REACH: an inpatient cardiac risk reduction program. *Crit Pathw Cardiol* 2009;8(3):112-8. Paterno MD, Maviglia SM, Gorman PN, et al. Tiering drug-drug interaction alerts by severity increases compliance rates. *J Am Med Inform Assoc* 2009;16(1):40-6.
- Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58(6):1238-45.
- Peterson JF, Kuperman GJ, Shek C, et al. Guided prescription of psychotropic medications for geriatric inpatients. *Arch Intern Med* 2005;165(7):802-7.
- Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129(Pt 2):1037-40.
- Peterson KA, Radosevich DM, O'Connor PJ, et al. Improving Diabetes Care in Practice: findings from the TRANSLATE trial. *Diabetes Care* 2008;31(12):2238-43.
- Phillips LS, Ziemer DC, Doyle JP, et al. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. *Diabetes Care* 2005;28(10):2352-60.
- Piontek F, Kohli R, Conlon P, et al. Effects of an adverse-drug-event alert system on cost and quality outcomes in community hospitals. *Am J Health Syst Pharm* 2010;67(8):613-20.
- Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18(4):223-9.
- Poley MJ, Edelenbos KI, Mosseveld M, et al. Cost consequences of implementing an electronic decision support system for ordering laboratory tests in primary care: evidence from a controlled prospective study in the Netherlands. *Clin Chem* 2007;53(2):213-9.
- Porter SC, Kaushal R, Forbes PW, et al. Impact of a patient-centered technology on medication errors during pediatric emergency care. *Ambul Pediatr* 2008;8(5):329-35.
- Price M. Can hand-held computers improve adherence to guidelines? A (Palm) Pilot study of family doctors in British Columbia. *Can Fam Physician* 2005;51:1506-7.
- Putney DR, Kleiman NS, Fromm RE, Jr., et al. Impact of computerized dosing on eptifibatide-associated bleeding and mortality. *Am Heart J* 2009;158(6):1018-23.
- Raebel MA, Charles J, Dugan J, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. *J Am Geriatr Soc* 2007;55(7):977-85.
- Raebel MA, Chester EA, Newsom EE, et al. Randomized trial to improve laboratory safety monitoring of ongoing drug therapy in ambulatory patients. *Pharmacotherapy* 2006;26(5):619-26.
- Raebel MA, Lyons EE, Chester EA, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. *Arch Intern Med* 2005;165(20):2395-401.
- Ramnarayan P, Winrow A, Coren M, et al. Diagnostic omission errors in acute paediatric practice: impact of a reminder system on decision-making. *BMC Med Inform Decis Mak* 2006;6:37.
- Rana R, Afessa B, Keegan MT, et al. Evidence-based red cell transfusion in the critically ill: quality improvement using computerized physician order entry. *Crit Care Med* 2006;34(7):1892-7.
- Reeve JF, Tenni PC, Peterson GM. An electronic prompt in dispensing software to promote clinical interventions by community pharmacists: a randomized controlled trial. *Br J Clin Pharmacol* 2008;65(3):377-85.

- Riggio JM, Cooper MK, Leiby BE, et al. Effectiveness of a clinical decision support system to identify heparin induced thrombocytopenia. *J Thromb Thrombolysis* 2009;28(2):124-31.
- Rind DM, Safran C, Phillips RS, et al. The effect of computer-based reminders on the management of hospitalized patients with worsening renal function. *Proc Annu Symp Comput Appl Med Care* 1991:28-32.
- Rind DM, Safran C, Phillips RS, et al. Effect of computer-based alerts on the treatment and outcomes of hospitalized patients. *Arch Intern Med* 1994;154(13):1511-7.
- Roberts GW, Farmer CJ, Cheney PC, et al. Clinical decision support implemented with academic detailing improves prescribing of key renally cleared drugs in the hospital setting. *J Am Med Inform Assoc* 2010;17(3):308-12.
- Rocha BH, Christenson JC, Evans RS, et al. Clinicians' response to computerized detection of infections. *J Am Med Inform Assoc* 2001;8(2):117-25.
- Rohrig R, Niczko EJ, Beutefuhr H, et al. Examination of computer assisted prescribing of an initial calculated antibiotic treatment. *Stud Health Technol Inform* 2008;136:63-8.
- Rollman BL, Hanusa BH, Gilbert T, et al. The electronic medical record. A randomized trial of its impact on primary care physicians' initial management of major depression [corrected]. *Arch Intern Med* 2001;161(2):189-97.
- Rolnick SJ, Jackson JM, Amundson JH. Development, implementation and evaluation of an electronic medical record prompt for bone density testing. *Health Informatics Journal* 2009;15(4):296-304.
- Rood E, Bosman RJ, van der Spoel JJ, et al. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. *J Am Med Inform Assoc* 2005;12(2):172-80.
- Rosenbloom ST, Chiu KW, Byrne DW, et al. Interventions to regulate ordering of serum magnesium levels: report of an unintended consequence of decision support. *J Am Med Inform Assoc* 2005;12(5):546-53.
- Rosser WW, Hutchison BG, McDowell I, et al. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992;146(6):911-7.
- Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. *CMAJ* 1991;145(7):807-14.
- Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. *J Gen Intern Med* 1997;12(11):672-8.
- Rothschild JM, Keohane CA, Cook EF, et al. A controlled trial of smart infusion pumps to improve medication safety in critically ill patients. *Crit Care Med* 2005;33(3):533-40.
- Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion (Paris)* 2007;47(2):228-39.
- Roukema J, Steyerberg EW, van der Lei J, et al. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. *J Am Med Inform Assoc* 2008;15(1):107-13.
- Roumie CL, Elasy TA, Greevy R, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. *Ann Intern Med* 2006;145(3):165-75.
- Roy PM, Durieux P, Gillaizeau F, et al. A computerized handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151(10):677-86.
- Rudkin SE, Langdorf MI, Macias D, et al. Personal digital assistants change management more often than paper texts and foster patient confidence. *Eur J Emerg Med* 2006;13(2):92-6.
- Ruland CM. Clinicians' use of a palm-top based system to elicit patient preferences at the bedside: a feasible technique to improve patient outcomes. *Proc Amia Symp* 2000:739-43.
- Safran C, Rind DM, Davis RB, et al. Effects of a knowledge-based electronic patient record in adherence to practice guidelines. *MD Comput* 1996;13(1):55-63.

Safran C, Rind DM, Davis RB, et al. Guidelines for management of HIV infection with computer-based patient's record. *Lancet* 1995;346(8971):341-6.

Safran C, Rind DM, Davis RB, et al. A clinical trial of a knowledge-based medical record. *Medinfo* 1995;8 Pt 2:1076-80.

Safran C, Rind DM, Davis RM, et al. An electronic medical record that helps care for patients with HIV infection. *Proc Annu Symp Comput Appl Med Care* 1993:224-8.

Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA* 2005;294(18):2305-14.

Sanders DL, Miller RA. The effects on clinician ordering patterns of a computerized decision support system for neuroradiology imaging studies. *Proc Amia Symp* 2001:583-7.

Sard BE, Walsh KE, Doros G, et al. Retrospective evaluation of a computerized physician order entry adaptation to prevent prescribing errors in a pediatric emergency department. *Pediatrics* 2008;122(4):782-7.

Schriefer SP, Landis SE, Turbow DJ, et al. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41(7):502-7.

Schriger DL, Baraff LJ, Buller K, et al. Implementation of clinical guidelines via a computer charting system: effect on the care of febrile children less than three years of age. *J Am Med Inform Assoc* 2000;7(2):186-95.

Schriger DL, Baraff LJ, Rogers WH, et al. Implementation of clinical guidelines using a computer charting system. Effect on the initial care of health care workers exposed to body fluids. *JAMA* 1997;278(19):1585-90.

Scotton DW, Wierman H, Coughlan A, et al. Assessing the appropriate use of metformin in an inpatient setting and the effectiveness of two pharmacy-based measures to improve guideline adherence. *Qual Manag Health Care* 2009;18(1):71-6.

Seidling HM, Schmitt SPW, Bruckner T, et al. Patient-specific electronic decision support reduces prescription of excessive doses. *Quality & Safety in Health Care* 2010;19(5).

Sellier E, Colombet I, Sabatier B, et al. Effect of alerts for drug dosage adjustment in inpatients with renal insufficiency. *J Am Med Inform Assoc* 2009;16(2):203-10.

Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12(4):431-7.

Sequist TD, Zaslavsky AM, Marshall R, et al. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169(4):364-71.

Shiffman RN, Freudigman KA, Brandt CA, et al. A guideline implementation system using handheld computers for office management of asthma: effects on adherence and patient outcomes. *Pediatrics* 2000;105(4 part 1):767-773.

Shojania KG, Yokoe D, Platt R, et al. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5(6):554-62.

Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-968.

Sintchenko V, Iredell JR, Gilbert GL, et al. Handheld computer-based decision support reduces patient length of stay and antibiotic prescribing in critical care. *J Am Med Inform Assoc* 2005;12(4):398-402.

Sistrom CL, Dang PA, Weilburg JB, et al. Effect of computerized order entry with integrated decision support on the growth of outpatient procedure volumes: seven-year time series analysis. *Radiology* 2009;251(1):147-55.

Smith DH, Feldstein AC, Perrin NA, et al. Improving laboratory monitoring of medications: an economic analysis alongside a clinical trial. *Am J Manag Care* 2009;15(5):281-9.

Smith DH, Perrin N, Feldstein A, et al. The impact of prescribing safety alerts for elderly persons in an electronic medical record: an interrupted time series evaluation. *Arch Intern Med* 2006;166(10):1098-104.

Smith SA, Shah ND, Bryant SC, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83(7):747-57.

Sobieraj DM. Development and implementation of a program to assess medical patients' need for venous thromboembolism prophylaxis. *Am J Health Syst Pharm* 2008;65(18):1755-60.

Solberg LI, Wei FF, Butler JC, et al. Effects of Electronic Decision Support on High-Tech Diagnostic Imaging Orders and Patients. *Am J Manag Care* 2010;16(2):102-106.

St Jacques P, Sanders N, Patel N, et al. Improving timely surgical antibiotic prophylaxis redosing administration using computerized record prompts. *Surg Infect (Larchmt)* 2005;6(2):215-21.

Staes CJ, Evans RS, Rocha BH, et al. Computerized alerts improve outpatient laboratory monitoring of transplant patients. *J Am Med Inform Assoc* 2008;15(3):324-32.

Steele AW, Eisert S, Davidson A, et al. Using computerized clinical decision support for latent tuberculosis infection screening. *Am J Prev Med* 2005;28(3):281-4.

Steele AW, Eisert S, Witter J, et al. The effect of automated alerts on provider ordering behavior in an outpatient setting. *PLoS Med* 2005;2(9):e255.

Steinmann J, Knaust A, Moussa A, et al. Implementation of a novel on-ward computer-assisted surveillance system for device-associated infections in an intensive care unit. *Int J Hyg Environ Health* 2008;211(1-2):192-9.

Stevenson KB, Barbera J, Moore JW, et al. Understanding keys to successful implementation of electronic decision support in rural hospitals: analysis of a pilot study for antimicrobial prescribing. *Am J Med Qual* 2005;20(6):313-8.

Stiell IG, Clement CM, Grimshaw J, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.

Strom BL, Schinnar R, Aberra F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med* 2010;170(17):1578-83.

Strom BL, Schinnar R, Bilker W, et al. Randomized clinical trial of a customized electronic alert requiring an affirmative response compared to a control group receiving a commercial passive CPOE alert: NSAID-warfarin co-prescribing as a test case. *J Am Med Inform Assoc* 2010;17(4):411-5.

Subramanian U, Fihn SD, Weinberger M, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. *Am J Med* 2004;116(6):375-84.

Sundaram V, Lazzeroni LC, Douglass LR, et al. A randomized trial of computer-based reminders and audit and feedback to improve HIV screening in a primary care setting. *Int J STD AIDS* 2009;20(8):527-33.

Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169(6):549-56.

Tamblyn R, Huang A, Taylor L, et al. A randomized trial of the effectiveness of on-demand versus computer-triggered drug decision support in primary care. *J Am Med Inform Assoc* 2008;15(4):430-8.

Tamblyn R, Reidel K, Huang A, et al. Increasing the Detection and Response to Adherence Problems with Cardiovascular Medication in Primary Care through Computerized Drug Management Systems: A Randomized Controlled Trial. *Med Decis Making* 2009.

Tang PC, LaRosa MP, Newcomb C, et al. Measuring the effects of reminders for outpatient influenza immunizations at the point of clinical opportunity. *J Am Med Inform Assoc* 1999;6(2):115-21.

Tape TG, Campbell JR. Computerized medical records and preventive health care: success depends on many factors. *Am J Med* 1993;94(6):619-25.

Taylor V, Thompson B, Lessler D, et al. A clinic-based mammography intervention targeting inner-city women. *J Gen Intern Med* 1999;14(2):104-11.

Terrell KM, Perkins AJ, Dexter PR, et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57(8):1388-94.

Terrell KM, Perkins AJ, Hui SL, et al. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56(6):623-9.

Thomas AN, Marchant AE, Ogden MC, et al. Implementation of a tight glycaemic control protocol using a web-based insulin dose calculator. *Anaesthesia* 2005;60(11):1093-100.

Thomas HV, Lewis G, Watson M, et al. Computerised patient-specific guidelines for management of common mental disorders in primary care: a randomised controlled trial. *Br J Gen Pract* 2004;54(508):832-7.

Thursky KA, Buising KL, Bak N, et al. Reduction of broad-spectrum antibiotic use with computerized decision support in an intensive care unit. *Int J Qual Health Care* 2006;18(3):224-31.

Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care* 1986;24(8):659-66.

Tierney WM, McDonald CJ, Hui SL, et al. Computer predictions of abnormal test results. Effects on outpatient testing. *JAMA* 1988;259(8):1194-8.

Tierney WM, McDonald CJ, Martin DK, et al. Computerized display of past test results. Effect on outpatient testing. *Ann Intern Med* 1987;107(4):569-74.

Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18(12):967-76.

Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40(2):477-97.

Toth-Pal E, Nilsson GH, Furhoff AK. Clinical effect of computer generated physician reminders in health screening in primary health care--a controlled clinical trial of preventive services among the elderly. *Int J Med Inform* 2004;73(9-10):695-703.

Trick WE, Das K, Gerard MN, et al. Clinical trial of standing-orders strategies to increase the inpatient influenza vaccination rate. *Infect Control Hosp Epidemiol* 2009;30(1):86-8.

Trick WE, Linn ES, Jones Z, et al. Using computer decision support to increase maternal postpartum tetanus, diphtheria, and acellular pertussis vaccination. *Obstet Gynecol* 2010;116(1):51-7.

Turner BJ, Day SC, Borenstein B. A controlled trial to improve delivery of preventive care: physician or patient reminders? *J Gen Intern Med* 1989;4(5):403-9.

Unrod M, Smith M, Spring B, et al. Randomized controlled trial of a computer-based, tailored intervention to increase smoking cessation counseling by primary care physicians. *J Gen Intern Med* 2007;22(4):478-84.

Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997;314(7089):1252-6.

Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. *Clin Lab Haematol* 1997;19(3):203-7.

van Wijk MA, van der Lei J, Mosseveld M, et al. Assessment of decision support for blood test ordering in primary care. a randomized trial. *Ann Intern Med* 2001;134(4):274-81.

van Wyk JT, van Wijk MA, Sturkenboom MC, et al. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117(3):371-8.

Vardi A, Efrati O, Levin I, et al. Prevention of potential errors in resuscitation medications orders by means of a computerised physician order entry in paediatric critical care. *Resuscitation* 2007;73(3):400-6.

Vincent WR, Martin CA, Winstead PS, et al. Effects of a pharmacist-to-dose computerized request on promptness of antimicrobial therapy. *J Am Med Inform Assoc* 2009;16(1):47-53.

Visser MC, Biert J, van der Linden CJ, et al. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. *Comput Methods Programs Biomed* 1996;49(2):177-84.

Visser MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. *Comput Methods Programs Biomed* 1995;48(1-2):53-8.

Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37(7):445-50.

Wax DB, Beilin Y, Levin M, et al. The effect of an interactive visual reminder in an anesthesia information management system on timeliness of prophylactic antibiotic administration. *Anesth Analg* 2007;104(6):1462-6, table of contents.

Weir CJ, Lees KR, MacWalter RS, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM* 2003;96(2):143-53.

Were M, Shen C, Bwana M, et al. Creation and evaluation of EMR-based paper clinical summaries to support HIV-care in Uganda, Africa. *Int J Med Inf* 2010;79(2):90-96.

White KS, Lindsay A, Pryor TA, et al. Application of a computerized medical decision-making process to the problem of digoxin intoxication. *J Am Coll Cardiol* 1984;4(3):571-6.

Williams EC, Achtmeyer CE, Kivlahan DR, et al. Evaluation of an Electronic Clinical Reminder to Facilitate Brief Alcohol-Counseling Interventions in Primary Care. *Journal of Studies on Alcohol and Drugs* 2010;71(5):720-725.

Williams EC, Lapham G, Achtmeyer CE, et al. Use of an Electronic Clinical Reminder for Brief Alcohol Counseling is Associated with Resolution of Unhealthy Alcohol Use at Follow-Up Screening. *J Gen Intern Med* 2010;25:11-17.

Wilson BJ, Torrance N, Mollison J, et al. Cluster randomized trial of a multifaceted primary care decision-support intervention for inherited breast cancer risk. *Fam Pract* 2006;23(5):537-44.

Yilmaz M, Keegan MT, Iscimen R, et al. Toward the prevention of acute lung injury: protocol-guided limitation of large tidal volume ventilation and inappropriate transfusion. *Crit Care Med* 2007;35(7):1660-6; quiz 1667.

Zanetti G, Flanagan HL, Jr., Cohn LH, et al. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24(1):13-6.

Ziemer DC, Doyle JP, Barnes CS, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting: Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. *Arch Intern Med* 2006;166(5):507-13.

Appendix B: Exact Search Strings

Seven separate searches were performed in four online databases:

CDSS PubMed Search Strategy (performed December 23, 2010):

((("case-control studies"[MeSH Terms] OR "cohort studies"[MeSH Terms] OR Clinical Trial[PT] OR randomized[tiab] OR randomised[tiab] OR Multicenter Study[PT] OR Evaluation Studies[PT] OR Comparative Study[PT] OR practice Guideline[PT] OR "intervention studies"[MeSH Terms] OR validation studies[PT] OR meta-analysis[PT] OR systematic[sb] OR "systematic review"[tiab]) NOT ("animals"[MeSH Terms] NOT "humans"[MeSH Terms])) AND ((("decision support" [tiab]) OR ("decision support systems, clinical"[MeSH Terms] OR "therapy, computer-assisted"[Mesh:noexp] OR "reminder systems"[MeSH Terms] OR "drug therapy, computer-assisted"[MeSH Terms] OR "medical order entry systems"[MeSH Terms] OR "Decision Making, Computer-Assisted"[Mesh:noexp]) OR ((computer*[tiab] OR electronic[tiab]) AND (alert*[tiab] OR reminder*[tiab] OR recommendation*[tiab] OR dashboard[tiab] OR "order set" OR "order sets" OR guideline*)) OR ((randomized[tiab] AND reminder*[tiab]) OR (randomised [tiab] AND reminder* [tiab])) OR (cpoe[tiab] OR "physician order entry"[tiab] OR "provider order entry"[tiab] OR "clinical decision support system"[tiab] OR "clinical decision support systems"[tiab]))

Resources and Tools PubMed Search Strategy (performed December 23, 2010):

((("case-control studies"[MeSH Terms] OR "cohort studies"[MeSH Terms] OR Clinical Trial[PT] OR randomized[tiab] OR randomised[tiab] OR Multicenter Study[PT] OR Evaluation Studies[PT] OR Comparative Study[PT] OR practice Guideline[PT] OR "intervention studies"[MeSH Terms] OR validation studies[PT] OR meta-analysis[PT] OR systematic[sb] OR "systematic review"[tiab]) NOT ("animals"[MeSH Terms] NOT "humans"[MeSH Terms])) AND (bedside[tiab] OR decision[tiab] OR decisions[tiab] OR point-of-care[tiab] OR "Decision Making"[Mesh] OR real-time OR just-in-time OR "Physician's Practice Patterns"[Mesh] OR "Nurse's Practice Patterns"[Mesh] OR "practice patterns"[tiab] OR "practice pattern"[tiab] OR "Point-of-Care Systems"[Mesh] OR "patient-related question" OR "patient-related questions" OR ((consultation [tiab] OR consultations[tiab]) AND (patient OR patients [tiab])) OR "clinical practice"[tiab] OR "point of clinical opportunity" OR "point of visit" OR "point of patient encounter")) AND ((infobutton OR infobuttons) OR ("Information Storage and Retrieval"[Mesh:noexp] OR (MEDLARS [Mesh] AND MEDLARS [tiab]) OR (PubMed [Mesh] AND PubMed [tiab]) OR "Information Services"[Mesh:noexp] OR "Information Dissemination"[Mesh] OR "Drug Information Services"[Mesh] OR "Knowledge Bases"[Mesh] OR "Computers, Handheld"[Mesh] OR "Databases as Topic"[Mesh:noexp] OR "Databases, Bibliographic"[Mesh] OR "Databases, Factual"[Mesh:noexp]) AND ("Medical records systems, computerized" [Mesh])) OR (diseasedex[tiab] OR firstconsult[tiab] OR clineguide[tiab] OR inforetriever[tiab] OR "essential evidence"[tiab] OR emedicine[tiab] OR "evidence matters"[tiab] OR UpToDate[tiab] OR dynamed[tiab] OR epocrates[tiab] OR zynx[tiab] OR micromedex[tiab] OR mdconsult[tiab] OR md-consult[tiab] OR infopoems[tiab] OR pier[tiab])

OR "5-minute clinical consult"[tiab] OR (Isabel[tiab] AND diagnosis) OR (MEDLARS[Mesh] AND MEDLARS[tiab]) OR (PubMed[Mesh] AND PubMed[tiab]) OR "national guideline clearinghouse"[tiab] OR Stat!Ref [tiab] OR ("Online systems"[Mesh] OR "Information Storage and Retrieval"[Mesh:noexp] OR (MEDLARS[Mesh] AND MEDLARS[tiab]) OR (PubMed[Mesh] AND PubMed[tiab]) OR "Information Services"[Mesh:noexp] OR "Information Dissemination"[Mesh] OR "Drug Information Services"[Mesh] OR "Knowledge Bases"[Mesh] OR "Computers, Handheld"[Mesh] OR "Databases as Topic"[Mesh:noexp] OR "Databases, Bibliographic"[Mesh] OR "Databases, Factual"[Mesh:noexp] OR "Point-of-Care Systems"[Mesh] OR Internet[Mesh:noexp]) OR (("reference books"[Mesh] OR "Manuals as Topic"[Mesh] OR "Textbooks as Topic"[Mesh] OR textbook*[tiab]) AND (computer* OR electronic OR online OR on-line OR wireless OR internet OR digital)) OR (("knowledge resources" OR "information resources" OR "health resources" OR "clinical resources" OR "knowledge resource" OR "information resource" OR "health resource" OR "clinical resource") AND (computer* OR electronic OR online OR on-line OR wireless OR internet OR digital OR microcomputer)))

CDSS PsycINFO Search Strategy (performed January 7, 2011):

Evaluation (S1):

(DE "Meta Analysis") or (DE "Experimental Design") or (DE "Clinical Trials" or DE "Cohort Analysis" or DE "Followup Studies" or DE "Qualitative Research" or DE "Quantitative Methods") or (DE "Longitudinal Studies" OR DE "Prospective Studies") OR (DE "Experimental Methods") OR (DE "Quasi Experimental Methods") OR (DE "Retrospective Studies") OR (DE "Treatment Guidelines") OR (TI systematic review) OR (AB systematic review) OR (TI randomized) OR (AB randomized) OR (TI randomised) OR (AB randomised)

Clinical Decision Support_1 (S2):

((DE "Decision Support Systems") AND ((TI clinical) OR (AB clinical))) OR (DE "Computer Assisted Therapy")

Clinical Decision Support_2 (S3):

((TI computer*) OR (AB computer*) OR (TI "electronic") OR (AB "electronic")) AND ((TI alert*) OR (AB alert*) OR (TI reminder*) OR (AB reminder*) OR (TI recommendation*) OR (AB recommendation*) OR (TI "dashboard") OR (AB "dashboard") OR ("order set") OR ("order sets") OR ("guideline"))

Clinical Decision Support_3 (S4):

((((TI "randomized") OR (AB "randomized")) AND ((TI reminder*) OR (AB reminder*))) OR (((TI "randomised") OR (AB "randomised")) AND ((TI reminder*) OR (AB reminder*))))

Clinical Decision Support_4 (S5):

(TI cpoe) OR (AB cpoe) OR (TI "physician order entry") OR (AB "physician order entry") OR (TI "provider order entry") OR (AB "provider order entry") OR (TI "clinical decision support system") OR (AB "clinical decision support system") OR (TI "clinical decision support systems") OR (AB "clinical decision support systems")

CDSS condition (*S2 OR S3 OR S4 OR S5*):
Evaluation AND CDSS condition (*S1 AND S6*):
with English Language limit
with Population Group-Human limit
with Publication Type All Journals limit

Resources and Tools PsycINFO Search Strategy (performed January 7, 2011):

Evaluation (*S1*):

(DE "Meta Analysis") or (DE "Experimental Design") or (DE "Clinical Trials" or DE "Cohort Analysis" or DE "Followup Studies" or DE "Qualitative Research" or DE "Quantitative Methods") or (DE "Longitudinal Studies" OR DE "Prospective Studies") OR (DE "Experimental Methods") OR (DE "Quasi Experimental Methods") OR (DE "Retrospective Studies") OR (DE "Treatment Guidelines") OR (TI systematic review) OR (AB systematic review) OR (TI randomized) OR (AB randomized) OR (TI randomised) OR (AB randomised)

Point of Care (*S2*):

(TI "bedside") OR (AB "bedside") OR (TI "decision") OR (AB "decision") OR (TI "decisions") OR (AB "decisions") OR (TI "point-of-care") OR (AB "point-of-care") OR ("real-time") OR ("just-in-time") OR (TI("practice pattern")) OR (AB ("practice pattern")) OR (TI("practice patterns")) OR (AB ("practice patterns")) OR ("patient-related question ") OR ("patient-related questions") OR (((TI "consultation") OR (AB "consultations")) AND ((TI "patient") OR (AB "patients"))) OR (TI "clinical practice") OR (AB "clinical practice") OR (DE Decision Making)

Information Retrieval Tools_1 (*S3*):

("infobutton") OR ("infobuttons")

Information Retrieval Tools_2 (*S4*):

((DE "Automated Information Storage") OR (DE "Automated Information Retrieval") OR (DE "Information Services") OR (DE "Information Dissemination") or (DE "Databases") OR (TI "Medlars") OR (AB "Medlars ") OR (TI "PubMed ") OR (AB "PubMed ") OR (TI "Knowledge Bases") OR (AB "Knowledge Bases") OR (TI "Knowledge Base") OR (AB "Knowledge Base") OR (TI "handheld computers") OR (AB "handheld computers") OR (TI "handheld computer") OR (AB "handheld computer") OR (TI "personal digital assistant") OR (AB "personal digital assistant")) AND ((TI computerized medical record system) OR (AB computerized medical record system) OR (TI computerized patient record) OR (AB computerized patient record))

Knowledge Resources_1 (*S5*):

(TI "diseasedex") OR (AB "diseasedex") OR (TI "firstconsult") OR (AB "firstconsult") OR (TI "clineguide") OR (AB "clineguide") OR (TI "info retriever") OR (AB "info retriever") OR (TI "essential evidence") OR (AB "essential evidence") OR (TI "emedicine") OR (AB "emedicine") OR (TI "evidence matters") OR (AB "evidence matters") OR (TI "UpToDate") OR (AB "UpToDate") OR (TI "dynamed") OR (AB "dynamed") OR (TI "epocrates") OR (AB "epocrates") OR (TI "zynx") OR (AB "zynx") OR (TI "micromedex") OR (AB "micromedex") OR (TI "mdconsult") OR (AB "mdconsult") OR (TI "md-consult") OR (AB "md-consult") OR

(TI "infopoems") OR (AB "infopoems") OR (TI "pier") OR (AB "pier") OR (TI "5-minute clinical consult") OR (AB "5-minute clinical consult") OR (((TI "Isabel") OR (AB "Isabel")) AND ("diagnosis")) OR ("mdconsult") OR (TI "Medlars") OR (AB "Medlars ") OR (MH "PubMed") AND (TI "PubMed") OR (AB "PubMed") OR (TI "national guideline clearinghouse") OR (AB "national guideline clearinghouse") OR (TI "Stat!Ref") OR (AB "Stat!Ref")

Knowledge Resources_2 (S6):

(TI "Online Systems") OR (AB "Online Systems") OR (TI "Online System") OR (AB "Online System") OR (DE "Automated Information Storage") OR (DE "Automated Information Retrieval") OR (DE "Information Services") OR (DE "Information Dissemination") or (DE "Databases") OR (TI "Medlars") OR (AB "Medlars ") OR (TI "PubMed ") OR (AB "PubMed ") OR (TI "Knowledge Bases") OR (AB "Knowledge Bases") OR (TI "Knowledge Base") OR (AB "Knowledge Base") OR (TI "handheld computers") OR (AB "handheld computers") OR (TI "handheld computer") OR (AB "handheld computer") OR (TI "personal digital assistant") OR (AB "personal digital assistant") OR (DE "Internet")

Knowledge Resources_3 (S7):

((TI "Reference Books") OR (AB "Reference Books") OR (TI "Reference Book") OR (AB "Reference Book") OR (DE "Textbooks") OR (TI textbook*) OR (AB textbook*)) AND ((TI computer*) OR (AB computer*) OR (TI "electronic") OR (AB "electronic") OR (TI "online") OR (AB "online") OR (TI "on-line") OR (AB "on-line") OR (TI "wireless") OR (AB "wireless") OR (TI "internet") OR (AB "internet") OR (TI "digital") OR (AB "digital"))

Knowledge Resources_4 (S8):

((TI "knowledge resources") OR (AB "knowledge resources") OR (TI "information resources") OR (AB "information resources") OR (TI "health resources") OR (AB "health resources") OR (TI "clinical resources") OR (AB "clinical resources") OR (TI "knowledge resource") OR (AB "knowledge resource") OR (TI "information resource") OR (AB "information resource") OR (TI "health resource") OR (AB "health resource") OR (TI "clinical resource") OR (AB "clinical resource")) AND ((TI computer*) OR (AB computer*) OR (TI "electronic") OR (AB "electronic") OR (TI "online") OR (AB "online") OR (TI "on-line") OR (AB "on-line") OR (TI "wireless") OR (AB "wireless") OR (TI "internet") OR (AB "internet") OR (TI "digital") OR (AB "digital") OR (TI "microcomputer") OR (AB "microcomputer"))

Evaluation AND Point of care condition (S1 AND S2)

Tools and Resources condition (S3 OR S4 OR S5 OR S6 OR S7 OR S8)

(Evaluation AND Point of care) AND Tools and Resources (S9 AND S10)

with English Language limit

with Population Group-Human limit

with Publication Type All Journals limit

CDSS CINAHL Search Strategy (performed January 7, 2011):

Evaluation (S1):

(TI ("randomized")) OR (AB ("randomized")) OR (TI ("randomised")) OR (AB ("randomised")) OR (MH "Study Design+") OR (MH "Multi center Studies") OR (MH "Evaluation Research+") OR (MH "Comparative Studies") OR (MH "Practice Guidelines") OR (MH "Validation Studies") OR (MH "Meta Analysis") OR (MH "Systematic Review")

Clinical Decision Support_1 (S2):

(TI("decision support")) OR (AB ("decision support")) OR (MH "Decision Support Systems, Clinical") OR (MH "Therapy, Computer Assisted") OR (MH "Reminder Systems") OR (MH "Drug Therapy, Computer Assisted") OR (MH "Electronic Order Entry") OR (MH "Decision Making, Computer Assisted") OR (MH "Expert Systems")

Clinical Decision Support_2 (S3):

((TI(computer*)) OR (AB (computer*)) OR (TI("electronic")) OR (AB ("electronic"))) AND ((TI(alert*)) OR (AB (alert*)) OR (TI(reminder*)) OR (AB (reminder*)) OR (TI(recommendation*)) OR (AB (recommendation*)) OR (TI("dashboard")) OR (AB ("dashboard")) OR ("order set") OR ("order sets") OR ("guideline"))

Clinical Decision Support_3 (S4):

((TI ("randomized")) OR (AB ("randomized"))) AND ((TI (reminder*)) OR (AB (reminder*))) OR (((TI ("randomised")) OR (AB ("randomised"))) AND ((TI (reminder*)) OR (AB (reminder*))))

Clinical Decision Support_4 (S5):

(TI(cpoe)) OR (AB (cpoe)) OR (TI("physician order entry")) OR (AB ("physician order entry")) OR (TI("provider order entry")) OR (AB ("provider order entry")) OR (TI("clinical decision support system")) OR (AB ("clinical decision support system")) OR (TI("clinical decision support systems")) OR (AB ("clinical decision support systems"))

CDSS condition (S2 OR S3 OR S4 OR S5)

Evaluation AND CDSS condition (S1 AND S6):

with English Language limit

with exclude Medline records limit

Resources and Tools CINAHL Search Strategy (performed January 7, 2011):

Evaluation (S1):

(TI ("randomized")) OR (AB ("randomized")) OR (TI ("randomised")) OR (AB ("randomised")) OR (MH "Study Design+") OR (MH "Multi center Studies") OR (MH "Evaluation Research+") OR (MH "Comparative Studies") OR (MH "Practice Guidelines") OR (MH "Validation Studies") OR (MH "Meta Analysis") OR (MH "Systematic Review")

Point of Care (S2):

(TI("bedside")) OR (AB ("bedside")) OR (TI("decision")) OR (AB ("decision")) OR (TI("decisions")) OR (AB ("decisions")) OR (TI("point-of-care")) OR (AB ("point-of-care")) OR ("real-time") OR ("just-in-time") OR (TI("practice pattern")) OR (AB ("practice pattern")) OR (TI("practice patterns")) OR (AB ("practice patterns")) OR ("patient-related question ") OR ("patient-related questions") OR (((TI("consultation ") OR (AB ("consultations ")))) AND ((TI("patient") OR (AB ("patients")))) OR (TI("clinical practice")) OR (AB ("clinical practice")) OR (MH "Decision Making") OR (MH "Practice Patterns") OR (MH "Clinical Information Systems"))

Information Retrieval Tools_1 (S3):

("infobutton") OR ("infobuttons")

Information Retrieval Tools_2 (S4):

((MH "Information Retrieval") OR (MH "Information Storage") OR ((MH "Medlars") AND ((TI("Medlars")) OR (AB ("Medlars ")))) OR ((MH "PubMed") AND ((TI("PubMed ") OR (AB ("PubMed ")))) OR (MH "Information Services") OR (MH "Information Management") OR (MH "Drug Information Services") OR (MH "Knowledge Bases") OR (MH "Computers, Portable+") OR (MH "Databases+")) AND (MH "Computerized Patient Record"))

Knowledge Resources_1 (S5):

(TI("diseasedex")) OR (AB ("diseasedex")) OR (TI("firstconsult")) OR (AB ("firstconsult")) OR (TI("clineguide")) OR (AB ("clineguide")) OR (TI("info retriever")) OR (AB ("info retriever")) OR (TI("essential evidence")) OR (AB ("essential evidence")) OR (TI("emedicine")) OR (AB ("emedicine")) OR (TI("evidence matters")) OR (AB ("evidence matters")) OR (TI("UpToDate")) OR (AB ("UpToDate")) OR (TI("dynamed")) OR (AB ("dynamed")) OR (TI("epocrates")) OR (AB ("epocrates")) OR (TI("zynx")) OR (AB ("zynx")) OR (TI("micromedex")) OR (AB ("micromedex")) OR (TI("mdconsult")) OR (AB ("mdconsult")) OR (TI("md-consult")) OR (AB ("md-consult")) OR (TI("infopoems")) OR (AB ("infopoems")) OR (TI("pier")) OR (AB ("pier")) OR (TI("5-minute clinical consult")) OR (AB ("5-minute clinical consult")) OR (((TI("Isabel")) OR (AB ("Isabel"))) AND ("diagnosis")) OR ((MH "Medlars") AND ((TI("Medlars")) OR (AB ("Medlars ")))) OR ((MH "PubMed") AND ((TI("PubMed ") OR (AB ("PubMed ")))) OR (TI("national guideline clearinghouse")) OR (AB ("national guideline clearinghouse")) OR (TI("Stat!Ref")) OR (AB ("Stat!Ref"))

Knowledge Resources_2 (S6):

(MH "Online Systems+") OR (MH "Information Retrieval") OR (MH "Information Storage") OR ((MH "Medlars") AND ((TI("Medlars")) OR (AB ("Medlars ")))) OR ((MH "PubMed") AND ((TI("PubMed ") OR (AB ("PubMed ")))) OR (MH "Information Services") OR (MH "Information Management") OR (MH "Drug Information Services") OR (MH "Knowledge Bases") OR (MH "Computers, Portable+") OR (MH "Databases+") OR (MH "Clinical Information Systems") OR (MH "Internet"))

Knowledge Resources_3 (S7):

((MH "Reference Books+") OR (MH "Textbooks") OR (TI(textbook*)) OR (AB (textbook*)))
AND ((computer*) OR ("electronic") OR ("online") OR ("on-line") OR ("wireless") OR
("internet") OR ("digital"))

Knowledge Resources_4 (S8):

((("knowledge resources") OR ("information resources") OR ("health resources") OR ("clinical
resources") OR ("knowledge resource") OR ("information resource") OR ("health resource") OR
("clinical resource"))) AND ((computer*) OR ("electronic") OR ("online") OR ("on-line") OR
("wireless") OR ("internet") OR ("digital") OR ("microcomputer"))

Evaluation AND Point of care condition (S1 AND S2)

Tools and Resources condition (S3 OR S4 OR S5 OR S6 OR S7 OR S8)

(Evaluation AND Point of care) AND Tools and Resources condition (S9 AND S10)

with English Language limit

with exclude Medline records limit

CDSS Web of Science Search Strategy (performed January 7, 2011)

References used:

1. Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ* 2005 Apr 2;330(7494):765.
2. Eccles M, McColl E, Steen N, Rousseau N, Grimshaw J, Parkin D, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002 Oct 26;325(7370):941.
3. Friedman C, Wyatt J. Evaluation methods in medical informatics. Springer-Verlag, editor 1997.
4. Garg AX, Adhikari NK, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. *JAMA* 2005 Mar 9;293(10):1223-38.
5. Grimshaw J, Freemantle N, Wallace S, Russell I, Hurwitz B, Watt I, et al. Developing and implementing clinical practice guidelines. *Qual Health Care* 1995 Mar;4(1):55-64.
6. Sim I, Gorman P, Greenes RA, Haynes RB, Kaplan B, Lehmann H, et al. Clinical decision support systems for the practice of evidence-based medicine. *J Am Med Inform Assoc* 2001 Nov-Dec;8(6):527-34.
7. Bates DW, Evans RS, Murff H, Stetson PD, Pizziferri L, Hripcsak G. Detecting adverse events using information technology. *J Am Med Inform Assoc* 2003 Mar-Apr;10(2):115-28.
8. Bates DW, Gawande AA. Improving safety with information technology. *N Engl J Med* 2003 Jun 19;348(25):2526-34.

9. Ash JS, Anderson NR, Tarczy-Hornoch P. People and organizational issues in research systems implementation. *J Am Med Inform Assoc* 2008 May-Jun;15(3):283-9.
10. Shekelle PG, Morton SC, Keeler EB. Costs and Benefits of Health Information Technology. Evidence Report/Technology Assessment No. 132. (Prepared by the Southern California Evidence-based Practice Center under Contract No. 290-02-0003.) AHRQ Publication No. 06-E006. Rockville, MD: Agency for Healthcare Research and Quality. April 2006.
11. Gibbons MC, Wilson RF, Samal L, Lehmann CU, Dickersin K, Lehmann HP, Aboumatar H, Finkelstein J, Shelton E, Sharma R, Bass EB. Impact of Consumer Health Informatics Applications. Evidence Report/Technology Assessment No. 188. (Prepared by Johns Hopkins University Evidence-based Practice Center under contract No. HHSA 290-2007-10061-I). AHRQ Publication No. 09(10)-E019. Rockville, MD. Agency for Healthcare Research and Quality. October 2009.

Citations for references #1,2, 4-10*

#3- book and #11- no references in Web of Science or Google Scholar

#10- Web of Science had ~15 citations, but not available, so searched Scholar and received 93 citations

Appendix C: Sample Data Abstraction Form (Key Questions 2–4)

Study	Study and sample characteristics	CDSS/KMS test intervention	Comparator(s)	Results	Comments/ quality/applicability
Study ID:	Geographical location: Study dates: General setting: - Academic - Community Specific setting: - Inpatient – ICU - Inpatient – non-ICU - Outpatient - Specify if acute or chronic if possible Study design: - RCT, parallel group - RCT, crossover - RCT, cluster randomization - Other RCT [specify] Unit of randomization: - Clinic or team - Clinician - Patient - Other [specify] Duration of intervention: - X week(s) - X month(s) - X year(s) Sample type(s) (with N randomized for each):	Authors' basic description of system: Source/origin of system: - Locally developed - Commercially available Content: <i>a) Objective(s):</i> - Diagnosis - Immunization - Pharmacotherapy - Lab test ordering - Chronic disease management - Initiating discussion with patient - Preventive care - Other [describe] <i>b) Relationship to point of care:</i> - Synchronous - Asynchronous Decision support: <i>Response requirement:</i> - Noncommittal acknowledgement - Justification for not complying - No response requirement - Mandatory response - NR (assume no response requirement) - NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> - Online access - Integrated with CPOE/EHR - Standalone system - Paper-based - Other [specify] <i>b) Delivery mode:</i>	Comparator(s): - Usual care/no CDSS or KMS - Another CDSS/KMS [specify differences from intervention]	1) Impact on clinical outcomes: - Length of stay: - Morbidity: - Mortality: - Validated measure of HRQOL or functional status: - Adverse events: 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: - Recommended clinical study ordered/completed: - Recommended treatment ordered/prescribed: - Impact on user knowledge: 3) Impact on workload, efficiency, and organization of health care delivery: - Number of patients seen/unit time: - Clinician workload: - Efficiency: 4) Impact on relationship-centered outcomes: - Patient satisfaction: 5) Impact on economic outcomes: - Cost: - Cost-effectiveness: 6) Impact on HCP use and implementation: - HCP acceptance:	Exclusion reasons (if appropriate): General comments: Quality assessment: Overall rating: Comments: Applicability/generalizability:

Study	Study and sample characteristics	CDSS/KMS test intervention	Comparator(s)	Results	Comments/ quality/applicability
	<ul style="list-style-type: none"> - Patients - Clinics/practices/hospitals - Individual HCPs: <ul style="list-style-type: none"> > Training MDs > MDs [note specialty, if any] > PAs/NPs > Nurses > Care managers > Pharmacists > Other [specify] - Events - Other [specify] <p>User level of expertise/proficiency:</p>	<ul style="list-style-type: none"> - System-initiated ("push") - User-initiated ("pull") <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i></p> <ul style="list-style-type: none"> - Integration with charting or order entry system to support workflow integration: Y/N/Can't tell <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y/N/Can't tell - No need for additional clinician data entry: Y/N/Can't tell - Request documentation of the reason for not following CDSS recommendations: Y/N/Can't tell - Provision of decision support at time and location of decision making: Y/N/Can't tell - Recommendations executed by noting agreement: Y/N/Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y/N/Can't tell - Promotion of action rather than inaction: Y/N/Can't tell - Justification of decision support via provision of reasoning: Y/N/Can't tell - Justification of decision support via provision of research evidence: Y/N/Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y/N/Can't tell - Provision of decision support results to patients as well as providers: Y/N/Can't tell - CDSS accompanied by periodic performance feedback: Y/N/Can't tell - CDSS accompanied by conventional education: Y/N/Can't tell <p><i>e) Other [specify]</i></p>		<ul style="list-style-type: none"> - HCP satisfaction: - HCP use: - Implementation of CDSS/KMS: 	

Appendix D: Data Abstraction Guidance

This appendix contains guidance followed by the Duke EPC team to abstract data and assess the quality and applicability of the included studies.

General Instructions for Data Abstraction

Notes:

- (1) *Before* abstracting any data, ensure that the study reports at least one of the outcomes listed in the “Results” column. If not, exclude it and enter the exclusion reason “No outcomes of interest” in the last column.
- (2) If a study includes more than one comparator, please use a separate data abstraction form for each comparison.
- (3) Please do not use bulleted or numbered lists in your responses on the data abstraction form.

“STUDY AND SAMPLE CHARACTERISTICS” COLUMN
--

Geographical location

Defined as city and country where study participants were recruited

- If 1 site, give city, state, and country
- If > 1 and ≤ 4 sites, give cities, states, and countries/regions
- If > 4 sites, state “[x] sites in [countries/regions]”

Study dates: Give the dates of the study period at the most detailed level reported.

General setting: Delete any that do not apply.

- Academic
- Community

Specific setting: Delete any that do not apply, and specify as needed.

- Inpatient—intensive care unit (ICU)
- Inpatient—non-ICU
- Outpatient
- Specify if acute or chronic if possible

Study design: Delete any that do not apply, and specify as needed.

- RCT, parallel group
- RCT, cross-over
- RCT, cluster randomization
- Other RCT [specify]

Unit of randomization: Delete any that do not apply, and specify as needed.

- Clinic or team
- Clinician
- Patient
- Other [specify]

Duration of intervention

Specify the number of weeks, months, or years of the intervention period (use the author's words as reported in the article).

Sample type(s) (with N randomized for each)

For each sample type reported in the article, record the sample type and N for the number randomized:

- Patients
- Clinics/practices/hospitals
- Individual health care providers (HCPs)
 - Training MDs (e.g., residents, fellows)
 - MDs (e.g., attending, general practitioners—note specialty if any, e.g., surgery)
 - Physician assistants (PAs)/nurse practitioners (NPs)
 - Nurses
 - Care managers
 - Pharmacists
 - Other (specify)
- Events (specify: e.g., alerts, procedures, orders)
- Other [specify]

User level of expertise/proficiency

In this free text field, specify the user expertise with CDSS/KMS system.

“CDSS/KMS TEST INTERVENTION” COLUMN
--

For all items in this column **except factors/features**, delete any options that do not apply, or delete all options and enter “NR” if not reported. If you cannot determine the data from the description, enter “Not clearly described.” **For each of the “Contextual factors/features influencing the implementation and use of CDSS/KMS,” please record “Y,” “N,” or “Can’t tell.”**

Authors' basic description of system

Briefly describe the system using the authors' words. If the system combines more than one type of intervention, note the information.

Source/origin of system

- Locally developed (i.e., intervention was implemented in a system developed within the health care organization)
- Commercially available (i.e., intervention was implemented in a commercially available system)

Content

- Objective(s): What was the main objective of the intervention? (can have multiple responses)
 - Diagnosis (i.e., provide decision support for making a diagnosis; e.g., diagnosing an infection)
 - Immunization (i.e., provide decision support regarding immunization; e.g., immunization for pneumococcal vaccine)
 - Pharmacotherapy (i.e., provide decision support regarding pharmacotherapy; e.g., medication prescribing, drug dosage calculator, anticoagulation calculator)
 - Lab test ordering (i.e., provide decision support regarding laboratory test ordering; e.g., order a serum creatinine test before ordering vancomycin)
 - Chronic disease management (i.e., provide decision support regarding the management of a chronic medical condition; e.g., managing type 2 diabetes)
 - Initiating discussion with patient (i.e., provide decision support regarding discussion with patients for addressing specific issues; e.g., end-of-life care issues)
 - Preventive care (i.e., provide decision support regarding preventative care management; e.g., prevention of diabetes)
 - Other (describe)
- Relationship to point of care: When was the recommendation presented to aid decisionmaking?
 - Synchronous (i.e., recommendations were provided in real-time to enable decisions to be made during the HCP-patient encounter)
 - Asynchronous (i.e., recommendations were not provided in real-time, and decisions were made outside of the HCP-patient encounter)

Decision support

- Response requirement: How did the user respond to the recommendation?
 - Noncommittal acknowledgement
 - Justification for not complying
 - No response requirement
 - Mandatory response
 - NR (assume no response requirement)
 - NR (unclear whether response requirement)

Information delivery

- Delivery format: What medium was used to deliver the recommendation to the user?
 - Online access (e.g., internet)
 - Integrated with CPOE or EHR (i.e., recommendation presented to user within some type of electronic system)
 - Standalone system
 - Paper-based (e.g., recommendation was provided to user via fax or computer printout)
 - Other (specify: e.g., phone, pager, email)
- Delivery mode: How was the recommendation presented to the user?
 - System-initiated (“push”) (i.e., the system automatically delivers the recommendation to the user without user action or request)
 - User-initiated (“pull”) (i.e., the user needs to perform some type of action or request to receive the recommendation)

Contextual factors/features influencing the implementation and use of CDSS/KMS (Y/N/Can’t tell)

- a) General system features
 - Integration with charting or order entry system to support workflow integration
- b) Clinician-system interaction features
 - Automatic provision of decision support as part of clinician workflow
 - No need for additional clinician data entry
 - Request documentation of the reason for not following CDSS recommendations
 - Provision of decision support at time and location of decision making
 - Recommendations executed by noting agreement
- c) Communication content features
 - Provision of a recommendation, not just an assessment
 - Promotion of action rather than inaction
 - Justification of decision support via provision of reasoning
 - Justification of decision support via provision of research evidence
- d) Auxiliary features
 - Local user involvement in development process
 - Provision of decision support results to patients as well as providers
 - CDSS accompanied by periodic performance feedback
 - CDSS accompanied by conventional education
- e) Other [specify]

“COMPARATOR(S)” COLUMN

Comparator(s): Delete any that do not apply, and specify as needed. If the study includes more than one comparator, use a separate data abstraction form for each comparison.

- Usual care/no CDSS/KMS
- Another CDSS/KMS (specify differences from intervention)
 - If the same CDSS/KMS intervention is used, specify the different features (basic/generic vs. advanced/specific); e.g., CDSS 1 included an alert with

- recommendation to order vaccine vs. CDSS 2 included an alert with recommendation to order vaccine with the vaccine order prepopulated as one action; or e.g., KMS 1 included infobuttons with generic links to UpToDate vs. KMS 2 included infobuttons with context-specific (or patient-specific) links to UpToDate
- If one CDSS/KMS is compared to a different CDSS/KMS, specify the differences or product name if available; e.g., KMS 1 Micromedex vs. KMS 2 UpToDate

“RESULTS” COLUMN

Please refer to “Outcomes Abstraction” below for details about each category. For each outcome of interest, abstract the data in detail, record N and the unit of analysis, and abstract P values. Report results clearly by treatment group. Enter “NR” if the outcome is not reported. If results are reported by the user’s level of expertise/proficiency with CDSS/KMS, record this information.

1. Impact on clinical outcomes
2. Impact on health care process outcomes
3. Impact on workload, efficiency, and organization of health care delivery
4. Impact on relationship-centered outcomes
5. Impact on economic outcomes
6. Impact on HCP use and implementation

“COMMENTS/QUALITY SCORING” COLUMN
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Exclusion reason(s)

If you decide, on reflection, that the article you are abstracting should be excluded, please explain why at the top of this column using the full-text exclude criteria (see “Exclusion Criteria” below for details). In such cases, there is no need to complete a detailed abstraction of the article.

General comments

Please use this space to comment on any study biases, design issues, etc., that may affect interpretation.

Quality assessment

Refer to “Quality Assessment” below.

Applicability/generalizability

Refer to “Applicability Assessment” below.

Outcomes Abstraction

Category	Outcome	Guidance
1) Impact on clinical outcomes	Length of stay	Mean length of stay in days (with range, standard deviation [SD], or 95% confidence interval). Preferred data would be the mean/average length of stay, but we should abstract median (interquartile range) length of stay if that is the only data reported.
	Morbidity	This will be some type of symptom scale or scale for measuring the morbidity of an individual or population. Ideal data to abstract is the mean value (SD) for each group at followup, as reported from an analysis of covariance. This will be true for all continuous outcomes. If these values are not given, look for change scores (baseline-f/u, with SD) for each group <u>or</u> difference in change scores (change in group A minus change in group B, along with SD of the change score).
	Mortality	The timeframe for the mortality measure should be noted (3-day, 1-year, etc.); if cause of death is categorized, that should also be abstracted. Ideal data to abstract is the number of deaths/total enrolled for each group. If raw numbers are not given, abstract the hazard ratio, risk ratio, or odds ratio, with 95% confidence intervals. This will be true for all dichotomous outcomes.
	Validated measure of health-related quality of life (HRQOL) or functional status	Utility score/functional status score. Preferred quality-of-life data are utilities obtained through a time-tradeoff, standard gamble, or visual analog method. Other measures include the HUI or EuroQOL. Preferred functional status data may be measured using several measures such as “Zimmerman Revised,” “Zimmerman Decline,” “ADL Index,” “Mukamel Summary Score,” “Linn Summary Score,” or the “Rudman Summary Score”—they should measure a patient’s loss of independence in activities of daily living (ADL) over time. Note that some studies may merely count the number of dependent areas to create an ADL summary score, whereas others weight certain ADLs more.
	Adverse events	Incidence of adverse events with CDSS compared with comparator intervention.
2) Impact on health care process outcomes	Recommended preventive care ordered/completed	If available, we will abstract both whether the recommended preventive care was ordered and whether it was completed.
	Recommended clinical study ordered/completed	If available, we will abstract both whether the recommended clinical study was ordered and whether it was completed.
	Recommended treatment ordered/prescribed	If available, we will abstract both whether the recommended treatment was ordered and whether it was performed/prescribed.

Category	Outcome	Guidance
	Impact on user knowledge	Difference in user knowledge with CDSS system compared with comparator intervention – note that knowledge most likely will be specific to the clinical domain and therefore be unique to the study – include description from authors of how “knowledge” was measured.
3) Impact on workload, efficiency, and organization of health care delivery	Number of patients seen/unit time	Mean number of patients seen per unit time (e.g., per month or per year).
	Clinician workload	Examples of measuring physician workload include: Number of patients enrolled in a HCP’s duty of care Number of patients handled in a particular period Estimation of annual workload in hours worked per year (e.g., Nelson model, Wachter-Lurie model, Hoffey model) Note that information about the patient complexity/mix may be involved in workload data.
	Efficiency	As we do not have a standard definition of “efficiency” noted, the abstractor should defer to the author’s definition of CDSS “efficiency” outcomes and include in the abstraction the specific definition used.
4) Impact on relationship-centered outcomes	Patient satisfaction	This outcome would include data regarding measures of “overall satisfaction” (which often includes features of access, the staff, etc.), satisfaction with the HCP, or satisfaction with the recommended treatment/service.
5) Impact on economic outcomes	Cost	Mean cost of strategy; incremental cost per quality-adjusted life year (\$/QALY) or cost per life year (\$/LY) of CDSS compared with comparator intervention Note what components of the strategy are included in the costs (e.g., are both direct and indirect costs included, are they long-term or just short-term costs).
	Cost-effectiveness	Incremental cost per quality-adjusted life year (\$/QALY) or cost per life year (\$/LY) of CDSS compared with comparator intervention. As above, note what components of the strategy are included in the costs.
6) Impact on HCP use and implementation	HCP acceptance	Mean differences in provider acceptance (usually through a survey) with CDSS compared with comparator intervention. This outcome would include data regarding measures of “overall provider acceptance of intervention”—how specifically this is measured should be abstracted from author-provided information.
	HCP satisfaction	Mean differences in provider satisfaction (usually through a survey) with CDSS compared with comparator intervention. This outcome would include data regarding measures of “overall satisfaction”—how specifically this is measured should be abstracted from author-provided information.
	HCP use	Mean differences in provider use (usually through monitoring of actual use of the

Category	Outcome	Guidance
		system) with CDSS compared with comparator intervention”—how specifically this is measured should be abstracted from author-provided information.
	Implementation of CDSS	Outcomes that are listed as indicating a successful implementation of CDSS or comparator intervention should be listed here—how specifically this is measured should be abstracted from author-provided information.

Notes: Throughout, preferred data include the mean and standard deviation for each measure (range, median, and 95% confidence intervals should be abstracted as available).

When available, abstract outcome measures by the following subgroups:

Novice users

Expert users

Exclusion Criteria

Additional exclusion criteria agreed on with Technical Expert Panel:

1. Exclude studies of closed-loop systems that do not involve a provider.
2. Exclude studies of systems that require mandatory compliance with the CDSS intervention, defined as when the clinician at the point-of-care is not given a choice on whether or not to follow the CDS recommendations. Instead, compliance is mandated by the study protocol.
3. Exclude studies that have no outcomes of interest.

Original exclusion criteria:

Publication must report original data (excludes systematic reviews, dissertations, commentaries, editorials, letters to the editor, etc.).

Note: Relevant systematic reviews and important background/discussion documents are excluded, but should be “flagged” on the screening form under the “OTHER” column.

Publication must report sufficient details for data extraction and analysis (excludes posters and other publication types reporting insufficient details).

Electronic CDSS/KMS interventions of interest:

Electronic CDSS will be defined as “any electronic system designed to aid directly in clinical decision making, in which characteristics of individual patients are used to generate patient-specific assessments or recommendations that are then presented to clinicians for consideration.” Examples include alerts and reminders, dashboards, computer-assisted diagnosis, order sets, and drug dosage calculations. Systems that provide paper/printed patient-specific recommendations are OK as long as the paperwork is generated by a computerized CDSS.

Electronic KMS will be defined as either:

Knowledge resource: Any electronic system based on the distillation of primary literature used at the point-of-care to inform decisionmaking. Examples include UpToDate, Epocrates, and infobuttons.

Information retrieval tool: An electronic tool designed to aid clinicians in the search and retrieval of context-specific knowledge from information sources based on patient-specific information from a clinical information system to facilitate decision making at the point of care or for a specific care situation. An example of an information retrieval tool is an infobutton embedded in a clinical information system, such as an electronic health record (EHR), that when selected, provides context-specific links to various information sources.

Intervention must be implemented in a real clinical setting. Excludes lab settings, use of paper cases, etc. Any real clinical setting is acceptable (e.g., academic medical centers, community hospitals, federally-funded hospitals, etc.).

Acceptable comparisons are:

Electronic CDSS/KMS vs. no electronic CDSS/KMS (usual care);

Basic (generic) CDSS/KMS vs. advanced (specific) CDSS/KMS in computerized provider order entry (CPOE);

Basic (generic) CDSS/KMS vs. advanced (specific) CDSS/KMS in a stand-alone system;

One CDSS/KMS vs. a different CDSS/KMS.

Note: Exclude if the comparator is literature based.

Intervention must be aimed at health care providers (including care managers, but not, e.g., administrators, librarians, patients, or care takers). Note: Study may evaluate outcomes at the level of the individual system user or the larger health care organization.

Note: Exclude if the study evaluates only the performance of the system as opposed to the impact on clinical practice.

Intervention must be used to aid decisionmaking at the point of care or for a specific care situation. Study must evaluate and report outcomes related to this use/setting (excludes surveys, questionnaires, content analyses, interviews, etc.).

Study must be an evaluation study.

Quality Assessment

Please assign each study an **overall quality rating** of “Good,” “Fair,” or “Poor” based on the following definitions:

A “Good” study has the least bias, and results are considered valid. A good study has a clear description of the population, setting, interventions, and comparison groups; uses a valid

approach to allocate patients to alternative treatments; has a low dropout rate; and uses appropriate means to prevent bias, measure outcomes, and analyze and report results.

A “Fair” study is susceptible to some bias but probably not enough to invalidate the results. The study may be missing information, making it difficult to assess limitations and potential problems. As the fair-quality category is broad, studies with this rating vary in their strengths and weaknesses. The results of some fair-quality studies are possibly valid, while others are probably valid.

A “Poor” rating indicates significant bias that may invalidate the results. These studies have serious errors in design, analysis, or reporting; have large amounts of missing information; or have discrepancies in reporting. The results of a poor-quality study are at least as likely to reflect flaws in the study design as to indicate true differences between the compared interventions.

Additional comments on “Fair” and “Poor” studies

If a study is rated as “Fair” or “Poor,” please note any important limitations on internal validity based on the Cochrane Risk of Bias Criteria, as adapted here:

1. Were the groups similar at baseline in terms of baseline characteristics? (Consider baseline characteristics of intervention/control groups including patient characteristics [e.g. age, sex, race, medical condition], provider characteristics [e.g. age, sex, years of clinical practice, clinical specialty, computer usage], and practice characteristics [e.g. number of providers, practice size— single vs. group])

No important baseline differences

Important baseline differences

Can’t tell if important baseline differences (not reported or key baseline characteristics not reported)

2. Were outcomes assessed using a valid methodology and criteria? (*See more detailed guidance below.*)

Valid method used (assessment method and definition)

Valid method used only in some of the subjects

Valid method not used

3. Were subjects and providers blind to the intervention/exposure status of participants?*

* Note: If the unit of randomization were patients, this is applicable to both subjects and providers. If the unit of randomization were providers, providers could not be blinded to the intervention.

Subjects blind to exposure/intervention

Providers blind to exposure/intervention

4. Were outcome assessors blind to exposure/intervention status?

When considering this item in the overall quality rating, consider the potential for bias if the outcome assessor is not blind to the intervention status. For example, lack of blinding is unlikely to substantially bias mortality rates determined through death certificates. However,

lack of blinding may bias symptom assessments, physical examinations, global judgments (e.g., overall response to treatment).

5. Were incomplete outcome data adequately addressed? (*See more detailed guidance below.*)

6. Was the differential loss to follow-up between the compared groups low (defined as < 10%)?* †

*Note: If outcomes were measured cross-sectionally, apply the following principle to those outcomes: if no follow-up, of 100 intervention subjects, how many times do you know the outcome? Of 100 control subjects or cases, how many times do you know the outcome?

†Note: If event rates are low, then even smaller differences in f/u by group could lead to large biases in estimate of effect.

7. Was the overall loss to follow-up low? (Taken from AHRQ et al., 2007.1 and Higgins et al., 2008.2)

Where different numbers of patients are followed up for different outcomes, use the number followed up for the primary outcome for this calculation.

8. Conflict of interest reported and insignificant?

Is the source of funding identified?

Is the funding from a source that does *not* have a vested interest in the study results?

9. Were the methods used for randomization adequate?

Yes, true random number generator (e.g., computer randomization)

No, not true random number generator (e.g., every other, odd or even DOB, patient record number)

10. Was allocation concealment adequate? (Allocation sequence should be described in sufficient detail to determine whether intervention allocations could have been foreseen in advance of, or during, enrollment.)

Allocation concealment was adequate (e.g., call central number for intervention allocation after eligibility confirmed, sequentially numbered sealed opaque envelopes, sequentially numbered drug containers of identical appearance)

Allocation concealment inadequate

Detailed guidance for Item 2 – assessment of outcomes

Principles for an acceptable outcome assessment:

1. Uses an acceptable method for obtaining the necessary data to apply the outcome criteria. For example, if the instrument is designed and validated as an interviewer-administered instrument, then the data were collected by an appropriately trained interviewer. If chart-based data are used, legible charts are available.
2. Uses an acceptable instrument/measure to ascertain the outcome. For example, HRQOL measured by the SF-36 (a valid, reliable instrument), A1c (measured by a laboratory using appropriate analytic standards).

Detailed guidance for Item 5 (“Were incomplete outcome data adequately addressed?”) – taken from *Cochrane Handbook for Systematic Reviews of Interventions*2, Table 8.5.c

Criteria for a judgment of “Yes” (i.e., low risk of bias)	Any one of the following: <ul style="list-style-type: none"> - No missing outcome data; - Reasons for missing outcome data unlikely to be related to true outcome (for survival data, censoring unlikely to be introducing bias); - Missing outcome data balanced in numbers across intervention groups, with similar reasons for missing data across groups; - For dichotomous outcome data, the proportion of missing outcomes compared with observed event risk not enough to have a clinically relevant impact on the intervention effect estimate; *(see example below) - For continuous outcome data, plausible effect size (difference in means or standardized difference in means) among missing outcomes not enough to have a clinically relevant impact on observed effect size; - Missing data have been imputed using appropriate methods.
Criteria for the judgment of “No” (i.e., high risk of bias)	Any one of the following: <p>Reason for missing outcome data likely to be related to true outcome, with either imbalance in numbers or reasons for missing data across intervention groups;</p> <ul style="list-style-type: none"> - For dichotomous outcome data, the proportion of missing outcomes compared with observed event risk enough to induce clinically relevant bias in intervention effect estimate; ; *(see example below) - For continuous outcome data, plausible effect size (difference in means or standardized difference in means) among missing outcomes enough to induce clinically relevant bias in observed effect size; - “As-treated” analysis done with substantial departure of the intervention received from that assigned at randomization; - Potentially inappropriate application of simple imputation.
Criteria for the judgment of “Can’t tell” (uncertain risk of bias)	Any one of the following: <ul style="list-style-type: none"> - Insufficient reporting of attrition/exclusions to permit judgment of “Yes” or “No” (e.g., number randomized not stated, no reasons for missing data provided); - Study did not address/report this outcome.

*Example for risk of bias due to incomplete follow-up

Historically, methodologists have sometimes suggested somewhat arbitrary thresholds for acceptable loss to follow-up (e.g. less than 20%). The significance of particular rates of loss to follow-up, however, varies widely and is dependent on the relation between loss to follow-up and number of events. For instance, loss to follow-up of 5% in both intervention and control groups provides little threat to bias if event rates were 20% and 40% in intervention and control groups respectively. If event rates were 2% and 4%, however, concern with 5% loss to follow-up is much greater.

Example where lost to f/u is a relatively low proportion of those with events and little risk of bias. RR=0.5 (.21/.42) and if assumed all lost to f/u had events, RR=0.55 (0.25/0.45).

Enrolled/FU outcomes	Lost to F/U	Event rate	Event rate if lost to f/u had events
Intervention 100/95	5	20/95=.21	25/100=.25
Control 100/95	5	40/95=.42	45/100=.45

Example where lost to f/u is a relatively higher proportion of those with events and significant risk of bias. It only takes a few lost to follow to have had events to change the difference in event rates substantially. RR=0.5 (.02/.04) and if assumed all lost to f/u had events, RR=0.78 (0.07/0.09) and may be distorted further if event rates in the lost to f/u differed between intervention and control.

Enrolled/FU outcomes	Lost to F/U	Event rate	Event rate if lost to f/u had events
Intervention 100/95	5	2/95=.02	7/100=.07
Control 100/95	5	4/95=.04	9/100=.09

References

1. Agency for Healthcare Research and Quality. Methods Reference Guide for Effectiveness and Comparative Effectiveness Reviews, Version 1.0 [Draft posted Oct. 2007]. Rockville, MD: Agency for Healthcare Research and Quality. Available at: http://effectivehealthcare.ahrq.gov/repFiles/2007_10DraftMethodsGuide.pdf. Accessed September 20, 2010.
2. Higgins J, Altman D. Assessing the risk of bias. In: Higgins J, Green S, eds. *Cochrane Handbook for Systematic Reviews of Interventions (version 5.0.1) updated September 2008*.: The Cochrane Collaboration.

Applicability Assessment

Do not assign an overall applicability score. Instead, list the most important (up to 3) limitations affecting applicability, if any, based on the following list in the evidence table.

(Note: **bolded** criteria are among the most important for our purposes).

Setting of the study

1. In which country (or countries) was the study conducted?
2. In what general setting (academic or community) was the study conducted?
3. Did the study take place at an institution other than Vanderbilt Medical Center, Massachusetts General Hospital, Brigham & Women's Hospital, Kaiser Permanente, Stanford Hospital, or Intermountain Healthcare?

Selection of participants

4. How were participants identified for eligibility screening before random allocation?
5. What were the study eligibility criteria?
6. What were the study exclusion criteria?
7. Did the study report the ratio of randomly allocated participants to nonallocated participants (who were eligible)?
8. Did the study report the proportion of eligible participants who declined random allocation?

Characteristics of study participants

9. Did the study report participants' baseline characteristics?
10. If participants were patients, did the study report participants' socioeconomic status?
11. If participants were patients, did the study report participants' general medical conditions?
12. If participants were patients, did the study report participants' comorbid conditions or chronic disease score?
13. If participants were providers, did the study report clinical years of experience with CDSS, electronic health record (EHR) systems or computer provider order entry systems (CPOE)?
14. If participants were providers, did the study report that there were incentives (financial, CME) to use the intervention?
15. If participants were providers, did the study report how chaotic or stressful the organization was (i.e. change in leadership or personnel, financial stress)?

Characteristics of CDSS or KMS intervention

16. Was the intervention a locally developed system?
17. Were providers required to use the intervention during daily practice?
18. Was the intervention integrated in a commercially available EHR or CPOE system?

19. Were providers involved in the design of the intervention?

Differences between the study protocol and routine clinical practice

20. Was the study's control arm appropriate and relevant in relation to routine clinical practice?

21. Were the study's cointerventions—which were not randomly allocated—adequate to reflect routine clinical practice?

Outcome measures and followup

22. Did the study use patient-centered outcomes? Did they use a measure that is relevant, valid, and reproducible?

23. If applicable, was the intervention beneficial on the most relevant components of the composite outcome?

24. Was the duration of participant followup adequate?

Appendix E: Evidence Table

Evidence table (key questions 2–4)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Alper, White, and Ge, 2005 #9344	<p>Geographical location: U.S., Israel, Lebanon, Pakistan</p> <p>Study dates: January 20, 2004–June 23, 2004</p> <p>General setting: NR</p> <p>Specific setting: NR</p> <p>Study design: RCT, crossover</p> <p>Unit of randomization: System query</p> <p>Duration of intervention: 3 months</p> <p>Sample type(s) (with N randomized for each): Individual HCPs: - MDs [family medicine, internal medicine, pediatrics, women's health]: 60 randomized, 52 included - MDs: 49 - NP: 3 - Clinician system queries: 780; 698</p>	<p>Authors' basic description of system: DynaMed is a database of synthesized evidence. Authors investigated whether primary care clinicians would answer more clinical questions, change clinical decision making, and alter search time using DynaMed in addition to their usual information sources.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Other; answering specific clinician questions <i>b) Relationship to point of care:</i> - Synchronous - Asynchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: Total number of questions answered/asked (%)— With DynaMed: 263 of 347 (75.8) Without DynaMed: 250 of 351 (71.2)</p> <p>Number of questions for which the answer changed decisionmaking/total asked (%)— With DynaMed: 224 of 347 (64.6) Without DynaMed: 209 of 351 (23.4)</p> <p>Questions for which the participant did not find an answer when the answer would have changed decisionmaking (%)— With DynaMed: 68 (19.6) Without DynaMed: 82 (23.4)</p>	<p>General comments: Participants could still use their usual information sources</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Baseline issues—participants recruited, not compelled to participate</p> <p>Applicability/generalizability: Participants recruited voluntarily</p> <p>Intervention was not locally developed</p> <p>The study did not use patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/proficiency: NR	<p>Information delivery:</p> <p><i>a) Delivery format:</i> Online access</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can’t tell - Justification of decision support via provision of reasoning: Y - Justification of decision support 		<p>3) Impact on workload, efficiency, and organization of health care delivery:</p> <ul style="list-style-type: none"> - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: Median time searching (n = 695 questions), minutes— With DynaMed: 4.95 Without DynaMed: 4.98 <p>Median time to find answers (n = 510 questions), minutes— With DynaMed: 4.78 Without DynaMed: 4.89</p> <p>Median time for unsuccessful searches (n = 185 questions), minutes— With DynaMed: 5.23 Without DynaMed: 5.1</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: Answered more questions (n = 46 [%])— With DynaMed: 23 (50) Without DynaMed: 13 (28.3) Difference: 10 (21.7), P = 0.05 <p>Found more answers that changed clinical decisionmaking (n = 46 [%])— With DynaMed: 25 (54.3)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		via provision of research evidence: Can't tell		Without DynaMed: 13 (28.3) Difference: 8 (17.4), P = 0.01	
		<i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N		Had better overall impact on decisionmaking (n = 46 [%])— With DynaMed: 28 (60.9) Without DynaMed: 15 (32.6) Difference: 3 (6.5), P = 0.007 Spent less time searching (n = 46 [%])— With DynaMed: 22 (47.8) Without DynaMed: 23 (50) Difference: 1 (2.2), P = 0.59 Found answers faster (n = 42 [%])— With DynaMed: 20 (47.6) Without DynaMed: 22 (52.4), P = 0.64 Stopped unsuccessful searches earlier (n = 28 [%])— With DynaMed: 16 (57.1) Without DynaMed: 12 (42.7), P = 0.69 - HCP Use: NR - Implementation of CDSS/KMS: NR	
Ansari, Shlipak, Heidenreich, et al., 2003 #4529	Geographical location: San Francisco, CA Study dates: February 1, 2000–April 16, 2001 General setting: VA	Authors' basic description of system: We conducted a randomized trial to determine whether two intervention strategies, a nurse facilitator, and a combination of patient-specific computer reminders and patient letters could improve the utilization of beta blockers in appropriate,	Comparator(s): Another CDSS/KMS 3 groups: 1) Provider education only (control)	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Hospitalizations and ER visits of study patients during followup (# [%]) P = 0.81 Control (n = 51): 25 (49) Nurse Facilitator (n = 54): 23 (43) CDSS Notification (n = 64): 29 (45)	General comments: None Quality assessment: Overall rating: Good Applicability/

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): Patients: 169</p> <p>User level of expertise/ proficiency: System users were physicians using the CDSS for the first time during this intervention phase</p>	<p>stable outpatients with CHF compared with an aggressive provider education program alone.</p> <p>Source/origin of system: Locally developed</p> <p>Content: a) <i>Objective(s):</i> - Pharmacotherapy - Chronic disease management</p> <p>b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: a) <i>Delivery format:</i> Integrated with CPOE/EHR</p> <p>b) <i>Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: a) <i>General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p>b) <i>Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician</p>	<p>2) Nurse facilitator</p> <p>3) Provider and patient notification via CDSS</p>	<p>Hospitalizations for CHF: Control (n = 51): 5(10%) Nurse Facilitator (n = 54): 5 (9%) CDSS Notification (n = 64): 9(14%) P = 0.66</p> <p>Median hospitalizations or ER visits per patient: Control (n = 51): 1(2%) Nurse Facilitator (n = 54): 2 (4%) CDSS Notification (n = 64): 1(2%) P = 0.14</p> <p>- Mortality: Deaths of study patients during followup (# [%]) P = 0.05— Control (n = 51): 7 (14) Nurse Facilitator (n = 54): 5 (9) CDSS Notification (n = 64): 1 (2)</p> <p>- Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Patients initiated or uptitrated on beta blockers (# [%]) P < 0.001— Control (n = 51): 14 (27) Nurse Facilitator (n = 54): 36 (67) CDSS Notification (n = 64): 10 (16)</p> <p>Patients at target beta blocker doses at end of study (# [%]) P < 0.001—</p>	<p>generalizability: Setting was VA hospital</p> <p>Study used patient centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y 		<p>Control (n = 51): 5 (10)</p> <p>Nurse Facilitator (n = 54): 23 (43)</p> <p>CDSS Notification (n = 64): 1 (2)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Apkon, Mattera, Lin, et al., 2005</p> <p>#3126</p>	<p>Geographical location: Fort Knox, KY Mayport, FL</p> <p>Study dates: Patient screening: 4/22/2004–12/31/2002</p> <p>General setting: Community; 2 military treatment facilities dealing with ambulatory practice</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): Patients: 1902 (936 intervention [I], 966 control [C])</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: Problem-knowledge couplers, a decision support tool that used structured questions based on patient's chief complaint to elicit information from the patient and the provider. That information is linked to a proprietary database of medical knowledge that generates suggestions for appropriate patient care strategies.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> - Diagnosis - Chronic disease management - Preventive care <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: I: 722 of 2074 (34.8%) C: 603 of 1983 (30.4%); $p = 0.03$ - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: For acute/chronic disease management— I: 83 of 300 (27.7%) C: 92 of 282 (32.6%); $p = 0.26$ - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: Patient satisfaction (mean values): Speed, efficiency, and courtesy during visit— I: 4.17 C: 4.19 $P = .23$ Health care provider— I: 4.40 C: 4.37 $P = .82$ Personal issues— I: 4.24 C: 4.27 $P = \text{NA}$ Overall visit assessment – I: 4.27</p>	<p>General comments: Providers cared for both intervention and control patients; a historical control and a concurrent control clinic were also used for comparison</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Evaluated among patients seen at ambulatory care practices that were part of the military health system; patient characteristics and needs may be different from general population</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as</p>		<p>C: 4.30 P= 0.74</p> <p>5) Impact on economic outcomes: - Cost: Coupler patients used more laboratory and pharmacy resources than usual care patients (logarithmic mean difference \$71). Multivariable analysis using logarithmic cost as the outcome showed a significant main effect of treatment, with coupler patients using a logarithmic mean difference of \$46 more than usual care patients. - Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: Strongest level of perceived satisfaction related to information quality—75% agreed that the system provided high-quality information 83% disagreed or strongly disagreed that the problem-knowledge couplers involved acceptable amounts of time - HCP use: NR - Implementation of CDSS/KMS: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: Can't tell - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Can't tell			
Bates, Kuperman, Rittenberg, et al., 1999 #6103	Geographical location: Boston, MA Study dates: June 28, 1994–October 30, 1994 General setting: Academic Specific setting: Inpatient – non-ICU Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 4 months Sample type(s) (with N randomized for each): Patients: 11,586 User level of expertise/proficiency: NR	Authors' basic description of system: Computerized reminders at the time a test was ordered that appeared to be redundant. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Justification for not complying Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Number of tests performed when reminder was triggered by a test *— Intervention: 117 (27%) Control: 257 (51%) (P < 0.001) * In this context, the reminder is for a redundant test, and a lower rate of test orders is an indicator of the effectiveness of the reminder - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: - Cost: Charge savings identified as a result of canceling redundant tests = \$35,000 (0.15% of the annual	General comments: None Quality assessment: Overall rating: Fair Comments: Tests ordered using written instructions and tests ordered as part of an order set were outside the purview of the intervention As a result, only 44% of the tests performed had an associated computer order; further, 50% of the tests with a computer order were not screened for redundancy because they were ordered as part of an order set

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>laboratory budget)</p> <ul style="list-style-type: none"> - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation: NR</p>	<p>Applicability/generalizability:</p> <p>Conducted in an academic tertiary care institution</p> <p>Designed to evaluated only a limited number of tests</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Bell, Grundmeier, Localio, et al., 2010 #13008	Geographical location: Philadelphia, PA Study dates: Dec 1, 2005–Apr 15, 2008 General setting: - Academic (4 urban practices) - Community (8 suburban practices) Academic as well as community practices affiliated with the Children’s Hospital of Philadelphia Pediatric Research Consortium (CHOP), a primary care practice-based research network Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 2.4 years	Authors’ basic description of system: Clinical decision support tool embedded in an electronic health record (EHR) to improve clinician adherence to National Asthma Education and Prevention Program (NAEPP) guidelines. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Spirometry performed: Urban Practices— I: 24% (147 of 604) C: 22% (150 of 690) P = 0.04 Suburban practices— I: 14% (67 of 464) C: 1% (2 of 185) P = 0.003 - Recommended treatment ordered/prescribed: Recommended controller medication prescribed: Urban Practices— I: 78% (943 of 1205) C: 80% (1068 of 1328); P = 0.006 Suburban practices— I: 74% (682 of 926) C: 51% (209 of 409); P = not significant Asthma Care Plan (ACP) filed under treatment outcome: Urban practices— I: 63% (763/1205) C: 68% (903/1328) P not significant Suburban practices— I: 53% (491/926) C: 36% (148/409) P = 0.03	General comments: None Quality assessment: Overall rating: Good Comments: Intervention and characteristics of study population well described Valid outcome measures; baseline differences between intervention and controls also determined during stages of study named pre-education and education Applicability/generalizability: Study population includes those served by an academic urban practice as well as primary practices serving mainly suburban population

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each): Clinics/practices/hospitals: 12</p> <p>User level of expertise/proficiency: Practicing primary care physicians trained in the use of the CDSS</p>	<p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y (developed and validated by a multidisciplinary team at Children's Hospital of Philadelphia Pediatric Research Consortium) - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic 		<p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		performance feedback: N - CDSS accompanied by conventional education: Y			
Bertoni, Bonds, Chen, et al., 2009 #501	Geographical location: Winston-Salem, NC Study dates: June 1, 2001–May 31, 2003 (baseline) May 1, 2004–Apr 30, 2006 (followup) General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, parallel group Unit of randomization: Clinic Duration of intervention: NR Sample type(s) (with N randomized for each): Clinics/practices/hospitals: N = 66 (34 JNC-7 intervention, 32 ATP III intervention)	Authors' basic description of system: Computerized decision support system (CDSS) that calculates the Framingham risk score (FRS) and delivers recommendations. Recommendations for lipid screening and management were based on the National Cholesterol Education Program Adult Treatment Panel (ATP III) guidelines (Intervention) or on JNC guidelines (Control). Source/origin of system: Locally developed CDSS based on ATP III guidelines dissemination and available on the National Heart Lung and Blood Institute ATP III website that was modified to include additional information on therapy to lower lipid levels (LLT). Content: a) <i>Objective(s):</i> Chronic disease management b) <i>Relationship to point of care:</i> Synchronous Decision support:	Comparator(s): Another CDSS/KMS In the control CDSS, recommendation s were based on the Seventh Report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7)	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Proportion of patients screened Intervention: 49.0% (n = 1811) [baseline 43.6%; (n = 2216)] Control: 50.8% (n = 2010) [baseline 40.1% (n = 2841)] Net change -5.3%; P=0.22 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Appropriate Management— Intervention: 72.3% (n = 709) [baseline 73.4%, (n = 842)] Control: 68.9.3% (n = 771) [baseline 79.7% (n = 855)] Net change +9.7%; 95% CI, 2.8%-16.6%; P < 0.01 Appropriate prescription of LLT— Intervention: 24.8% (n = 190) [baseline 38.8%; (n = 216)] Control: 24.1% (n = 200) [baseline 45.3% (n = 205)] Net change +7.2%; P = 0.37 Inappropriate prescription of LLT – Intervention: 3.9% (n = 519) [baseline 6.6%; (n = 626)] Control: 6.4% (n = 571)	General comments: Intervention is a standalone PDA that was not integrated into electronic medical record. Provider use of PDA decreased during the latter half of the intervention particularly if they had adopted electronic health records. Quality assessment: Overall rating: Good Comments: Intervention not blinded; outcome assessors blind to assignment of intervention/control Applicability/generalizability: Practices included were those that were community and not affiliated

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/proficiency: NR	<p><i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system (PDA-based)</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”) (response to user-entered data)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than</p>		<p>[baseline 4.2% (n = 650)] Net change -4.9%; P = 0.01</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	with the medical school or a residency program

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>inaction: Y</p> <ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p>d) <i>Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 			
<p>Bird, McPhee, Jenkins, et al., 1990</p> <p>#7221</p> <p>Comparison 1 of 3</p>	<p>Geographical location: San Francisco, CA</p> <p>Study dates: 1984–1987</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group, 2 x 3 factorial design</p> <p>Unit of randomization: Clinician</p>	<p>Authors' basic description of system: Cancer screening reminder intervention provided residents with up-to-date records of their patient's screening status at the time of each practice visit.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p>a) <i>Objective(s):</i> Preventive care</p> <p>b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement (no</p>	<p>Comparator(s): <u>Cancer screening reminders</u></p> <p>2 x 3 factorial design: Patient education (present or absent) by:</p> <ul style="list-style-type: none"> - Cancer screening reminders versus - Audit with feedback versus - No physician intervention 	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Total cost of implementation—Cancer screening reminders: \$5820 Per patient: \$12.93 Labor cost: Cancer screening reminders (by inference, n = 21)—Total cost: \$12,222 Prorated cost: \$5820 	<p>General comments: This was a secondary (feasibility) analysis of a previously published study: McPhee SJ, Bird JA, Jenkins C, Fordham D. Promoting cancer screening: a randomized, controlled trial of three interventions. Arch Intern Med 1989; 149:1866.</p> <p>Patient education intervention only</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): - Individual HCPs: > Training MDs: residents in internal medicine (N = 62; 21 cancer screening reminders, 20 audit with feedback, 21 no physician education)</p> <p>User level of expertise/proficiency: Computer was used to generate recommendations that were printed out and provided to the physician. As such, interaction with the computer-based system was limited and user level of expertise/proficiency may not be relevant.</p>	<p>response required for the recommendation as such; however, residents were asked to note on the reminder form whether they performed or ordered any screening test during the patient visit)</p> <p>-Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content</i></p>	<p>Total of 6 groups, but results reported only for 5 of the 6 possible cells in the 2 x 3 factorial design; primary outcome of cost of intervention reported for single interventions only:</p> <p>Cancer screening with and without patient education</p> <p>Audit with feedback with and without patient education</p> <p>No physician intervention, by inference, with only the patient education group</p>	<p>No tests of significance reported</p> <p>- Cost-effectiveness: Implementation cost— Cost per additional test: \$18.19 # of tests promoted per \$1000 expenditure: 55</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Residents’ use of the reminders also indicated general acceptance of the intervention. Residents made notations on 2397 (70%) of 3441 reminders for completed patient appointments; they returned 793 (23%) without notations and failed to return 251 (7%).</p> <p>- HCP satisfaction: Most of the residents were also enthusiastic; 14 of 21 residents found the reminders very useful/helpful</p> <p>- HCP use: NR</p> <p>- Implementation of CDSS/KMS: NR</p>	<p>addressed screening for breast cancer among women, while intervention arms had screening strategies with broader focus (including other cancers and male patients)</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Methods used for randomization and allocation concealment not adequately described</p> <p>Small sample size (~10 per cell in 2 x 3 factorial design)</p> <p>Inadequate reporting of methods and results</p> <p>Potential for multiple confounders</p> <p>Applicability/generalizability:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 			<p>Technical features of the intervention may be outdated by the standards of current information technology</p> <p>Assessed among residents in an academic teaching hospital</p> <p>Units of costs in 1984–1987 dollars</p>
<p>Bird, McPhee, Jenkins, et al., 1990</p> <p>#7221</p> <p>Comparison 2 of 3</p>	<p>Geographical location: San Francisco, CA</p> <p>Study dates: 1984–1987</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group, 2 x 3 factorial design</p>	<p>Authors' basic description of system: Cancer screening reminder intervention provided residents with up-to-date records of their patient's screening status at the time of each practice visit.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i></p>	<p>Comparator(s): <u>Audit with feedback</u></p> <p>2 x 3 factorial design: Patient education (present or absent) by:</p> <ul style="list-style-type: none"> - Cancer screening reminders versus - Audit with feedback 	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: Total cost of implementation— Audit with feedback: \$4488 Per patient: \$9.63</p>	<p>General comments: This was a secondary (feasibility) analysis of a previously published study: McPhee SJ, Bird JA, Jenkins C, Fordham D. Promoting cancer screening: a randomized, controlled trial of three interventions.</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Unit of randomization: Clinician</p> <p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): - Individual HCPs: > Training MDs: residents in internal medicine (N = 62; 21 cancer screening reminders, 20 audit with feedback, 21 no physician education)</p> <p>User level of expertise/proficiency: Computer was used to generate recommendations that were printed out and provided to the physician. As such, interaction with the computer-based system was limited and user level of expertise/proficiency may not be relevant.</p>	<p>Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement (no response required for the recommendation as such; however, residents were asked to note on the reminder form whether they performed or ordered any screening test during the patient visit)</p> <p>-Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision</p>	<p>versus</p> <p>- No physician intervention</p> <p>Total of 6 groups, but results reported only for 5 of the 6 possible cells in the 2 x 3 factorial design; primary outcome of cost of intervention reported for single interventions only:</p> <p>Cancer screening with and without patient education</p> <p>Audit with feedback with and without patient education</p> <p>No physician intervention, by inference, with only the patient education group</p>	<p>Labor cost: Audit with feedback (by inference, n = 20)— Total cost: \$8976 Prorated cost: \$4488</p> <p>- Cost-effectiveness: Implementation cost— Cost per additional test: \$50.40 # of tests promoted per \$1000 expenditure: 20</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Arch Intern Med 1989; 149:1866.</p> <p>Patient education intervention only addressed screening for breast cancer among women, while intervention arms had screening strategies with broader focus (including other cancers and male patients)</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Methods used for randomization and allocation concealment not adequately described</p> <p>Small sample size (~10 per cell in 2 x 3 factorial design)</p> <p>Inadequate reporting of methods and results</p> <p>Potential for</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>making: Y</p> <p>- Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i></p> <p>- Provision of a recommendation, not just an assessment: Can't tell</p> <p>- Promotion of action rather than inaction: Can't tell</p> <p>- Justification of decision support via provision of reasoning: Can't tell</p> <p>- Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Can't tell</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: Y</p> <p>- CDSS accompanied by conventional education: Y</p>			<p>multiple confounders</p> <p>Applicability/generalizability:</p> <p>Technical features of the intervention may be outdated by the standards of current information technology</p> <p>Assessed among residents in an academic teaching hospital</p> <p>Units of costs in 1984–1987 dollars</p>
<p>Bird, McPhee, Jenkins, et al., 1990</p> <p>#7221</p> <p>Comparison 3 of 3</p>	<p>Geographical location:</p> <p>San Francisco, CA</p> <p>Study dates:</p> <p>1984–1987</p> <p>General setting:</p> <p>Academic</p> <p>Specific setting:</p>	<p>Authors' basic description of system:</p> <p>Cancer screening reminder intervention provided residents with up-to-date records of their patient's screening status at the time of each practice visit.</p> <p>Source/origin of system:</p> <p>Locally developed</p>	<p>Comparator(s):</p> <p><u>Patient education</u></p> <p>2 x 3 factorial design: Patient education (present or absent) by:</p> <p>- Cancer</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p>	<p>General comments:</p> <p>This was a secondary (feasibility) analysis of a previously published study: McPhee SJ, Bird JA, Jenkins C, Fordham D.</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Outpatient</p> <p>Study design: RCT, parallel group, 2 x 3 factorial design</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): - Individual HCPs: > Training MDs: residents in internal medicine (N = 62; 21 cancer screening reminders, 20 audit with feedback, 21 no physician education)</p> <p>User level of expertise/ proficiency: Computer was used to generate recommendations that were printed out and provided to the physician. As such, interaction with the computer-based system was limited and user level of expertise/proficiency</p>	<p>Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement (no response required for the recommendation as such; however, residents were asked to note on the reminder form whether they performed or ordered any screening test during the patient visit)</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y</p>	<p>screening reminders versus - Audit with feedback versus - No physician intervention</p> <p>Total of 6 groups, but results reported only for 5 of the 6 possible cells in the 2 x 3 factorial design; primary outcome of cost of intervention reported for single interventions only:</p> <p>Cancer screening with and without patient education</p> <p>Audit with feedback with and without patient education</p> <p>No physician intervention, by inference, with only the patient</p>	<p>5) Impact on economic outcomes: - Cost: Total cost of implementation— Patient education: \$1280 Per patient: \$ 3.11 Labor cost: Patient education (by inference, n = 10)— Total cost: \$3967 Prorated cost: \$1280</p> <p>No tests of significance reported</p> <p>- Cost-effectiveness: Implementation cost— Cost per additional test: \$51.20 # of tests promoted per \$1000 expenditure: 20</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Promoting cancer screening: a randomized, controlled trial of three interventions. Arch Intern Med 1989; 149:1866.</p> <p>Patient education intervention only addressed screening for breast cancer among women, while intervention arms had screening strategies with broader focus (including other cancers and male patients)</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Methods used for randomization and allocation concealment not adequately described</p> <p>Small sample size (~10 per cell in 2 x 3 factorial design)</p> <p>Inadequate</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	may not be relevant.	<ul style="list-style-type: none"> - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 	education group		<p>reporting of methods and results</p> <p>Potential for multiple confounders</p> <p>Applicability/generalizability: Technical features of the intervention may be outdated by the standards of current information technology</p> <p>Assessed among residents in an academic teaching hospital</p> <p>Units of costs in 1984–1987 dollars</p>
Bosworth, Olsen, Dudley, et al., 2009	Geographical location: Durham, NC	Authors' basic description of system: CDSS system used special features of the VA's computerized medical record and provided patient-specific	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency,	General comments: Primary outcome was the proportion of patients who achieved blood
#560	Study dates: March 2002–April 2005		2-level cluster RCT:		

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
AND Bosworth, Olsen, Goldstein, et al., 2005 #3481	<p>General setting: VA</p> <p>Specific setting: - Outpatient - Chronic</p> <p>Study design: 2-level (PCP and patient) RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 2 years</p> <p>Sample type(s) (with N randomized for each): Individual HCPs: > Training MDs > MDs: 23 general internists - PAs/NPs: 7</p> <p>User level of expertise/proficiency: NR</p>	<p>recommendations about hypertension decision support delivered at the point of care during each patient visit.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y</p>	<p>1) PCPs receiving intervention (n = 17)</p> <p>2) PCPs not receiving intervention (n = 15)</p> <p>3) Patients receiving usual care</p> <p>4) Patients receiving bimonthly tailored nurse-delivered behavioral telephone intervention to improve hypertension treatment</p>	<p>and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: Percentage of visits during which HCPs interacted with the system— 57% of the visits when the system displayed the decision support system - Implementation of CDSS/KMS: NR</p>	<p>pressure control over 24-month intervention period</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Long followup period; high retention rate; less than 3% dropped out; intervention evaluated in a veteran patient population (98% male, 40% African American)</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: N 			
Bourgeois, Linder, Johnson, et al., 2010,	Geographical location: 12 sites in Boston, MA Study dates:	Authors' basic description of system: Interactive, computerized, guideline-driven ("smart form") template to assist clinicians in	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes:	General comments: None Quality

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#14341	<p>October 2006–April 2007</p> <p>General setting: Community</p> <p>Specific setting: - Outpatient - Chronic and acute</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: - Clinic or team</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Clinics/practices/hospitals: 12 - Individual HCPs: 146</p> <p>User level of expertise/proficiency: Intervention clinics were given 3 months to familiarize with the CDSS. In-person training session on use of ARI-IT</p>	<p>antibiotic prescribing for acute respiratory illness (ARI).</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Pharmacotherapy - Lab test ordering - Disease management (chronic and acute)</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician</p>		<p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed:</p> <p>Antimicrobial prescriptions (percentage of total visits)— I = 5929/14934 (39.7%) C = 2303/5007 (46%) P = 0.844</p> <p>Macrolide prescriptions (percentage of total visits)— I = 1408/14934 (9.4%) C = 290/5007 (5.8%) P < 0.0001</p> <p>Antimicrobial prescriptions for viral illnesses (%)— I = 1526/14934 (17.9%) C = 408/5007 (15.7%) P = 0.129</p> <p>Macrolide prescription for viral illnesses (%)— I = 336/14934 (4%) C = 93/5007 (3.6%) P = 0.484</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p>	<p>assessment: Overall rating: Fair</p> <p>Comments: Valid outcome measures</p> <p>No details on randomization, concealment, or blinding provided</p> <p>More clinics, clinicians, and patients included in the intervention group</p> <p>Applicability/generalizability: Locally developed system by Partners Healthcare</p> <p>Low adoption rate among clinicians prevent accurate assessment for generalizability</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 		<p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: NR - HCP use: CDSS used during 419 of 14,934 visits, accounting for 2.8% of all visits. CDSS used by 32 of 112 (29%) intervention clinic clinicians. <p>- Implementation of CDSS/KMS: NR</p> <p>- Other: Clinicians who used the ARI-IT form reported that the features of greatest benefit and appeal included features that were most likely to improve efficiency, including (1) the note creation feature, (2) the automatically generated, weight-based, printable prescriptions, (3) patient handouts, and (4) excuse forms.</p> <p>Clinicians also identified a number of frustrations with the form, including (1) the overly detailed list of symptoms, (2) the need to add specific details in the physical exam (particularly appearance of tympanic membranes) and review of systems, (3) the need to immediately identify the patient's diagnoses as qualifying as an ARI diagnosis in order to launch the form, (4) the need to complete the entire template during the patient visit in order to save the visit note.</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Brier, Gaweda, Dailey et al., 2010 #14348	Geographical location: Louisville, KY Study dates: December 2006–July 2007 General setting: NR Specific setting: NR Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 8 months Sample type(s) (with N randomized for each): Patients: 60 User level of expertise/ proficiency: NR	Authors' basic description of system: Anemia management using model predictive control (MPC) recommends EPO dosing. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Asynchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i> Not clearly described Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Hospitalization events: Intervention = 53 Control = 47 - Mortality: 6 in intervention group; Two of the deaths were cardiovascular in nature; study mortality rate was below the facility rate - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Proportion 11.0 to 12.0 g/dl— Control = 42/112 (37%) Intervention = 34/92 (37%) Proportion > 13.0 and < 9.0 g/dl— Control = 30/112 (27%) Intervention = 15/92 (16%) Mean absolute difference from 11.5 g/dl— Control = 1.14 ± 1.18 Intervention = 0.96 ± 0.70 P < 0.001 (difference in variance)	General comments: None Quality assessment: Overall rating: Fair Comments: Dropout = 7 of 60 (> 10%) Small sample size Applicability/generalizability: Wide age gap patient inclusion (18 to 80) Locally developed system with proprietary software and unknown parameters (neural network) Possibly veteran population

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>support as part of clinician workflow: N</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>AUC— Control = 3.38 ± 2.69 Intervention = 2.86 ± 1.46 P = 0.025 (difference in variance)</p> <p>Number of dose changes— Control = 3.9 ± 1.6 Intervention = 4.8 ± 2.2</p> <p>Total EPO dose (1000U)— Control = 97.6 ± 66.1 Intervention = 129.3 ± 170.8 P = 0.005 (difference in variance)</p> <p>Total Iron dose (mg)— Control = 1133 ± 1212 Intervention = 1496 ± 1573 P = 0.261 (difference in variance)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Burack, Gimotty, George, et al., 1994</p> <p>#6957</p> <p>AND</p> <p>Burack and Gimotty, 1997</p> <p>#6473</p>	<p>Geographical location: Detroit, MI</p> <p>Study dates: May 1, 1989–Sep 1, 1991</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 2 years</p> <p>Sample type(s) (with N randomized for each): Patients: Year 1: 2725 Year 2: 1225</p> <p>User level of expertise/proficiency: NA; paper-based reminders</p>	<p>Authors' basic description of system: Computer-generated mammography reminder form for physicians, a mammography appointment postcard reminder for women, and an appointment rescheduling system for women who were unable to complete a scheduled mammography appointment.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Preventive care</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow</p>	<p>Comparator(s): No CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Screening for mammography among women aged 40 and over measured as annual completed mammography rates— Year 1 (n = 2,725) I: 53% C: 41% Year 2 (n = 1,225) I: 44% C: 28% (adjusted OR = 1.84; 95% CI 1.40 to 2.40)</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: Strategies to address barriers to screening such as elimination of out-of-pocket mammography expenses to patients and physician and staff orientation were implemented in both experiment as well as control groups</p> <p>Quality assessment: Overall rating: Good</p> <p>Comments: Study population, baseline characteristics well-described</p> <p>Applicability/generalizability: Intervention implemented in the community setting in three health care organizations serving urban, predominantly Medicaid-eligible population</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>integration: N</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			<p>Not a real-time system; recommendations generated offline by a dedicated research team using information from several sources such as medical chart review, site administration data, and mammography facility records to generate reminders</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Burack, Gimotty, George, et al., 1998 #6292	<p>Geographical location: Detroit, MI,</p> <p>Study dates: March 1993–April 1994</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): Patients: 5801</p> <p>User level of expertise/proficiency: NA; paper-based reminders</p>	<p>Authors' basic description of system: The computer-based reminder system generated pap smear reminders for both patients and physicians. The reminders were generated off-site. Physician reminder was a brightly colored reminder placed in the patient medical record while the patient reminder was a letter mailed to the patient.</p> <p>Eligible women were assigned to receive either physician reminder, patient reminder, or a combination of both; the control group participants were not assigned to receive any reminders.</p> <p>Source/origin of system: Locally developed</p> <p>Content: a) <i>Objective(s):</i> Preventive care b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: a) <i>Delivery format:</i> Paper-based</p>	<p>Comparator(s): No CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR</p> <p>Pap smear completion: Intervention— Physician and patient reminders: 32%; OR = 1.23; n = 960 Physician reminders alone 29%; OR = 1.05; n = 960 Patient reminders alone 29%; OR = 1.07; n = 964 Control— No reminders: 28%; (n = 964)</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Intervention implemented in the community setting at three sites of an HMO serving an urban, predominantly Medicaid-eligible population</p> <p>Not a real-time system; recommendations were generated offline</p> <p>Additional organizational resources to scan records and generate recommendations</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can’t tell - Justification of decision support via provision of research evidence: Can’t tell</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Burack, Gimotty, Simon, et al., 2003 #4609	Geographical location: Detroit, MI Study dates: Jan 1994–Feb 1995 General setting: Community Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 1 year Sample type(s) (with N randomized for each):	Authors' basic description of system: Combined pap smear and mammography reminder; reminders included both a mailed letter to the patient and a medical record prompt placed in the patient's medical chart. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: <i>a) Delivery format:</i> Paper-based	Comparator(s): Another CDSS/KMS Comparator was a mammography-only reminder; similar to the intervention, the control group included both a mailed letter to the patient and a medical record prompt with the only difference being that it addressed mammography alone.	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Pap smear completion— Intervention: 30% Control: 23%; $p = 0.007$ Adjusted OR = 1.39, 95% CI 1.08 to 1.63 Mammography completion— Intervention: 38.9% Control: 39.7%; Adjusted OR = 0.94 95% CI (0.78, 1.14) - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Intervention implemented in the community setting at three sites of an HMO serving an urban, predominantly Medicaid-eligible population Not a real-time system; recommendations were generated offline

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Patients: 2471</p> <p>User level of expertise/ proficiency: NA; paper- based reminders</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can’t tell - Justification of decision support via provision of research evidence: Can’t tell</p>		<p>outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Additional organizational resources to scan records and generate recommendations</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Cannon and Allen, 2000</p> <p>#5781</p>	<p>Geographical location: Salt Lake City, UT</p> <p>Study dates: Jan 5, 1998–Oct 7, 1998</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): Patients: 78</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: The computer system, called CaseWalker, reminded clinicians when guideline-recommended screening for mood disorder was due, ensured the fidelity of the diagnosis of major depressive disorder to criteria of DSM-IV, and generated a progress note.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Diagnosis <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system [The CDSS program ran on the same computer that was used for processing EHRs but was not integrated into the workflow of the EHR system.] <i>b) Delivery mode:</i> System-initiated ("push")</p>	<p>Comparator(s): No CDSS or KMS; manual reminder</p> <p>Manual reminder was a paper checklist that was inserted into the assessment section of the paper medical record of each patient assigned to the control arm. The paper checklist presented the diagnostic criteria used in the intervention in a paper form in exactly the same order.</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: percentage of patients screened for mood disorder— I: 86.5% C: 61%; $p = 0.008$ - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Small team of health care providers (clinical psychologist, registered nurse, social worker and addiction therapist) evaluated subjects in both arms of the study</p> <p>Potential for contamination across study arms as 4 HCPs administered care to all the subjects in the study.</p> <p>Applicability/generalizability: Small sample of highly select group of patients attending an outpatient clinic at a VA Health</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y</p>			Center staffed with 4 HCPs that were part of the Posttraumatic Stress Disorder (PTSD) clinical team; limited generalizability to other settings

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: NR - CDSS accompanied by conventional education: N 			
<p>Cavalcanti, Silva, Pereira, et al., 2009</p> <p>#216</p> <p>Comparison 1 of 2</p>	<p>Geographical location: Brazil; multicenter trial in 5 ICUs at 5 different Brazilian institutions</p> <p>Study dates: May 4, 2005–Dec 4, 2006</p> <p>General setting: - Academic - Community (3 ICUs associated with teaching hospitals and 2 associated with nonteaching hospitals)</p> <p>Specific setting: Inpatient – ICU</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p>	<p>Authors' basic description of system: Interventions were computer-assisted insulin protocol (CAIP), with continuous intravenous insulin infusion maintaining BG between 100 and 130 mg/dL.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy, insulin therapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR</p> <p>Information delivery: <i>a) Delivery format:</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p> <p><u>Comparator 1:</u> Leuven protocol with continuous insulin infusion maintaining BG between 80 and 110 mg/dL</p>	<p>1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Incidence of at least 1 episode of hypoglycemia— CAIP: 21.4% (n = 24) Leuven: 41.4% (n = 24); p = 0.04 Percentage of hypoglycemic episodes per patient— CAIP: 0.43 Leuven: 0.55; p = 0.04 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Computer-generated random numbers; centralized randomization using a Web site that assured concealment of the allocation list; no blinding of patients or investigators; insufficient and ambiguous reporting of</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 18 months</p> <p>Sample type(s) (with N randomized for each): Patients: 168 (56 CAIP, 58 Leuven protocol, 54 conventional)</p> <p>User level of expertise/ proficiency: NR</p>	<p>Standalone system</p> <p><i>b) Delivery mode:</i> NR</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell</p>		<p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>methods</p> <p>Applicability/ generalizability: Study carried out at multiple ICUs across Brazil; patients had longer ICU stay and greater frequency of hypoglycemia compared to studies in other settings</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>- Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Can't tell</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: N</p>			
<p>Cavalcanti, Silva, Pereira, et al., 2009</p> <p>#216</p> <p>Comparison 2 of 2</p>	<p>Geographical location: Brazil; multicenter trial in 5 ICUs at 5 different Brazilian institutions</p> <p>Study dates: May 4, 2005–Dec 4, 2006</p> <p>General setting: - Academic - Community (3 ICUs associated with teaching hospitals and 2 associated with nonteaching hospitals)</p> <p>Specific setting: Inpatient – ICU</p> <p>Study design: RCT, parallel group</p>	<p>Authors' basic description of system: Computer-assisted insulin protocol (CAIP), with continuous intravenous insulin infusion maintaining BG between 100 and 130 mg/dL.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy, insulin therapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR</p>	<p>Comparator(s): <u>Comparator 2:</u> Usual care; conventional treatment was subcutaneous insulin administration according to a sliding scale if glucose > 150 mg/dL</p>	<p>1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Patients with incidence of at least 1 episode of hypoglycemia— CAIP: 21.4% (n = 24) Usual care: 3.8% (n = 2); p = 0.006 Percentage of hypoglycemic episodes per patient— CAIP: 0.43 Usual: 0.03; p = 0.007 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Computer-generated random numbers; centralized randomization using a Web site that assured concealment of the allocation list; no blinding of patients or</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Unit of randomization: Patient</p> <p>Duration of intervention: 18 months</p> <p>Sample type(s) (with N randomized for each): Patients: 168 (56 CAIP, 58 Leuven protocol, 54 conventional)</p> <p>User level of expertise/proficiency: NR</p>	<p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> NR</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y/ - Promotion of action rather than inaction: Y</p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>investigators; insufficient and ambiguous reporting of methods</p> <p>Applicability/generalizability: Study carried out at multiple ICUs across Brazil; patients had longer ICU stay and greater frequency of hypoglycemia compared to studies in other settings</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Chambers, Balaban, Carlson, et al., 1989 #15368	<p>Geographical location: Philadelphia, PA</p> <p>Study dates: Nov 1, 1986–April 30, 1987</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p>	<p>Authors' basic description of system: A microcomputer reminder system prompting physicians to schedule periodic mammographic screenings for patients.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support:</p>	Usual care/no CDSS or KMS	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Up-to-date (at beginning of intervention period)— Control = 88 of 623 (14/.) Intervention = 87 of 639 (13.6%) P = 0.793 <p>Brought up-to-date (of those who start or who became due)— Control = 68 of 523 (12.1%) Intervention = 111 of 580 (19.1%) P = 0.001</p> <p>Up-to-date (at the end of the intervention period)—</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: A single site study located in an academic medical center</p> <p>Relatively older study involving computerized</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Duration of intervention: 6 months Sample type(s) (with N randomized for each): Patients 1262 User level of expertise/ proficiency: NR	<i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)		Control =128 of 623 (20.6%) Intervention = 170 of 639 (26.6%) P = 0.011 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	reminder that requires a print out in paper form Not a diverse patient population
		Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> - Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Christakis, Zimmerman, Wright, et al., 2001 #5448	Geographical location: Seattle, WA Study dates: - Baseline: March–September - Intervention: October–May (years NR) General setting: Academic Specific setting:	Authors' basic description of system: A point-of-care evidence-based message system presenting real-time evidence to providers based on their prescribing practice for otitis media. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i>	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prescription of antibiotics for otitis media that were for < 10 days (change in mean outcome before vs after)— I: 44.43% (standard error 4.24%)	General comments: Small sample size; possibility of diffusion of evidence between the experimental and control groups Outcomes expressed as change in individual

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 8 months</p> <p>Sample type(s) (38): Individual HCPs: > Training MDs: 29 > MDs: 7 > NPs: 2</p> <p>User level of expertise/ proficiency: NR</p>	<p>Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed</p>		<p>C: 10.48% (standard error 5.25%) Treatment of acute otitis media without antibiotics (change in mean outcome before vs after)— I: -4.33% C: -16.81% P < 0.01 - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>provider behavior; seasonal factors may have introduced trends in prescribing behavior since the baseline period was during summer, and the intervention was during fall and winter months</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Randomized using electronic random number generator; potential for diffusion of evidence between experimental and control arms</p> <p>Applicability/ generalizability: Intervention carried out in a resident teaching clinic of a large, academic hospital</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		by noting agreement: N c) <i>Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y d) <i>Auxiliary features:</i> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Cleveringa, Gorter, van den Donk, et al., 2008 #831 AND Cleveringa,	Geographical location: Primary care practices (55) throughout Netherlands Study dates: March 2005–August 2007 General setting: Community	Authors' basic description of system: Diabetes care protocol (DCP) characterized by delegation of routine tasks in diabetes care to a practice nurse, software that supports diabetes management, medical decisions and benchmarking.	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered	General comments: Details of the intervention are provided in a separate article; Cleveringa FGW, Gorter KG et al. (2007)

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Welsing, van den Donk, et al., 2010 #11	<p>Specific setting:</p> <ul style="list-style-type: none"> - Outpatient - Chronic <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Clinics/practices: 55 - Patients: 3391 <p>User level of expertise/ proficiency: NR</p>	<p>Source/origin of system: Commercially available</p> <p>Content:</p> <p><i>a) Objective(s):</i> Chronic disease management</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery:</p> <p><i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following 		<p>outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Intervention patients incurred higher total costs (€1415, \$1,967; P = NS) - Cost-effectiveness: Incremental cost per quality-adjusted year = € 38,243, \$27,808 per QALY gained <p>Calculated using a modified probabilistic diabetes model for Netherlands; model simulates the natural history of type 2 diabetes and calculates costs and QALYs for Dutch type 2 diabetic patients</p> <p>"In the long run, DCP is more costly and leads to only slightly more health than current care, although it does result in significantly lower CHD costs."</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Large, unselected primary care population receiving diabetes care at primary care practices across various locations in Netherlands; race/ethnicity is primarily Caucasian population</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>CDSS recommendations: Can't tell</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N/ - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Can't tell 			
Co, Johnson, Poon, et al., 2010,	Geographical location: 12 sites in Massachusetts, USA	Authors' basic description of system: EHR reminders and templates	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process	General comments: None

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#14409	<p>Study dates: December 2006 –July 2007</p> <p>General setting: Community</p> <p>Specific setting: - Outpatient - Chronic</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 412 - Clinics/practices/hospitals: 12 - Individual HCPs: > MDs [pediatricians]: 79</p> <p>User level of expertise/proficiency: Physicians have 6 weeks to get accustomed to the new CDSS features. They were given instructions through presentations at practice meetings and</p>	<p>in pediatric primary care to assess ADHD.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Diagnosis - Chronic disease management</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of</p>		<p>outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR Adherence to guidelines for recommended interval of followup: NR Patients with any visit at which ADHD was discussed— Control = 111 (53.9%) Intervention = 146 (70.9%) P = 0.04</p> <p>Patients with non-well child visit during which ADHD was discussed— Control = 69(33.5%) Intervention = 90 (43.7%) P = 0.27</p> <p>Patients with a well-child visit at which ADHD was discussed— Control = 46 (22.3%) Intervention = 59(28.2%) P = 0.33</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p>	<p>Quality assessment: Overall rating: Fair</p> <p>Comments: No details provided on randomization process, blinding or concealment</p> <p>Applicability/generalizability: Included children age 5 to 18 years—no distinction made in the analysis between young (age 5 to 12 years) and older children (age 13 to 18 years)</p> <p>All sites used the Partners Healthcare medical record</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	detailed email.	<p>clinician workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: ✗ - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: Satisfaction score with reminders and structured diagnosis and reminder template— Intervention = 4.3 Control = 3.3 P = 0.01 - HCP use: NR - Implementation of CDSS/KMS: The number of times a reminder appeared for a patient was not associated with increased likelihood of having a visit at which ADHD symptoms and treatments were discussed (P = 0.68) - Other: Physician focus groups revealed barriers for optimal use of the decision support tool, including (1) forgetting the templates were available, (2) preferring to use templates that they created themselves, and (3) finding the templates difficult to use efficiently. <p>They suggested that their template use may have been higher if (1) their availability within the long list of available templates was better highlighted, (2) they were introduced before having developed their own templates, and (3) the templates were simplified.</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Cobos, Vilaseca, Asenjo, et al., 2005 #11817	Geographical location: Barcelona, Spain Study dates: March 1999–April 2002 General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 1 year Sample type(s) (with N randomized for each): - Patients: 2221 - Clinics/practices/hospitals: 44 User level of expertise/proficiency: All practices had electronic health records; expertise with the specific computer module used in the intervention not specified	Authors' basic description of system: Clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for hypercholesterolemia management. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement</i> Justification for not complying Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Use of lipid lowering drugs— Intervention: 40.8% (n = 427) Usual Care: 59.1% (n = 677) Odds ratio: (95% CI) 0.37 (0.26, 0.52) P = 0.0001 - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: - Cost: Treatment cost per patient— Intervention: € 178 Control: € 237 ; Difference = € 59 (95%CI 34,83; p < 0.0001) Total costs per patient— Intervention: € 223 Control: € 283 - Cost-effectiveness: NR 6) Impact on HCP use and implementation:	General comments: None Quality assessment: Overall rating: Fair Comments: Loss to followup high (25%) in both arms of the study; unblinded, pragmatic trial Applicability/generalizability: Evaluated in 44 practices in Spain that were part of the public health system and were known to be using electronic health records; patient characteristics likely to be representative of public health clinics in Spain

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by 		<ul style="list-style-type: none"> - HCP acceptance: CDSS recommendations for lipid management were accepted in 71.3% of patient visits - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		periodic performance feedback: NR - CDSS accompanied by conventional education: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Davis, Wright, Chalmers, et al., 2007</p> <p>#2021</p>	<p>Geographical location: Seattle, WA</p> <p>Study dates: Nov 1999–Dec 2003</p> <p>General setting: - Academic - Community Intervention carried out at 2 sites: academic pediatric care center and pediatric clinic in the community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinicians</p> <p>Duration of intervention: 50 months at site 1 (academic primary care center) and 18 months at the site 2 (clinic in the community)</p> <p>Sample type(s) (44): Individual HCPs: 44 - Training MDs: 29 - MDs: 15</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: An evidence-based system that presented real-time evidence to providers based on prescribing practices for common pediatric conditions (acute otitis media, allergic rhinitis, sinusitis, constipation, pharyngitis, croup, urticaria and bronchiolitis).</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Percentage of prescriptions in accordance with evidence— At baseline: I: 38% C: 39% At conclusion of study period: I: 42% C: 40% Adjusted difference between the intervention and control groups: 8% (95% CI 1%, 15%) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: 36 providers based at the academic training facility and 8 providers based in a primary care clinic in the community</p> <p>Main outcome measure was change in prescribing behavior over the course of the trial</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Randomization using computer generated random numbers</p> <p>Applicability/generalizability: Study participants were primarily English speaking, fairly well educated and were in an urban and semiurban</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as 			<p>setting</p> <p>Intervention was implemented at a large academic training facility and a community-based clinic staffed by recent graduates of the academic center</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Del Fiol, Haug, Cimino, et al., 2008 #938	<p>Geographical location: Utah and Idaho</p> <p>Study dates: 5/2007–11/2007</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Individual HCPs: > MDs: 90 - Infobutton sessions: 3729</p> <p>User level of expertise/proficiency: Study clinicians had to have conducted 10 or</p>	<p>Authors' basic description of system: Infobuttons are decision support tools that provide links within electronic medical record systems to relevant content in online information resources.</p> <p>Two studies assessed the effectiveness of two versions of the medication order entry infobuttons—one that provided context-specific topic links and the other that provided general content through nonspecific links.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Other: To answer clinicians' questions at the point of care <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p>	<p>Comparator(s): Another CDSS/KMS:</p> <p>1) Intervention group: Clinicians had access to topic links</p> <p>2) Control group: Clinicians had access to nonspecific links</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: Subjects reported a high positive clinical impact (i.e., decision enhancement or knowledge update) in 62% of the sessions</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: Time spent seeking information (median session duration) — Intervention: 35.5 seconds Control: 43 seconds, $p = 0.008$</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Inadequate description of study population, incomplete and ambiguous reporting of findings, nonblinded participants, low response rate with followup survey</p> <p>Applicability/generalizability: Well-established health IT infrastructure and history of being an early adopter of health IT</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	more medication infobutton sessions; infobuttons have been implemented in the EMR since September 2001 for the laboratory results, problem list, and medication-ordering modules	<p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather</p>		<p>NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR</p> <p>- HCP satisfaction: Postsurvey study (n = 25 participants, with a total of 115 (9.9%) individual responses)—</p> <p>The information-seeking success rate was equally high in both groups. In the control group, 59 (89%) of the responses indicated that the information being sought was found compared to 41 (84%) in the intervention group, p = 0.9.</p> <p>- HCP use: Median number of infobutton sessions— Intervention: 22 Control: 17.5, p = 0.21</p> <p>- Implementation of CDSS/KMS: NR</p>	<p>Locally developed system</p> <p>No patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>than inaction: Can't tell</p> <ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p>d) <i>Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Demakis, Beauchamp, Cull, et al., 2000 #5631	<p>Geographical location: 12 VA medical centers, US</p> <p>Study dates: 1/31/1995–6/30/1996</p> <p>General setting: VA medical centers</p> <p>Specific setting: Outpatient (primary care), mostly for chronic care.</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Firms or team system and</p>	<p>Authors' basic description of system: Computerized system to remind physicians to provide appropriate care for 13 standards of care (SOCs).</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p>a) <i>Objective(s):</i></p> <ul style="list-style-type: none"> - Chronic disease management - Preventive care - Immunization <p>b) <i>Relationship to point of care:</i> Synchronous</p>	Usual care/no CDSS or KMS	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Visit-specific adherence rate to all SOCs, # (% adherent)— Intervention: 12,759 (17.9%) Control: 14,013 (12.2%) OR 1.57; 95% CI: 1.45, 1.71, P-value: <0.001 <p>Significantly higher adherence rates were found for 9 of the 13 SOCs examined individually</p> <p>General adherence rate to all SOC, # (% adherent)—</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: VA study; locally developed system; no patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>half-day blocks of residents</p> <p>Duration of intervention: 17 months</p> <p>Sample type(s) (with N randomized for each): - Patients: During the course of the study, the residents cared for 18,700 unique patients, and 12,989 of these patients were eligible for at least 1 of the investigated SOC - Individual HCPs: > Training MDs, residents: 299 initially randomized, 275 residents completed the study</p> <p>User level of expertise/proficiency: Intervention subjects received an introduction to the reminder system that consisted of an education session that lasted 1 to 2 hours and included a demonstration of how the reminder system worked</p>	<p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> - Integrated with CPOE/EHR - Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell</p>		<p>Intervention: 19,373 (58.8%) Control: 20,575 (53.5%) OR 1.24; 95% CI: 1.08,1.42, p = 0.002</p> <p>General adherence rate to pneumococcal vaccination— Intervention: 1759 (12.7%) Control: 1688 (4.3%) OR 3.26; 95% CI: 2.09,5.09, p < 0.001</p> <p>Significantly higher adherence rates were found for 5 of the 13 SOC examined individually</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
Dexter, Perkins, Overhage, et al., 2001 #5255	<p>Geographical location: Indianapolis, IN</p> <p>Study dates: 5/1/1997–10/31/1998</p> <p>General setting: Academic (urban public teaching hospital)</p> <p>Specific setting: Inpatient – non-ICU;</p>	<p>Authors' basic description of system: During the order-entry process, the system provided clinical-decision support to physicians and medical students by means of rule-based reminders, which were call care rules regarding the use of: (1) pneumococcal vaccination, (2) influenza vaccination, (3) aspirin for cardiovascular</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Percentage of hospitalizations during which therapy was ordered for an eligible patient—Pneumococcal vaccine: Intervention: 35.8% Control: 0.8% ($p < 0.001$) Influenza vaccine: 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Academic setting;</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>mostly acute care</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 18 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 6371 - Inpatient teams: 8 (4 in the intervention group, 4 in the control group) - Individual HCPs: > MDs: 202 - Hospitalizations: 10,065</p> <p>User level of expertise/ proficiency: The study hospital already had computer-generated reminder systems</p>	<p>disease, and (4) prophylactic subcutaneous heparin.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Immunization - Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y</p>		<p>Intervention: 51.4% Control: 1.0% ($p < 0.001$)</p> <p>Subcutaneous heparin: Intervention: 32.2% Control: 18.9% ($p < 0.001$)</p> <p>Aspirin at discharge: Intervention: 36.4% Control: 27.6% ($p < 0.001$)</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>locally developed system; site has a well-established health IT infrastructure and historically an early adopter of health IT</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Dexter,	Geographical location:	Authors' basic description of	Comparator(s):	1) Impact on clinical outcomes: NR	General

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Perkins, Maharry, et al., 2004 #3730	Indianapolis, IN Study dates: 11/1/199 –12/31/1999 General setting: Academic Specific setting: Inpatient —non-ICU Study design: RCT, cluster randomization Unit of randomization: General medical physician teams Duration of intervention: 14 months Sample type(s) (with N randomized for each): - Patients: 3777 - Physician teams: 8 - Individual HCPs: > Training MDs: 212 User level of expertise/ proficiency: NR	system: Computerized physician standing orders for influenza and pneumococcal vaccines were compared with computerized reminders to determine the impact on inpatient vaccination rates. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Immunization <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y	Another CDSS/KMS 1) Intervention: Computerized physician standing orders 2) Control: Computerized physician reminders	2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Vaccine administration: Influenza vaccinations, # (%)— Reminder: 137 of 463 (30%) Standing order: 163 of 385 (42%) p < 0.001 Pneumococcal vaccinations, # (%)— Reminder: 132/423 (31%) Standing order: 209/406 (51%) p < 0.001 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	comments: None Quality assessment: Overall rating: Good Applicability/ generalizability: Academic setting; no patient- centered outcomes Site has a well- established health IT infrastructure and was an early adopter of health IT

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		feedback: N - CDSS accompanied by conventional education: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Downs, Turner, Bryans, et al., 2006 #2818	<p>Geographical location:</p> <ul style="list-style-type: none"> - Central Scotland - London, England <p>Study dates: 1999–2002</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: General practices</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Patients: 13,068 registered patients - Practices: 36 workshops, 10 control <p>User level of expertise/proficiency: NR; practices had to be using EMIS or GPASS software for patient records</p>	<p>Authors' basic description of system: The decision support software was written inside the existing electronic medical record software and produced prompts for the investigation and management of dementia.</p> <p>Source/origin of system: Commercially available (EMIS or GPASS software for patient records)</p> <p>Content:</p> <p><i>a) Objective(s):</i></p> <ul style="list-style-type: none"> - Diagnosis - Chronic disease management <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery:</p> <p><i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of</p>	<p>Comparator(s): Another CDSS/KMS</p> <p>1) Electronic CD tutorial</p> <p>2) Decision support software (DSS)</p> <p>3) Small group workshops at the study practices</p> <p>4) Control (no intervention)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Difference in # of patients aged ≥ 75 diagnosed with dementia before and after intervention ($n = 280$), with p-value compared to control— Tutorial: 6.55 ($p = 0.02$) DSS: 1.80 ($p = 0.18$) Workshop: 7.31 ($p = 0.01$) <p>DSS ($p = 0.01$) and practice-based workshops ($p = 0.01$) both significantly improved rates of detection compared with control. There were no significant differences by intervention in the measures of concordance with guidelines.</p> <p>The number of people identified as having dementia after the interventions represents 31% of all cases diagnosed in the practice-based workshops arm, 20% in the electronic tutorial arm, 30% in the DSS arm, and 11% in the control arm</p> <ul style="list-style-type: none"> - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Study conducted in Scotland and England</p> <p>Study practices part of a nationalized healthcare system</p> <p>Commercially available system</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <i>d) Auxiliary features:</i> - Local user involvement in development process: Can't		delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Can't tell			
Dykes, Carroll, Hurley, et al., 2010 #15221	Geographical location: 4 sites, Boston, Massachusetts, USA Study dates: January 1, 2009 to June 30, 2009 General setting: - Academic - Community Specific setting: Inpatient Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 6 months Sample type(s) (with N randomized for each): - Patients: 10264	Authors' basic description of system: Fall prevention tool kit (FPTK) using health information technology (HIT) assesses fall risk and provides reminders to care providers. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Diagnosis - Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> - Online access - Paper-based	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Adherence to protocol through assessment of Morse Falls Scale completion— Control: 81% Intervention: 94% For all patients: Baseline fall rate per 1000 patient days— Control: 5.56 Intervention: 5.85 P = 0.61 Number of patients with falls per total number of patients— Control: 87 of 5104 Intervention: 67 of 5160 P = 0.02 Total number of falls— Control: 89 Intervention: 71 Number of repeat falls— Control: 2 Intervention: 4	General comments: Specific details of the CDSS unclear Quality assessment: Overall rating: Fair Comments: No details provided on randomization process, blinding or concealment Interventions not blinded Applicability/generalizability: Studies were conducted in academic and community medical centers

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>- Clinics/practices/hospitals: 8 units</p> <p>User level of expertise/proficiency: NR</p>	<p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N</p>		<p>P = 0.46 Fall rate (95% CI) per 1000 patient-days— Control: 4.64 (3.86 to 5.57) Intervention: 3.48 (2.83 to 4.28) P = 0.04 Fall rate (95% CI) per 1000 patient-days adjusted for site, sex, race, insurance, age— Control: 4.18 (3.45 to 5.06) Intervention: 3.15 (2.54 to 3.90) P = 0.04</p> <p>For patients aged < 65 years: Baseline fall rate per 1000 patient days— Control: 4.93 Intervention: 4.73 P = 0.81 Number of patients with falls per total number of patients— Control: 36 of 2595 Intervention: 33 of 2405 P = 0.72 For patients aged ≥ 65 years: Baseline fall rate per 1000 patient days— Control: 5.22 Intervention: 5.97 P = 0.34 Number of patients with falls per total number of patients: Control: 51 of 2509 Intervention: 34 of 2755 P = 0.004</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment</p>	<p>All 4 sites used a single health care system, i.e. Partners Healthcare system</p> <p>Multi-intervention makes it harder to assess the effectiveness of individual intervention leading to potential bias</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<ul style="list-style-type: none"> ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: Fall prevention tool kit outputs were printed for 93.2% of patients. - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Eccles, McColl, Steen, et al., 2002</p> <p>#2</p> <p>Comparison 1 of 2</p>	<p>Geographical location: 60 sites in Northeast England</p> <p>Study dates: NR</p> <p>General setting: Community</p> <p>Specific setting: - Outpatient - Chronic disease management</p> <p>Study design: Before and after pragmatic cluster; pragmatic cluster randomized controlled trial using a 2 x 2 incomplete block design</p> <p>Unit of randomization: General practice</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): General practices: 62</p> <p>User level of</p>	<p>Authors' basic description of system: The system anticipated clinicians' requirements by using information contained within a patient's computerized record to trigger the guideline and present patient scenarios.</p> <p>Source/origin of system: Commercially available, adapted for this study's purposes</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i></p>	<p>Comparator(s): Another CDSS/KMS</p> <p><u>1) Computerized guidelines for the management of asthma (with control patients for the management of angina)</u></p> <p>2) Computerized guidelines for the management of angina (with control patients for the management of asthma)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Process of care for patients with asthma based on clinical records before and after introduction of computerized decision support system—</p> <p>Number (%) of patients consulting before and after intervention period: Intervention n = 1200 Control n = 1163 OR (95% CI)</p> <p>Lung function assessed: All patients I: 516 (43); 511 (43) C: 492 (42); 517 (45) OR: 0.94 (0.67 to 1.33)</p> <p>Compliance checked: All patients I: 426 (36); 442 (37) C: 446 (38); 471 (41) OR: 0.82 (0.58 to 1.15)</p> <p>Inhaler technique assessed: All patients I: 203 (17); 224 (19) C: 234 (20); 262 (23) OR: 0.8 (0.5 to 1.28)</p> <p>Asthma education, action plan, or both: All patients I: 79 (7); 60 (5) C: 108 (9); 78 (7) OR: 0.84 (0.4 to 1.74)</p>	<p>General comments: Authors note that the lack of effect associated with the DSS was probably due to low levels of use of the software.</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Unblinded, outcomes assessment not validated, comparator introduces bias</p> <p>Applicability/generalizability: Comparator (the same DSS but for a different condition) may bias the estimate in the direction of no difference</p> <p>Study conducted in England</p> <p>Study practices were chosen</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	expertise/ proficiency: Intervention practices were invited to send two members to a one-day workshop on using the system (training materials were supplied)	Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as		Smoking status known: All patients I: 285 (24); 370 (32) C: 305 (26); 367 (32) OR: 0.97 (0.65 to 1.45) Smoking cessation advice or nicotine replacement therapy: All patients I: 57 (5); 81 (7) C: 68 (6); 103 (9) OR: 0.75 (0.45 to 1.26) - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: "Levels of use of the software were low." - Implementation of CDSS/KMS: NR	because their computer systems were extensively used

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell			
Eccles, McColl, Steen, et al., 2002 #2 Comparison 2 of 2	Geographical location: 60 sites in Northeast England Study dates: NR General setting: Community Specific setting: - Outpatient - Chronic disease management Study design: Before and after pragmatic cluster; pragmatic cluster randomized controlled trial using a 2 x 2 incomplete block design Unit of randomization: General practice Duration of intervention: 12 months	Authors' basic description of system: The system anticipated clinicians' requirements by using information contained within a patient's computerized record to trigger the guideline and present patient scenarios. Source/origin of system: Commercially available, adapted for this study's purposes Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i>	Comparator(s): Another CDSS/KMS 1) Computerized guidelines for the management of asthma (with control patients for the management of angina) <u>2) Computerized guidelines for the management of angina (with control patients for the management of asthma)</u>	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Process of care for patients with angina based on clinical records before and after introduction of computerized decision support system Number (%) of patients consulting before and after intervention period Intervention n = 1117 Control n = 1218 OR (95% CI) Blood pressure recorded: All patients I: 859 (77); 889(80) C: 935 (77); 969 (80) OR: 1.01 (0.74 to 1.39) Exercise recorded or advised: All patients I: 99 (9); 113 (10) C: 156 (13); 153 (13) OR: 0.91 (0.55 to 1.50) Weight recorded or advised: All patients I: 253 (23); 282 (26)	General comments: Authors note that the lack of effect associated with the DSS was probably due to low levels of use of the software. Quality assessment: Overall rating: Fair Comments: Unblinded, outcomes assessment not validated, comparator introduces bias Applicability/generalizability: Comparator (the same DSS but for a different condition) may bias the estimate in the direction of

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each): General practices: 62</p> <p>User level of expertise/ proficiency: Intervention practices were invited to send two members to a one-day workshop on using the system (training materials were supplied)</p>	<p>System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can’t tell - Justification of decision support via provision of reasoning: Can’t tell - Justification of decision support via provision of</p>		<p>C: 288 (24); 362 (30) OR: 0.86 (0.54 to 1.35)</p> <p>Smoking status known: All patients I: 222 (20); 243 (22) C: 261 (22); 378 (32) OR: 0.68 (0.42 to 1.11)</p> <p>Smoking education given: All patients I: 33 (3); 47 (4) C: 41 (3); 48 (4) OR: 1.08 (0.86 to 1.77)</p> <p>12 lead electrocardiogram recorded: All patients I: 162 (15); 154 (14) C: 197 (16); 164 (14) OR: 1.01 (0.68 to 1.52)</p> <p>Exercise electrocardiogram recorded: All patients I: 46 (4); 28 (3) C: 46 (4); 30 (3) OR: 1.01 (0.56 to 1.80)</p> <p>Haemoglobin concentration recorded: All patients I: 322 (29); 371 (33) C: 355 (29); 400 (33) OR: 1.01 (0.72 to 1.42)</p> <p>Thyroid function recorded: All patients I: 192 (17); 214 (19) C: 215 (18); 264 (22) OR: 0.83 (0.62 to 1.12)</p> <p>Cholesterol or other lipid concentrations recorded: All patients I: 395 (35); 482 (43)</p>	<p>no difference</p> <p>Study conducted in England</p> <p>Study practices were chosen because their computer systems were extensively used</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
		research evidence: Can't tell <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell		C: 427 (35); 574 (47) OR: 0.85 (0.65 to 1.12) Blood glucose or HbA1c concentrations recorded: All patients I: 221 (20); 300 (27) C: 267 (22); 334 (27) OR: 0.96 (0.67 to 1.39) - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: "Levels of use of the software were low." - Implementation of CDSS/KMS: NR	
Emery, Morris, Goodchild, et al., 2007 #1851	Geographical location: East Anglia, UK Study dates: NR	Authors' basic description of system: The GRAIDS software links a user-friendly pedigree-drawing tool to patient-specific	Comparator(s): Another CDSS/KMS 1) Intervention	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care	General comments: None Quality

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Practice</p> <p>Duration of intervention: 12 months minimum</p> <p>Sample type(s) (with N randomized for each): Clinics: 45</p> <p>User level of expertise/ proficiency: Each intervention practice selected a clinician to serve as the “lead clinician,” and they received a 90-minute interactive training session to learn about the GRAIDS software</p>	<p>management advice regarding a family history of breast/ovarian and colorectal cancer.</p> <p>Source/origin of system: Commercially available</p> <p>Content: a) <i>Objective(s):</i> Other: referral for genetic counseling b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: a) <i>Delivery format:</i> Not clearly described b) <i>Delivery mode:</i> NR</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: a) <i>General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell b) <i>Clinician-system interaction features:</i> - Automatic provision of</p>	<p>1: Adaptive subgroup, with opportunity for practice to assess and resolve problems using the software</p> <p>2) Intervention 2: Fixed subgroup, with no opportunity to assess and resolve problems using software</p> <p>3) Comparison: “Best practice” (practitioners attended a 45-minute educational session on cancer genetics and received a copy of regional guidelines)</p>	<p>ordered/completed: NR</p> <p>- Recommended clinical study or referral ordered: Practice referral rate, mean (SD) per 10,000 patients registered patients per year— Intervention (n = 23): 6.2 (3.1) Control (n = 22): 3.2 (2.8) Mean difference: 3.0 referrals; 95% CI: 1.2, 4.8; p = 0.001</p> <p>Referrals from GRAIDS practices were more likely to be consistent with referral guidelines (OR 5.2; 95% CI: 1.7, 15.8; p = 0.006)</p> <p>Patients referred from GRAIDS practices had lower cancer worry scores at the point of referral (p = 0.02)</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: The intervention increased GPs’ confidence in managing familial cancer</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and</p>	<p>assessment: Overall rating: Fair</p> <p>Comments: Incomplete and ambiguous reporting throughout</p> <p>Applicability/ generalizability: Study conducted in England</p> <p>Unclear how DSS was integrated into practice</p> <p>Commercially available system</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>decision support as part of clinician workflow: Can't tell</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: Can't tell - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by 		<p>implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: Lead clinicians' confidence in managing people with a family history of cancer increased significantly after training, and this increase was maintained at 12 months. <p>Their attitudes toward the software were generally positive, such that it was felt to be simple, easy, beneficial and cost-effective and these positive attitudes remained at 12 months. However, there was some reduction over time, in agreement with the statement that the software enhanced consultations (mean score 2.1 [0.8] post-training; 3.0 [1.7] at 12 months; mean change 0.8 95% CI 0.1 to 1.6; p = 0.04; n = 26) and persistent agreement that it would prolong consultations (mean score 2.5 [1.2] post training; mean score 2.3 [1.2] at 12 months).</p> <p>Median consultation time with the lead clinician was 28 min.</p> <ul style="list-style-type: none"> - HCP use: Software used with patients 219 times, mean use of 8.27 per 10,000 registered patients per year (intervention only) <p>Software use at 12 months per 10,000 registered patients per year, mean, [SD]</p> <p>Intervention 1 (adaptive practices): 8.8 [4.1]</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		conventional education: Y		Intervention 2 (fixed practices): 7.8 [4.7] Mean difference 0.9; 95% CI (-2.8, -4.8); p value = 0.60 - Implementation of CDSS/KMS: NR	
Etchells, Adhikari, Cheung, et al., 2010 #14484	Geographical location: Toronto, Ontario, Canada Study dates: February to May 2006 General setting: Academic Specific setting: Inpatient Study design: RCT, parallel group Unit of randomization: Other: critical abnormal results Duration of intervention: 4 months Sample type(s) (with N randomized for each): - Patients: 108 - Events: 165 critical values	Authors' basic description of system: Automated system for paging critical laboratory values from the laboratory information system directly to physician. Source/origin of system: Commercially available Content: a) <i>Objective(s):</i> Lab test ordering b) <i>Relationship to point of care:</i> Asynchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: a) <i>Delivery format:</i> Alphanumeric pager b) <i>Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of	Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: Median physician response time (IQR)— Primary analysis: comparison of critical values with measurable response time (n = 165): Intervention = 16 min (IQR 2–141) Control = 39.5 min (IQR 7–104.5) P = 0.33 Secondary analysis: comparison of critical values with documented time of order (n = 141): Intervention = 12 min (IQR 1–124) Control = 36 min (IQR 5–97) P = 0.20 Secondary analysis: Comparison of critical values, using imputed data for missing values (n = 226): Intervention = 30 min (IQR 2–155)	General comments: None Quality assessment: Overall rating: Fair Comments: High dropout rate/exclusions Learning bias Applicability/generalizability: Single study conducted in an academic medical center Short study duration Residents were the targeted system users, and total number of subjects not disclosed

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/proficiency: NR	<p>CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N 		<p>Control = 43 min (IQR 5–132) P = 0.67</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Feldstein, Elmer, Smith, et al., 2006 #2858 Comparison 1 of 2	Geographical location: Pacific Northwest, US Study dates: 1999 General setting: Community (nonprofit HMO) Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 6 months Sample type(s) (with N randomized for each): - Patients: 327	Authors' basic description of system: Patient-specific clinical guideline advice to the primary care provider delivered by electronic medical record (EMR) message versus electronic reminder to the provider plus an educational letter mailed to the patient. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR	Comparator(s): Another CDSS/KMS 1) Usual care <u>2) EMR reminders to physician plus letter sent to patients</u> 3) EMR reminders to physicians	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: See below. - Recommended treatment ordered/prescribed: At 6 months, provider reminder resulted in 51.5% of patients receiving BMD measurement or osteoporosis medication. Provider reminder plus patient education resulted in 43.1%. Usual care resulted in 5.9% ($p < 0.001$). The effect of provider advice combined with patient education was not significantly different from provider advice alone ($p = 0.88$). - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Well-established health IT infrastructure and history of being an early adopter of health IT Locally developed system No patient-centered outcomes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<ul style="list-style-type: none"> - Clinics/practices/hospitals: 15 - Individual HCPs: > MDs: 159 <p>User level of expertise/proficiency: NR</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><u>EMR reminders to physicians plus letter to patients</u></p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision 		<p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>support via provision of reasoning: Can't tell</p> <p>- Justification of decision support via provision of research evidence: Y</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Y</p> <p>- Provision of decision support results to patients as well as providers: Y</p> <p>- CDSS accompanied by periodic performance feedback: Can't tell</p> <p>- CDSS accompanied by conventional education: Can't tell</p>			
Feldstein, Elmer, Smith, et al., 2006 #2858 Comparison 2 of 2	<p>Geographical location: Pacific Northwest, US</p> <p>Study dates: 1999</p> <p>General setting: Community (nonprofit HMO)</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization:</p>	<p>Authors' basic description of system: Patient-specific clinical guideline advice to the primary care provider delivered by electronic medical record (EMR) message versus electronic reminder to the provider plus an educational letter mailed to the patient.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i></p>	<p>Comparator(s): Another CDSS/KMS</p> <p>1) Usual care</p> <p>2) EMR reminders to physician plus letter sent to patients</p> <p><u>3) EMR reminders to physicians</u></p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: See below.</p> <p>- Recommended treatment ordered/prescribed: At 6 months, provider reminder resulted in 51.5% of patients receiving BMD measurement or osteoporosis medication. Provider reminder plus patient education resulted in 43.1%. Usual care resulted in 5.9% ($p < 0.001$). The effect of provider advice combined with patient education was not significantly different from provider advice alone (p</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Well-established health IT infrastructure and history of being an early adopter of health IT</p> <p>Locally</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Patient</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 327 - Clinics/practices/hospitals: 15 - Individual HCPs: > MDs: 159</p> <p>User level of expertise/proficiency: NR</p>	<p>Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <u>EMR reminders only</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p>		<p>= 0.88). - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>developed system</p> <p>No patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			
Feldstein, Smith, Perrin, et al., 2006 #2502	Geographical location: NR Study dates: 9/6/2004–12/20/2004 General setting: NR Specific setting: Outpatient	Authors' basic description of system: The EMR intervention consisted of a patient-specific electronic message to the PCP from the chair of the patient safety committee. The message referenced internal and external guideline resources, recommended specific tests, and provided a	Comparator(s): Another CDSS/KMS: 1) Usual care (UC) 2) EMR messages to PCP	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: By day 9 (immediately before the second reminder)— 34 (14.3%) of 237 patients in the UC	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Primary care clinic</p> <p>Duration of intervention: 14 weeks</p> <p>Sample type(s) (with N randomized for each): - Patients: 961 - Clinics: 15 (4 usual care, 4 EMR, 3 automated voice messages, 4 pharmacy team) - Individual HCPs: > MDs: 200</p> <p>User level of expertise/ proficiency: NR</p>	<p>sample letter that the PCP could send to the patient to request that he or she go to the laboratory.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of</p>	<p>3) Automated voice messages (AVM) to patients</p> <p>4) Pharmacy team outreach</p>	<p>group, 61 (31.1%) of 196 patients in the EMR group, 117 (43.8%) of 267 patients in the AVM group, and 184 (70.5%) of 261 patients in the pharmacy team outreach group had completed all monitoring ($p < 0.001$) All differences among arms were statistically significant at $p < 0.05$</p> <p>At 25 days (approximately 2 weeks after the second reminder)— EMR group: 95 (48.5%) of 196 AVM group: 177 (66.3%) of 267 Pharmacy team group: 214 (82.0%) of 261 UC: 53 (22.4%) of 237 All differences among arms were statistically significant at $P < 0.05$</p> <p>Hazard ratios for completing laboratory monitoring compared with usual care— EMR: 2.5 (95% CI: 1.8-3.5) P value: <0.01 AVM: 4.1 (95% CI: 3.0-5.6) P value: <0.01 Pharmacy team: 6.7 (95% CI: 4.9-9.0) P value: <0.01</p> <p>- Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered</p>	<p>Well-established health IT infrastructure and EMR used since 1996</p> <p>Locally developed system</p> <p>Multiple relevant comparisons</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>clinician workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 		<p>outcomes:</p> <p>Patient satisfaction: The qualitative interviews found that all 3 interventions were acceptable to PCPs and patients.</p> <p>5) Impact on economic outcomes:</p> <p>NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Field, Rochon, Lee, et al., 2009 #341	<p>Geographical location: Canada</p> <p>Study dates: NR</p> <p>General setting: Academic</p> <p>Specific setting: Long-term facility</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Long-stay units</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 833 - Long-stay units: 22</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: We developed a CDSS built on a commercially purchased CPOE system that provided recommendations for long-term care residents with renal insufficiency.</p> <p>The CDSS included 4 types of alerts: (1) alerts recommending maximum total daily dose of the medication, (2) alerts recommending maximum frequency of administration, (3) alerts recommending that the medication be avoided, and (4) alerts notifying prescribers that no creatinine clearance could be calculated for this resident because of missing serum creatinine test results or weight .</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Noncommittal acknowledgement</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: RR (95% CI) for the alerts and overall, compared to control: Dose: 0.95 (0.83, 1.1) Frequency: 2.4 (1.4, 4.4) Avoid: 2.6 (1.4, 5.0) Missing info: 1.8 (1.1, 3.4) Overall: 1.2 (1.0, 1.4) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Canadian study</p> <p>Modified, commercially available system</p> <p>Longstanding use of EHR and CPOE, and participants had prior experience with the CDSS</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 			
Fihn, McDonell, Vermes, et al., 1994 #6979	<p>Geographical location: 5 sites in US</p> <p>Study dates: NR</p> <p>General setting: Academic (2 university clinics and 3 VA clinics)</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of</p>	<p>Authors' basic description of system: Computer-generated recommendations for scheduling next anticoagulation clinic visit.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Other: scheduling next clinic visit <i>b) Relationship to point of care:</i> Synchronous</p>	Usual care/no CDSS or KMS	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: NR - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: After adjusting for intensity of anticoagulation, the risks of bleeding and thromboembolic complications in the intervention group were not significantly different from those in the control group (RR = 1.1 [95% CI = 0.5, 2.3] and 2.1 [95% CI = 0.5, 8.4], respectively) <p>Three intervention patients and three control patients experienced a second</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Inadequate reporting throughout; no intention-to-treat analysis</p> <p>Applicability/</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>randomization: Patient</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Patients: 849 randomized, 19 withdrew; 620 with at least one visit where a recommendation was generated and a subsequent followup visit was completed - Clinics: 5</p> <p>User level of expertise/ proficiency: NR</p>	<p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Not clearly described <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell <i>c) Communication content</i></p>		<p>complication during the study.</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Followup interval (weeks, mean \pm SD)— Intervention (n = 301) Recommended: 5.5 ± 2.1 Scheduled: 4.4 ± 1.8 Actual: 4.4 ± 1.8 Control (n = 319) Recommended: 5.2 ± 2.2 Scheduled: 3.5 ± 1.4 Actual: 4.1 ± 1.8 P < 0.05 - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Number of visits with recommendation (n = 2472)— Number of modifications (%) Total: 992 (40) Longer than recommended: 99 (10)</p>	<p>generalizability: Insufficient reporting to determine generalizability of clinics; locally developed CDSS</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N		Shorter than recommended: 893 (90) Mean length of modification (weeks)— Longer than recommended: 2.2 Shorter than recommended: 3.5 Reason for modification (%)— Scheduling convenience: 131 (13) Interval not acceptable: 807 (81) Other: 54 (5) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	
Fiks, Hunter, Localio, et al., 2009 #360	Geographical location: 20 sites in the US from the Pediatric Research Consortium, a multistate, hospital-owned, primary care practice-based research Study dates: 10/1/200–3/31/2007	Authors' basic description of system: Influenza vaccine alerts. Source/origin of system: Commercially available Content: <i>a) Objective(s):</i> Immunization <i>b) Relationship to point of care:</i> Synchronous	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Captured opportunities for vaccination increased 3.8% from 12.7% to 16.3% at control practices and 4.8% from 14.4% to 19.2% at intervention sites, a difference of 1% (95% CI: -2.4% to 4.9%)	General comments: None Quality assessment: Overall rating: Fair Comments: Statistical analysis plan does not appear

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>General setting: Academic and community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Pediatric practice</p> <p>Duration of intervention: - 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 11,919 - Practices: 20 - Clinic visits: 23,418</p> <p>User level of expertise/proficiency: All practices had previously implemented the ambulatory EHR EpicCare, and intervention sites received a presentation on how to use the system; physicians also received a copy of</p>	<p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell <i>c) Communication content</i></p>		<p>With standardization for selected covariates, overall rates of captured opportunities increased from 14.4% to 18.6% at intervention sites and from 12.7% to 16.3% at control sites, a 0.3% (95% CI: -1.9 to 2.5%) greater improvement</p> <p>Rates of up-to-date influenza vaccination increased from 44.2% to 48.2% at control sites and from 45.0% to 53.0% at intervention sites, a 4.0% (95% CI: 1.3% to 9.1%) greater but not statistically significant improvement</p> <p>With standardization for selected covariates, up-to-date vaccination rates increased similarly by 3.4% (95% CI:-1.4% to 9.1%), a statistically nonsignificant improvement - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>to differentiate between primary and secondary outcomes or to account for multiple tests. Authors’ conclusions don’t appear to be fully supported by the findings.</p> <p>Applicability/generalizability: Primary care practice based research network; commercially available system; no patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	the presentation	<p><i>features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
<p>Filippi, Sabatini, Badioli, et al., 2003</p> <p>#4586</p>	<p>Geographical location: Italy</p> <p>Study dates: 5/1/200 –11/30/2001</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p>	<p>Authors' basic description of system: Electronic reminders to physicians for antiplatelet drug prescribing in diabetic patients.</p> <p>Source/origin of system: NR</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Patients with antiplatelet drug prescription at the end of the followup— 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Insufficient reporting on</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Study design: RCT, cluster randomization Unit of randomization: Clinician Duration of intervention: 6 months Sample type(s) (with N randomized for each): - Patients: 15,343 (7,313 control, 8,030 intervention) - Individual HCPs: > MDs, GPs: 300 User level of expertise/proficiency: NR	<i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N		Control: 2,242 (30.7%) Intervention: 3,012 (37.5%) (OR 1.99; 95% CI: 1.79, 2.22) - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: Data showed that 128 of 150 GPs activated the electronic prompt - Implementation of CDSS/KMS: NR	randomization, allocation concealment, outcomes assessment, blinding Applicability/generalizability: Study conducted in Italy

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y 			
Fitzmaurice, Hobbs, Murray, et al., 2000 #5655	<p>Geographical location: 12 sites in Birmingham, England</p> <p>Study dates: 02/1995–02/1996</p> <p>General setting: Community</p>	<p>Authors' basic description of system: A novel, complete care package comprising near-patient testing (NPT) and CDSS for oral anticoagulation monitoring within nurse-led primary care clinics.</p> <p>Source/origin of system: Commercially available</p>	<p>Comparator(s): Another CDSS/KMS</p> <p>1) Near-patient testing for INR along with CDSS</p> <p>2) Two sets of control patients:</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Time spent in the INR range showed significant 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Insufficient and</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Specific setting: Outpatient</p> <p>Study design: Other RCT: 12 primary care practices randomized; patients also randomized, with 2 control groups (intrapractice and interpractice controls)</p> <p>Unit of randomization: - Clinic - Patient</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 367 - Clinics: 12</p> <p>User level of expertise/proficiency: Intervention clinicians received an afternoon session on practical instruction in the use of the CDSS and NPT and one on-site visit was provided</p>	<p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> NR <i>b) Delivery mode:</i> NR</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support</p>	<p>(a) patients randomized to no intervention within intervention practices and (b) patients in practices allocated to no intervention</p>	<p>improvement for patients in the intervention group ($p = 0.008$) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: The intervention cost, on average, was approximately \$160 per patient per year more than for controls - Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>ambiguous reporting of methods, atypical (and not clearly justified) selection of controls</p> <p>Applicability/generalizability: Study conducted in England; multifaceted intervention; uncertain generalizability</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>at time and location of decision making: Can't tell</p> <p>- Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i></p> <p>- Provision of a recommendation, not just an assessment: Y</p> <p>- Promotion of action rather than inaction: Can't tell</p> <p>- Justification of decision support via provision of reasoning: Can't tell</p> <p>- Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Can't tell</p> <p>- Provision of decision support results to patients as well as providers: Can't tell</p> <p>- CDSS accompanied by periodic performance feedback: Can't tell</p> <p>- CDSS accompanied by conventional education: Y</p>			
Flanagan, Doebbeling, Dawson, et al., 1999 #6163	<p>Geographical location: Iowa</p> <p>Study dates: NR</p>	<p>Authors' basic description of system: Online immunization reminders.</p> <p>Source/origin of system:</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: Compliance with</p>	<p>General comments: None</p> <p>Quality assessment:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, crossover</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 10 months</p> <p>Sample type(s) (with N randomized for each): - Patients: NR - Individual HCPs: > MDs: 30 > Trainee MDs: 55</p> <p>User level of expertise/proficiency: Nursing staff received 2 hours of training, and resident and staff physicians received 1 hour of training; both groups also received assistance during the first month of use</p>	<p>Locally developed</p> <p>Content: <i>a) Objective(s):</i> Immunization</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Noncommittal acknowledgement</p> <p>Information delivery: <i>a) Delivery format:</i> Online access</p> <p><i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following</p>		<p>guidelines was improved significantly for tetanus and for hepatitis B in several analyses. No such effects were found for pneumococcal, measles, or influenza vaccines.</p> <ul style="list-style-type: none"> - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: Those sessions involving physicians in the reminder arm were less likely to involve an order for a vaccine (p value < 0.0005, RR 0.73, 95% CI 0.60, 0.88)</p>	<p>Overall rating: Poor</p> <p>Comments: Inadequate and ambiguous reporting of methods and results; inappropriate analytical methods</p> <p>Applicability/generalizability: Locally developed system</p> <p>Crossover design, 5 months in each arm, in the course of a single year, without regard to flu season</p> <p>Academic setting was a single institution</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N</p>			
Flottorp, Oxman, Havelrud, et al., 2002	Geographical location: Norway	Authors' basic description of system: The Mediata software also included an interactive	Comparator(s): Another CDSS/KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes:	General comments: None

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#4933	<p>Study dates: 1/1/2000–1/31/2001 Intervention: 5/2000–1/2001</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: General practices</p> <p>Duration of intervention: 7 to 8 months</p> <p>Sample type(s) (with N randomized for each): Practices: 142</p> <p>User level of expertise/proficiency: NR</p>	<p>decision support application and a tool to collect additional data from pop-up screens that were triggered when a diagnosis code for a sore throat or urinary tract infection was entered into a patient's record.</p> <p>The main components of the tailored interventions were patient educational material, computer based decision support and reminders, an increase in the fee for telephone consultations, and interactive courses for general practitioners and practice assistants.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Acute disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR</p> <p>Information delivery: <i>a) Delivery format:</i> NR <i>b) Delivery mode:</i> NR</p> <p>Contextual factors/features</p>	Practices randomized to DSS for sore throat vs UTI	<p>- Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Use of laboratory testing— “The absolute reduction in the proportion of consultations for urinary tract infection where a laboratory test was ordered for urinary tract infections was 5.1% greater in the intervention group. No significant differences were found between the groups for use of laboratory tests for sore throat.”</p> <p>- Recommended treatment ordered/prescribed: Use of antibiotics— “The absolute reduction in the proportion of consultations where antibiotics were prescribed for sore throat was 3.0% greater in the intervention group. For patients with urinary tract infection there was little change in the proportion of consultations where antibiotics were prescribed in both the intervention group (-0.2%) and the control group (0.2%).”</p> <p>- Impact on user knowledge: NR</p> <p>From the text: “Passively delivered, complex interventions targeted at identified barriers to change had little effect in changing practice.”</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p>	<p>Quality assessment: Overall rating: Poor</p> <p>Comments: Inadequate reporting throughout; nonvalidated outcome assessments</p> <p>Applicability/generalizability: Study conducted in Norway; multifaceted intervention with short followup period; very little information provided on CDSS</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: NR</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y			
Fordham, McPhee, Bird, et al., 1990 #7227 AND McPhee, Bird, Jenkins, et al., 1989 #7279	Geographical location: San Francisco, CA Study dates: NR General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Clinician Duration of intervention: 9 months Sample type(s) (with N randomized for each):	Authors' basic description of system: A reminder was generated for each patient encounter; reminders displayed the list of appropriate cancer screening procedures (based on the patient's age and sex), the recommended testing intervals, the last performances date, the due date for each test, and the patient's "due" status. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i>	Comparator(s): Usual care/no CDSS or KMS 3 arms: 1) Cancer screening reminders 2) Audit with feedback 3) No intervention (control)	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Cancer screening reminders— FOBT b coefficient 19.0 ($p = 0.002$) Rectal b coefficient 22.6 ($p < 0.001$) Sigmoidoscopy b coefficient 31.3 ($p = 0.002$) Pap smear b coefficient 34.8 ($p = 0.122$) Pelvic exam b coefficient 20.5 ($p = 0.004$) Breast exam b coefficient 24.3 ($p = 0.001$) Mammogram b coefficient 15.7 ($p = 0.040$) Audit with feedback— FOBT b coefficient 12.3 ($p = 0.048$) Rectal b coefficient 14.0 ($p = 0.020$) Sigmoidoscopy b coefficient -1.2 ($p = 0.899$) Pap smear b coefficient 29.5 ($p =$	General comments: None Quality assessment: Overall rating: Fair Comments: Not blinded; contamination; loss of followup for graduating residents Applicability/generalizability: One academic residency program Paper-based medical record system in 1990

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<ul style="list-style-type: none"> - Patients - Training MDs: 62 <p>User level of expertise/proficiency: Faculty oriented each resident to the reminders, explained their purpose, and demonstrated how to use them</p>	<p>Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y </p>		<p>0.198) Pelvic exam b coefficient 10.4 (p = 0.140) Breast exam b coefficient 25.3 (p = 0.001) Mammogram b coefficient 20.6 (p = 0.008)</p> <p>Patient education— Breast exam b coefficient 2.3 (p = 0.679) Mammogram b coefficient 16.7 (p = 0.009)</p> <p>Constant— FOBT b coefficient 54.7 (p<0.001) Rectal b coefficient 40.7 (p<0.001) Sigmoidoscopy b coefficient 21.8 (p = 0.009) Pap smear b coefficient 108.5 (p<0.001) Pelvic exam b coefficient 26.5 (p = 0.01) Breast exam b coefficient 37.9 (p = 0.001) Mammogram b coefficient 34.3 (p<0.001)</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y 		<p>outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	
<p>Fortuna, Zhang, Ross-Degnan, et al., 2009</p> <p>#265</p> <p>Comparison 1 of 2</p>	<p>Geographical location: 14 sites in Massachusetts</p> <p>Study dates: 3/11/2007–3/10/2008</p> <p>General setting: - Academic - Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster</p>	<p>Authors' basic description of system: Computerized prescription alerts embedded in an EHR to reduce the prescribing of heavily marketed hypnotic medications in the ambulatory setting.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i></p>	<p>Comparator(s): Another CDSS/KMS</p> <p><u>1) Computerized alerts only</u></p> <p>2) Computerized alerts plus physician-led educational sessions</p> <p>3) Control—neither alerts nor educational sessions</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prescriptions for heavily marketed medications— <p>Control group: Intervention period RR (95% CI): 1.27 (1.05, 1.54) Intervention period adjusted RR (95% CI): 1.31 (1.08, 1.60) Ratio of RR (95% CI): 1.0</p>	<p>General comments: Authors concluded that computerized decision support is an effective tool to reduce the prescribing of heavily marketed hypnotic medications in ambulatory settings</p> <p>Quality assessment:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	randomization	Synchronous			Overall rating: Good
	Unit of randomization: Clinic sites	Decision support: <i>Response requirement:</i> Mandatory response		Alert group: Intervention period RR (95% CI): 0.99 (0.84, 1.17) Intervention period adjusted RR (95% CI): 0.97 (0.82, 1.14) Ratio of RR (95% CI): 0.74 (0.57, 0.96)	Applicability/ generalizability: Commercially available system with locally developed modifications
	Duration of intervention: 12 months	Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR		Alert + Education group: Intervention period RR (95% CI): 1.03 (0.89, 1.21) Intervention period adjusted RR (95% CI): 0.98 (0.83, 1.17) Ratio of RR (95% CI): 0.74 (0.58, 0.97)	Desired outcome was reduction in number of prescriptions
	Sample type(s) (with N randomized for each): - Clinic sites: 14 - Individual HCPs: > Clinicians, internal medicine including MDs, NPs, and PAs: 257	Contextual factors/features influencing the implementation and use of CDSS/KMS: <u>Alerts only group</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N		- Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: Postimplementation survey (89 clinicians eligible, 51 responded) (% agree)— - HCP acceptance: Alerts changed my prescribing decision(s): 11 (23%) (95% CI: 12 to 37%)	Sites have used an Epic EHR for all ambulatory patient encounters since 1997
	User level of expertise/ proficiency: NR				

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 		<ul style="list-style-type: none"> - HCP satisfaction: Alerts did not interfere with workflow: 35 (70%) (95% CI: 55 to 82%) Alerts prompted me to spend more time discussing alternative treatments with my patient(s): 24 (47%) (95% CI: 33 to 62%) Alerts provided useful evidence to support prescribing decisions: 43 (88%) (95% CI: 75 to 95%) Alerts provided useful patient education materials regarding insomnia: 40 (83%) (95% CI: 70 to 93%) Alerts increased my awareness of hypnotic medication costs: 35 (71%) (95% CI: 57 to 83%) - HCP use: 89 of 257 internal medicine clinicians included in the study received at least one alert - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Fortuna, Zhang, Ross-Degnan, et al., 2009 #265 Comparison 2 of 2	<p>Geographical location: 14 sites in Massachusetts</p> <p>Study dates: 3/11/2007–3/10/2008</p> <p>General setting: - Academic - Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic sites</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Clinic sites: 14 - Individual HCPs: > Clinicians, internal medicine including MDs, NPs, and PAs: 257</p> <p>User level of</p>	<p>Authors' basic description of system: Computerized prescription alerts embedded in an EHR to reduce the prescribing of heavily marketed hypnotic medications in the ambulatory setting.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <u>Alerts plus educational sessions</u> <i>a) General system features:</i></p>	<p>Comparator(s): Another CDSS/KMS</p> <p>1) Computerized alerts only</p> <p><u>2) Computerized alerts plus physician-led educational sessions</u></p> <p>3) Control—neither alerts nor educational sessions</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prescriptions for heavily marketed medications— Control group: Intervention period RR (95% CI): 1.27 (1.05, 1.54) Intervention period adjusted RR (95% CI): 1.31 (1.08, 1.60) Ratio of RR (95% CI): 1.0</p> <p>Alert group: Intervention period RR (95% CI): 0.99 (0.84, 1.17) Intervention period adjusted RR (95% CI): 0.97 (0.82, 1.14) Ratio of RR (95% CI): 0.74 (0.57, 0.96)</p> <p>Alert + Education group: Intervention period RR (95% CI): 1.03 (0.89, 1.21) Intervention period adjusted RR (95% CI): 0.98 (0.83, 1.17) Ratio of RR (95% CI): 0.74 (0.58, 0.97)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care</p>	<p>General comments: Authors concluded that computerized decision support is an effective tool to reduce the prescribing of heavily marketed hypnotic medications in ambulatory settings</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Commercially available system with locally developed modifications</p> <p>Desired outcome was reduction in number of prescriptions</p> <p>Sites have used an Epic EHR for all ambulatory patient encounters since</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	expertise/ proficiency: NR	<p>Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as 		<p>delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: Postimplementation survey (89 clinicians eligible, 51 responded) (% agree)—</p> <ul style="list-style-type: none"> - HCP acceptance: Alerts changed my prescribing decision(s): 11 (23%) (95% CI: 12 to 37%) - HCP satisfaction: Alerts did not interfere with workflow: 35 (70%) (95% CI: 55 to 82%) Alerts prompted me to spend more time discussing alternative treatments with my patient(s): 24 (47%) (95% CI: 33 to 62%) Alerts provided useful evidence to support prescribing decisions: 43 (88%) (95% CI: 75 to 95%) Alerts provided useful patient education materials regarding insomnia: 40 (83%) (95% CI: 70 to 93%) Alerts increased my awareness of hypnotic medication costs: 35 (71%) (95% CI: 57 to 83%) - HCP use: 89 of 257 internal medicine clinicians included in the study received at least one alert 	1997

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: Y - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y		- Implementation of CDSS/KMS:NR	
Frame, Zimmer, Werth, et al., 1994 #6941	Geographical location: Dansville, NY Study dates: 1991–1992 General setting: Community Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 2 years Sample type(s) (with N randomized for each): Patients: 1665 User level of expertise/	Authors' basic description of system: A computer-based health maintenance tracking system that generates annual provider and patient reminders to all patients. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Initiating discussion with patient - Preventive care <i>b) Relationship to point of care:</i> Asynchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push")	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: - Cost: Estimated operating costs of operating the intervention for the generation of 1,000 patient and provider reminders— Patient reminders: \$545.03 Provider reminders: \$234.73 Cost of maintaining the computer system and generating patient and provider reminders— Per patient: \$0.78 Billings— C: (n = 837) Preintervention 1990: \$48,150 Intervention 1991: \$55,823 Intervention 1992: \$57,014	General comments: Provider compliance for individual procedures (11) available in article Multiple interventions; provider reminders and patient reminders Outcome for patient adherence was not reported Quality assessment: Overall rating: Fair Comments: Blinding and concealing methods not clearly described; baseline characteristics

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	proficiency: 2-hour provider instruction session was conducted by PI to teach providers how to use the computer-based system and the manual system	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N		I (n = 829): Preintervention 1991: \$54,834 Intervention 1991: \$58,201 Intervention 1992: \$57,604 - Cost-effectiveness: NR 6) Impact on HCP use and implementation: - HCP acceptance: Among active (n = 1324) and inactive patients (n = 145), overall mean baseline compliance for all 11 procedures was 52% Change in overall provider compliance for initially active patients (n = 1324)— C = 3.3% I = 13.5% P < 0.001 Change in overall provider compliance for initially inactive patients (n = 145)— C = 13.5% I = 27.1% P = 0.02 - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	unknown; no followup data Applicability/generalizability: Computer application, HTRAK, was built using legacy systems Rural and lower-middle class population

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i></p> <p>Allowed providers to specify or cancel sending patient reminders; including dates; protocols were modifiable without the assistance of programmers</p>			
Frank, Litt, and Beilby, 2004 #4200	<p>Geographical location: South Australia, Australia</p> <p>Study dates: NR</p> <p>General setting: Community</p> <p>Specific setting: - Outpatient - Acute and chronic</p> <p>Study design: RCT, parallel group</p>	<p>Authors' basic description of system: Opportunistic electronic reminders for preventive care in general practice.</p> <p>Source/origin of system: NR</p> <p>Content:</p> <p><i>a) Objective(s):</i></p> <ul style="list-style-type: none"> - Immunization - Preventive care <p><i>b) Relationship to point of care:</i> NR</p> <p>Decision support:</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Opportunities taken for preventive activity; relative changes (RC) in preventive activity performed (95% CI)— <p>Tetanus immunization: C = 222 of 15,089 (1.5%) I = 333 of 11,947 (2.8%) RC = 1.89 (1.59, 2.25)</p> <p>Recording of allergies: C = 682 of 13,713 (5.0%) I = 991 of 10,991 (9.0%) RC = 1.81(1.63, 2.02)</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Possible concealment issues because GPs were not blinded; no followup</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Unit of randomization: Patient Duration of intervention: NR Sample type(s) (with N randomized for each): - Patients: 10,507 (I = 5,118, C = 5,389) - Individual HCPs: > MDs, 10 GPs User level of expertise/proficiency: GPs had used computer medical records for 8 years	<i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> NR Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <i>c) Communication content features:</i> - Provision of a recommendation, not just an		Pneumococcal immunization: C = 39 of 2370 (1.6%) I = 58 of 2079 (2.8%) RC = 1.70 (1.10, 2.62) Recording of weight: C = 567 of 11,592 (4.9%) I = 654 of 10,476 (6.2%) RC = 1.28 (1.13, 1.44) Measles, mumps, and rubella immunization: C = 43 of 523 (8.2%) I = 46 of 446 (10.3%) RC = 1.25 (0.82, 1.93) Smoking status: C = 171 of 9407 (1.8%) I = 181 of 8908 (2.0%) RC = 1.12 (0.90, 1.39) Cervical smear: C = 348 of 4833 (7.2%) I = 343 of 4387 (7.8%) RC = 1.09 (0.91, 1.29) Blood pressure: C = 666 of 4404 (15.1%) I = 677 of 4370 (15.5%) RC = 1.02 (0.90, 1.16) Diabetes screening: C = 47 of 1900 (2.5%) I = 45 of 1858 (2.4%) RC = 0.98 (0.65, 1.48) Influenza immunization: C = 248 of 912 (27.2%) I = 245 of 935 (26.2%) RC = 0.96 (0.78, 1.18) Lipid screening: C = 215 of 7929 (2.7%) I = 176 of 7268 (2.4%) RC = 0.89 (0.73, 1.09) - Recommended clinical study	Applicability/generalizability: The use of Royal Australian College of General Practitioners' Guidelines

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>assessment: N</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>ordered/completed: NR</p> <ul style="list-style-type: none"> - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Fretheim, Aaserud, Oxman, 2006 #2688 AND Fretheim, Oxman, Havelsrud, et al., 2006 #2689	<p>Geographical location: Oslo, Norway Tromso, Norway</p> <p>Study dates: May 2002–Dec 2003</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): - Patients: > Choice of antihypertensive drug (1,968 + 2,184 = 4,152) > Achievement of treatment goals (17,123 + 16,593 = 33,716) > Started on</p>	<p>Authors' basic description of system: Computerized reminders present the physicians with performance of risk estimation and choice of drugs after being triggered by elevated blood pressure or low density lipoprotein in patients.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> - Pharmacotherapy - Preventive care</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Cardiovascular risk assessment done— C = 112 of 768 (14.6%) I = 147 of 854 (17.2%) ICC = 0.39 RR (95% CI) = 1.04 (0.60, 1.71) P = 0.90</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Prescribing of thiazides for hypertension— C = 218 of 1968 (11.1%) I = 378 of 2184 (17.3%) ICC = 0.087 RR (95% CI) = 1.94 (1.49, 2.49) P < 0.001</p> <p>Secondary outcomes: Prescribing of thiazides and beta blockers— C = 632 of 1968 (32.1%) I = 889 of 2184 (40.7%) ICC = 0.073 RR (95% CI) = 1.41 (1.27, 1.56) P < 0.001</p> <p>Prescribing of angiotensin II receptor blockers and alpha blockers— C = 945 of 1968 (48.0%) I = 876 of 2184 (40.1%) ICC = 0.084</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Investigators assessing outcomes and conducting analyses were blinded</p> <p>Block randomization with software allocation</p> <p>Multifaceted intervention that included educational outreach, audit and feedback, and computerized reminders—not possible to say which component contributed to the overall effectiveness of the intervention</p> <p>This was a</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>medication for hypertension and/or hypercholesterolemia (3,316 + 2,863 = 6,179)</p> <p>- Clinics/practices/hospitals: 146 practices (C = 73, I = 73)</p> <p>- Individual HCPs: > MDs: 501 (257 intervention, 244 control)</p> <p>User level of expertise/proficiency: NR</p>	<p>order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y 		<p>RR (95% CI) = 1.21(1.101,1.30) P < 0.001</p> <p>Treatment goals achieved— C = 6,056 of 16,593 (36.5%) I = 5,502 of 17,123 (32.0%) ICC = 0.026 RR (95% CI) = 0.98(0.93, 1.02) P = 0.33</p> <p>Secondary outcomes: Treatment goal achieved among diabetes patients— C = 994 of 2950 (33.7%) I = 905 of 2875 (31.5%) ICC = 0.028 RR (95% CI) = 0.96 (0.87,1.06) P = 0.46</p> <p>Treatment goal for hypertension achieved— C = 3,310 of 10,564 (31.3%) I = 3,073 of 11,308 (27.2%) ICC = 0.032 RR (95% CI) = 1.00 (0.95, 1.06) P = 0.89</p> <p>Treatment goal for cholesterol achieved— C = 3,770 of 7711 (48.9%) I = 3,545 of 7815 (45.4%) ICC = 0.040 RR (95% CI) = 0.97 (0.91, 1.02) P = 0.23</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p>	<p>multifaceted intervention that included a comparison with baseline data captured 1 year prior to the intervention</p> <p>Applicability/generalizability: Guidelines for antihypertensive and cholesterol-lowering drugs for the prevention of cardiovascular disease may vary in other countries.</p> <p>Study conducted in Norway</p> <p>Practices had to use one of two EHR systems that were compatible with the intervention software</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y <p><i>e) Other:</i> Supplementary materials for patients were available for print out</p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Net annual cost (cost minimization) in study population = \$53,395 Net annual savings in a national program after 2 years = \$761,998; per practice = \$540 - Cost-effectiveness: The cost effectiveness of the intervention was estimated as the cost per additional patient being started on thiazides Net annual cost (cost minimization) in study population per practice = \$454; cost-effectiveness = \$183 <p>6) Impact on HCP use and implementation: NR</p>	
<p>Gill, Chen, Glutting, et al., 2009</p> <p>#181</p>	<p>Geographical location: 35 sites in US</p> <p>Study dates: Nov 1, 2005–Oct 31, 2006</p> <p>General setting:</p> <ul style="list-style-type: none"> - Academic - Community <p>Specific setting:</p> <ul style="list-style-type: none"> - Outpatient - Chronic 	<p>Authors' basic description of system: EMR-based intervention for lipid management in a network of primary care practices. This intervention integrated nationally recognized guidelines (specifically the ATP-III guidelines) into the EMR and included prompts at the point of care.</p> <p>Source/origin of system: Commercially available</p> <p>Content:</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Proportion of patients tested adequately for hyperlipidemia—Univariate analysis: High risk I = 81.2 C = 77.9 Moderate risk I = 89.8 C = 89.9 Low risk 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Moderate baseline differences in provider and patient characteristics</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 1 year Sample type(s) (with N randomized for each): - Patients: 64,150 - Clinics/practices/hospitals: 25 offices - Individual HCPs: > Training MDs and > MDs in general internal medicine, family medicine, general practice: 105 User level of expertise/proficiency: Physicians used centrality EMR for at least 1 year before intervention	a) Objective(s): - Pharmacotherapy - Lab test ordering - Chronic disease management - Preventive care b) Relationship to point of care: Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: a) Delivery format: Integrated with CPOE/EHR b) Delivery mode: System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: a) General system features: Integration with charting or order entry system to support workflow integration: Y b) Clinician-system interaction features: - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of		I = 63.0 C = 65.2 The likelihood of lipid testing increased significantly from baseline to end point for all groups except for the high-risk control group. Multivariate analysis: High risk (n = 2,081) OR = 15.00 (P < 0.05) Moderate risk (n = 1286) OR = 1.47 Low risk (n = 14,384) OR = 0.97 - Recommended diagnostic study ordered/completed: NR - Recommended treatment ordered/prescribed: Proportion of high-risk patients who were prescribed lipid-lowering medications— Univariate analysis: I = 70.1 C = 62.8 Multivariate analysis: High risk (n = 663) OR = 0.05 Proportion of patients whose most recent low-density lipoprotein cholesterol was at goal (< 100 for high risk, < 130 for moderate risk, < 160 for low risk)— Univariate analysis: High risk I = 53.3 C = 56.1 Moderate risk	Blinding and concealment methods unknown No followup Randomization by block Several authors consulted for, or were employed by, the EHR vendor Included a comparison with baseline data captured 1 year prior to the intervention Applicability/generalizability: Geographic location of clinics unknown Physician practices were recruited through a consortium of offices that used a specific outpatient EHR Included resident

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>the reason for not following CDSS recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Can't tell - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i></p> <p>Supplementary materials (reporting tools, access to guidelines, Web sites for patient or physician education,</p>		<p>I = 64.7 C = 68.5</p> <p>Low risk I = 87.9 C = 90.9</p> <p>The proportion of patients at lipid goal increased significantly for all groups except the moderate-risk intervention group.</p> <p>The proportion of high-risk patients on medication if not at goal increased significantly for both the intervention and control groups.</p> <p>Multivariate analysis: High risk (n = 4043) OR = 1.17 Moderate risk (n = 2383) OR = 0.29 Low risk (n = 1955) OR = 1.74</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	physicians

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		document counseling)			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Gilutz, Novack, Shvartzman, et al., 2009 #745	Geographical location: Israel Study dates: NR General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 6 to 36 months Sample type(s) (with N randomized for each): - Patients: 7448 - Clinics/practices/hospitals: 112 clinics - Individual HCPs: > MDs: I = 204 GPs C = NR > Nurses I = 396 C = NR	Authors' basic description of system: The CDSS was programmed to automatically detect patients with coronary artery disease (CAD) and to evaluate the availability of an updated lipoprotein profile and treatment with lipid-lowering drugs. The program produced automatic computer-generated monitoring and treatment recommendations. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Pharmacotherapy - Chronic disease management - Preventive care <i>b) Relationship to point of care:</i> Not clearly described Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push")	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: All cardiovascular-related rehospitalization (major and nonmajor cardiac effects) and all-cause mortality during the first year— C = 59.2% I = 57.1% P < 0.03 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Appropriate lipoprotein monitoring (n = 7448)— I = 54.8% C = 48.7% P < 0.001 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Medication initiation recommended for patients with LDL levels above 110 mg/dL— I = 59.1% C = 53.7% P < 0.003 Patient compliance with statin treatment— N = 28% of patients taking clinically meaningful dose of lipid-lowering	General comments: CDSS intervention not clearly described Quality assessment: Overall rating: Poor Comments: More patients with MI (P = 0.004) and percutaneous coronary intervention (P = 0.019) in the intervention arm All-cause mortality data stated but not reported Blinding and concealment not reported Only followup data is presented Applicability/generalizability: Locally developed CDSS implemented in

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/ proficiency: NR	<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p>		<p>drugs < 25% of expected number of pills: 47% 25 to 49% of expected pills: 17% 50 to 75% of expected pills: 8% > 75% of expected pills: 28%</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>multiple clinics</p> <p>Study conducted in Israel</p> <p>6-month followup period</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i></p> <p>Data integration from hospital discharge diagnosis database, laboratory database, and Clalit Health Services central pharmacy database</p>			
<p>Goud, de Keizer, ter Riet, et al., 2009</p> <p>#490</p>	<p>Geographical location: 21 sites in Netherlands</p> <p>Study dates: January 2005–July 2006</p> <p>General setting:</p> <ul style="list-style-type: none"> - Academic - Community <p>Specific setting:</p> <ul style="list-style-type: none"> - Outpatient - Chronic <p>Study design: RCT, cluster</p>	<p>Authors' basic description of system:</p> <p>CARDSS assists in formulating a patient specific rehabilitation program by providing computerized decision support: it automatically shows whether each of the four treatments is recommended by the guidelines, on the basis of the patient's needs assessment data. On request, CARDSS provides the rationale behind its recommendations and links to relevant research evidence.</p> <p>Source/origin of system: Locally developed</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Concordance with guideline recommendations: Exercise— C: 933 of 1102 (84.7%) I: 1,508 of 1629 (92.6%) Adjusted difference 3.5 (95% CI: 0.1 to 5.2) 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Comments: Unknown followup data</p> <p>Applicability/generalizability: Multicenter trials only took place in Netherlands</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	randomization				
	Unit of randomization: Other outpatient centers Duration of intervention: NR Sample type(s) (with N randomized for each): - Patients: 2787 - Clinics/practices/hospitals: 21 User level of expertise/proficiency: All multidisciplinary cardiac rehabilitation teams received a standardized training course, designed by the investigators, during which both the control and intervention versions of CARDSS were demonstrated to all teams	Content: <i>a) Objective(s):</i> - Chronic disease management - Preventive care <i>b) Relationship to point of care:</i> - Synchronous - Asynchronous Decision support: <i>Response requirement:</i> Justification for not complying Information delivery: <i>a) Delivery format:</i> - Integrated with CPOE/EHR - Paper-based <i>b) Delivery mode:</i> User-initiated ("pull") Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N		<p>Concordance with the guideline for exercise therapy was higher in the control group than had been estimated in the sample size calculation, but it was much lower than estimated for the relaxation and lifestyle change therapy.</p> <p>The adjusted difference between the control arm and intervention arm in undertreatment was 42.8% (95% confidence interval 1.1% to 68.0%) for relaxation therapy and 25.8% (14.9% to 33.6%) for education therapy, in favor of the intervention arm. There was found a significant difference for overtreatment with exercise therapy.</p> <p>In the intervention arm, lack of sufficient facilities was another important reason for nonconcordance with recommendations about lifestyle change (160 of 686) and relaxation therapy (68 of 651)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and</p>	<p>Participants received incentives such as reimbursement of the purchasing costs of CARDSS, free training, and helpdesk services</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y 		<p>implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: In the intervention arm, patients' refusal was reported as the main reason for nonconcordance with recommendations for exercise (77 of 121), education (127 of 199), relaxation (407 of 651), and lifestyle change (381 of 686) <ul style="list-style-type: none"> - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR 	
Graumlich, Novotny, Nace, et al., 2009A	Geographical location: Central Illinois	Authors' basic description of system: The CPOE application	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR	General comments: None

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#347 AND Graumlich, Novotny, Nace, et al., 2009B #218	<p>Study dates: Nov 2004–Jan 2007</p> <p>General setting: Academic</p> <p>Specific setting: Inpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 26 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 631 - Individual HCPs: > Training MDs [internal medicine]: Postgraduate year 1: 41 Postgraduate years 2 to 4: 17 > MDs [internal medicine]: 12</p> <p>User level of expertise/ proficiency:</p>	<p>included basic levels of clinical decision support to facilitate communication at the time of hospital discharge to patients, retail pharmacists, and community physicians.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Other—discharge planning</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> Not clearly described</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction</i></p>		<p>- Morbidity: Readmitted within 6 months (Control = 315, Intervention = 316)— Control: 119 (37.8%) Intervention: 117 (37.0%) P value: 0.897 Parameter estimate without cluster correction intervention coefficient (95% CI) = -0.005 (-0.076 to 0.067) P value: 0.894 (adjusted) Parameter estimate with cluster correction intervention coefficient (95% CI) = -0.005 (-0.074 to 0.065)</p> <p>- Mortality: NR</p> <p>- Validated measure of HRQOL or functional status: NR</p> <p>- Adverse events: Adverse event within 1 month— Control: 23 (7.3%) Intervention: 23 (7.3%) P value: 0.886 (95% CI: -0.037 to 0.043) P value: 0.884 (95% CI: -0.037 to 0.043) (adjusted)</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: Effort for discharge planning—</p>	<p>Quality assessment: Overall rating: Good</p> <p>Applicability/ generalizability: CDSS was not integrated with EMR as intended, resulting in physicians having to enter patient data twice; this may have affected generalizability on physicians' behavior.</p> <p>Hospital had a standard medication reconciliation process in place</p> <p>Academic setting</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Physicians assigned to discharge software completed additional training via multimedia demonstration with one-on-one coaching as needed	<p><i>features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by 		<p>Mean (SD)</p> <p>Control: 7.9 (2.1)</p> <p>Intervention: 6.5 (1.9)</p> <p>Difference (95% CI) = 1.4 (0.3 to 2.4)</p> <p>P value: 0.011</p> <p>4) Impact on relationship-centered outcomes:</p> <ul style="list-style-type: none"> - Patient satisfaction: Patient perception of discharge preparedness— <p>Mean (SD)</p> <p>Control: 17.2 (4.0)</p> <p>Intervention: 17.7 (4.1)</p> <p>P value: 0.040 (95% CI: 0.006 to 0.288)</p> <p>P value: 0.042 (95% CI: 0.005 to 0.289) (adjusted)</p> <p>* When patient perception of discharge preparedness was the dependent variable, then physician level of training had a nonsignificant coefficient (P > 0.219)</p> <p>Patient satisfaction with medication information score—</p> <p>Mean (SD)</p> <p>Control: 12.1 (4.6)</p> <p>Intervention: 12.3 (4.8)</p> <p>P value: 0.587 (95% CI: -0.987 to 0.544)</p> <p>P value: 0.567 (95% CI: -0.937 to 0.513) (adjusted)</p> <p>* Physician level of training was nonsignificant in models of patient satisfaction with medication information (P > 0.068)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		conventional education: N <i>e) Other:</i> System did not perform error checking to warn about pending tests, drug-drug interactions, therapeutic duplications, or missing items (e.g., immunizations, drugs, education)		5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: Physician satisfaction— Mean (SD) Control: 7.9 (1.4) Intervention: 7.4 (1.4) P value: 0.129 (95% CI: -0.2 to 1.3) - HCP use: NR - Implementation of CDSS/KMS: NR	
Greiver, Drummond, White, et al., 2005 #9046	Geographical location: Toronto, Ontario, Canada Study dates: Mid Nov 2001–mid June 2002 General setting: - Academic - Community Specific setting: Outpatient Study design: RCT, cluster randomization Unit of randomization:	Authors' basic description of system: PDA software application assesses patient's risk of angina, using Diamond-Forrester risk-stratification model, and suggests appropriate diagnostic management. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Diagnosis - Lab test ordering <i>b) Relationship to point of care:</i> Synchronous Decision support:	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Test given appropriately— Cardiac stress testing: Control: 8 (28.6%) Intervention: 18 (48.6%) P value: (with 95% CI) = 0.28 (-11.54% to -51.4%) Nuclear cardiology testing: Control: 5 (45.5%) Intervention: 17 (63%) P value: (with 95% CI) = 0.4 (-13.9% to 48.9%) - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	General comments: Experiment not adequately described Quality assessment: Overall rating: Poor Comments: Blinding and concealment not reported Baseline characteristics not reported Unknown randomization

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Clinician</p> <p>Duration of intervention: 7 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 65 - Individual HCPs: > MDs: 17 (family medicine)</p> <p>User level of expertise/proficiency: NR</p>	<p><i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system (PDA)</p> <p><i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a</p>		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: Increase use of cardiac stress testing due to PDA use (81% vs 50%)</p>	<p>method</p> <p>Unknown followup data</p> <p>Applicability/generalizability: Small sample size</p> <p>Many physicians belonged to a research network</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>recommendation, not just an assessment: Y</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
<p>Gurwitz, Field, Rochon, et al., 2008</p> <p>#840</p>	<p>Geographical location:</p> <ul style="list-style-type: none"> - Connecticut, US - Ontario, Canada <p>Study dates: NR</p> <p>General setting: Academic</p> <p>Specific setting: Long-term facility</p> <p>Study design: RCT, cluster</p>	<p>Authors' basic description of system: Computerized provider order entry with clinical decision support for preventing adverse drug events in long-term care.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i> Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: NR - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: All adverse drug events— <p>C = 340 (100%) Rate/100 resident-years = 10.4</p> <p>I = 411 (100%) Rate/100 resident-years = 10.8 Rate ratio = 1.06 95% CI = 0.92 to 1.23</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Possible crossover contamination</p> <p>Unknown</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	randomization	Synchronous		Preventable— C = 126 (30.7%) Rate/100 resident-years = 3.9 I = 152 (37.0%) Rate/100 resident-years = 4.0 Rate ratio = 1.02 95% CI = 0.81 to 1.30	followup cases Only age as baseline characteristics Applicability/ generalizability: Baseline characteristics not reported No comorbid conditions or chronic disease reported
	Unit of randomization: Other—resident care units	Decision support: <i>Response requirement:</i> No response requirement			
	Duration of intervention: Site 1 – 1 year Site 2 – 6 months	Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> User-initiated (“pull”)		More severe— C = 97 (28.5%) Rate/100 resident-years = 3.0 I = 123 (30.0%) Rate/100 resident-years = 3.2 Rate ratio = 1.07 95% CI = 0.82 to 1.40	
	Sample type(s) (with N randomized for each): - Patients: 1118 - Other: 29 resident care units	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y		Preventable more severe— C = 58 (17.1%) Rate/100 resident-years = 1.8 I = 79 (19.2%) Rate/100 resident-years = 2.1 Rate ratio = 1.15 95% CI = 0.82 to 1.61	Locally developed system implemented in two different geographic areas
	User level of expertise/proficiency: NR	<i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N		Less severe— C = 243 (71.5%) Rate/100 resident-years = 7.5 I = 288 (70.1%) Rate/100 resident-years = 7.6 Rate ratio = 1.06 95% CI = 0.89 to 1.26	
		<i>c) Communication content</i>		Preventable less severe— C = 68 (20.0%) Rate/100 resident-years = 2.1 I = 73 (17.8%) Rate/100 resident-years = 1.9 Rate ratio = 0.92 95% CI = 0.66 to 1.28	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>features:</i> - Provision of a recommendation, not just an assessment: Y- Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N		2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	
Hamilton, Platt, Gauthier, et al., 2004 #4244	Geographical location: 7 sites in US and Canada Study dates: Feb 1, 1999–March 31, 2001 General setting: Academic Specific setting: Inpatient–non-ICU	Authors' basic description of system: The computer calculates the contraction frequency automatically from the obstetrical monitor that records the mother's contractions and the baby's heart rate, and the computer then displays a graph of the measured dilation, as well as a percentile comparison to the reference population using the mathematical model.	Comparator(s): Usual care/no CDSS or KMS Control: without reference range Intervention: with reference range	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Apgar scores reported at 1 and 5 minute intervals after birth by categories 0-2, 3-4, 5-6, 7-8, 9-10; no significant differences reported between the control and intervention group (p value > 0.41 for all comparisons) - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR	General comments: How many centers within each of the hospitals? Quality assessment: Overall rating: Fair Comments: Blinding and

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Other—centers</p> <p>Duration of intervention: 25 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 4993 - Clinics/practices/hospitals: 7</p> <p>User level of expertise/proficiency: NR</p>	<p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Diagnosis <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of</p>		<p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: Primary outcome: rates of caesarian section (CS)— Pretest-posttest analysis: CS fell from 1124 of 5753 (19.54%) in all eligible women in the year preceding the trial to 551 of 3234 (17.04%) ($p = 0.004$) by 6 months; and to 923 of 5554 (16.62%) by 12 months ($p = 0.00006$)</p>	<p>concealment not clearly described</p> <p>Baseline characteristics unknown</p> <p>Applicability/generalizability: Reliability and ranges of the model</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>the reason for not following CDSS recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Harpole, Khorasani, Fiskio, et al., 1997	Geographical location: Boston, MA	Authors' basic description of system: Real-time critiquing about the appropriateness of abdominal	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes:	Exclusion reasons (if appropriate): Phase 2 data

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
#6439	<p>Study dates:</p> <ul style="list-style-type: none"> - Phase 1: Aug 1–Sept 30, 1995 - Phase 2: Nov 10, 1995–March 21, 1996 <p>General setting: Academic</p> <p>Specific setting:</p> <ul style="list-style-type: none"> - Inpatient–ICU - Inpatient–non-ICU * Unclear if ICU or non-ICU <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Orders</p> <p>Duration of intervention: (Nonrandomized) Phase 2: 19 weeks</p> <p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Patients: 491 (Phase 2) - Individual HCPs: <ul style="list-style-type: none"> > Training MDs > MDs: 127 (85 medicine physicians, 42 surgical physicians) > Nurses: 109 - Other: 864 films 	<p>radiographs (KUB) during the use of POE system by physicians.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p>a) <i>Objective(s):</i></p> <ul style="list-style-type: none"> - Diagnosis - Other—radiograph ordering <p>b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery:</p> <p>a) <i>Delivery format:</i> Integrated with CPOE/EHR</p> <p>b) <i>Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p>a) <i>General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p>b) <i>Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of 	<p>1) Control: Phase 1 critique message</p> <p>2) Intervention: amended evidence-based critique message</p>	<p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: No differences in the rate of cancellation of low-yield films, change to suggested view(s), or results of low-yield films between the two randomized groups; no statistical test or details reported for these differences</p> <p>Phase 2 results: N (95% CI) KUB receiving ≥1 critique = 385 of 864 (45% ± 3%) Low-yield KUB cancelled = 10 of 283 (4% ± 2%) KUB orders changed to suggested views = 96 of 176 (55% ± 7%) Findings of films for Phase 2 only— Positive: Low-yield films = 12 of 255 (5%) Non-low-yield films = 101 of 514 (20%) Equivocal: Low-yield films = 55 of 25 (24%) Non-low-yield films = 165 of 514(32%) Negative: Low-yield films = 188 of 255 (73%) Non-low-yield films = 248 of 514 (48%)</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care</p>	<p>(randomized) merged; no acceptable comparator</p> <p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Possible learning or Hawthorn effect due to the two phases</p> <p>Fairly similar baselines</p> <p>Blinding and concealment not reported</p> <p>Applicability/generalizability: Study was conducted at Brigham and Women’s Hospital (academic medical center)</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/proficiency: NR	<p>clinician workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>delivery:</p> <ul style="list-style-type: none"> - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: NR <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Annual charge savings of \$6,000 of a potential \$98,500—based on 4% cancellation of low-yield film orders and 40% adherence to the critique to change from two KUB views to one. Data from Phase 2. Does not make a distinction between control and intervention. - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: Response to critique by provider type; does not make a distinction between Phase 1 or Phase 2 and control and intervention <p>Medicine:</p> <ul style="list-style-type: none"> No of KUBs ordered receiving low-yield critique = 189 of 337 (56%) No of KUBs ordered receiving alternate-view critique = 120 of 337 (36%) No of low-yield KUBs cancelled = 9 of 189 (5%) No of KUB orders changed to suggested views = 75 of 120 (63%) <p>Surgery:</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
				<p>No of KUBs ordered receiving low-yield critique = 205 of 466 (44%) No of KUBs ordered receiving alternate-view critique = 85 of 466 (18%) No of low-yield KUBs cancelled = 3 of 205 (1%) No of KUB orders changed to suggested views = 26 of 85 (31%)</p> <p>Nursing: No of KUBs ordered receiving low-yield critique = 131 of 231 (57%) No of KUBs ordered receiving alternate-view critique = 69 of 231 (30%) No of low-yield KUBs cancelled = 8 of 131 (6%) No of KUB orders changed to suggested views = 33 of 69 (48%)</p> <p>- HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR</p>	
<p>Heidenreich, Gholami, Sahay, et al., 2007</p> <p>#1968</p>	<p>Geographical location: Palo Alto, CA</p> <p>Study dates: May 2001–Nov 2005</p> <p>General setting: Academic</p> <p>Specific setting: - Inpatient–non-ICU - Outpatient</p>	<p>Authors' basic description of system: Effect of reminder attached to the echocardiography report on use of beta blockers for patients with reduced left ventricular ejection fraction.</p> <p>Source/origin of system: Locally developed</p> <p>Content: a) <i>Objective(s):</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: Hospitalization—One-year survival free of heart failure hospitalization was 77% Reminders had no measurable effect on survival free of hospitalization for heart failure <ul style="list-style-type: none"> Hazard ratio = 0.99 95% CI = 0.83 to 1.18 - Mortality: NR - Validated measure of HRQOL or functional status: NR 	<p>General comments: No description of features associated with clinician-system interaction</p> <p>Control group also experienced increase in beta blocker use over time (55% in</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	- Chronic	Pharmacotherapy		- Adverse events: NR	2001 versus 68% in 2004)
	Study design: RCT, parallel group	<i>b) Relationship to point of care:</i> Synchronous		2) Impact on health care process outcomes:	Quality assessment:
	Unit of randomization: Patient	Decision support: <i>Response requirement:</i> NR (assume no response requirement)		- Recommended preventive care ordered/completed: NR	Overall rating: Good
	Duration of intervention: 4.5 years	Information delivery: <i>Delivery format:</i> Paper-based		- Recommended clinical study ordered/completed: NR	
	Sample type(s) (with N randomized for each): Patients: 1546	<i>b) Delivery mode:</i> System-initiated ("push")		- Recommended treatment ordered/prescribed: Prescription for beta blocker at 9 months— I: 74%, 458 of 621, C: 66%, 428 of 650, $p = 0.002$	Comments: No significant baseline differences between control and intervention; adequate allocation concealment; computerized randomization; adequate intervention period (4.5 yr)
	User level of expertise/proficiency: NR	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y		Prescription for beta blocker on formulary: I: 42% C: 37% $P = 0.048$ Beta blocker prescriptions for inpatients: I: 75% C: 64% Beta blocker prescriptions for outpatients: I: 73% C: 67% - Impact on user knowledge: NR	Applicability/generalizability: Implemented in a system (VA) where the infrastructure and familiarity with electronic medical records (EHR) and CDSS is extensive
				3) Impact on workload, efficiency, and organization of health care delivery: NR	
				4) Impact on relationship-centered outcomes: NR	
				5) Impact on economic outcomes: NR	Study population was predominantly male and White
				6) Impact on HCP use and	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		implementation: <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: Majority of providers thought that the intervention should be continued (35 of 41; 50 providers in total, 41 participated in the survey) - HCP use: NR - Implementation of CDSS/KMS: NR 	
Hetlevik, Holmen, and Kruger, 1999 #6099 AND	Geographical location: Norway Study dates: NR General setting: Community	Authors' basic description of system: CDSS was implemented as an external computer program, accessible from the main computerized record system. The CDSS guided the doctors in diagnostics, history taking,	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR	General comments: Main outcome measures were changes in doctor's behavior, measured by registration of

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Hetlevik, Holmen, Kruger, et al., 1998 #6201	Specific setting: - Outpatient - Chronic Study design: RCT, parallel group Unit of randomization: Clinic or team Duration of intervention: 18 months Sample type(s) (with N randomized for each): - Patients: 2239 - Clinics/practices/hospitals: 29 - Individual HCPs: > MDs: 53 User level of expertise/proficiency: NR	physical examination, additional test taking and treatment. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> User-initiated (“pull”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of		4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Percentage of doctors who reported changes in their treatment strategies as a result of CDSS— Some change = 54% (n = 13) No change = 38% (n = 9) Large change = 0 Did not know = 0 - HCP satisfaction: NR - HCP use: Percentage of patients in which CDSS was used either partly or totally in treatment = 12% (104) - Implementation of CDSS/KMS: NR	recommended variables in the Norwegian clinical guidelines. Other outcomes were related to impact on HCP use and implementation Quality assessment: Overall rating: Fair

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>clinician workflow: Can't tell</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Hetlevik, Holmen, Kruger, et al., 2000</p> <p>#5862</p>	<p>Geographical location: Norway</p> <p>Study dates: NR</p> <p>General setting: Community</p> <p>Specific setting: - Outpatient - Chronic</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 18 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 2239 - Clinics/practices/hospitals: 29 - Individual HCPs: > MDs: 53</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: CDSS was implemented as an external computer program, accessible from the main computerized record system. The CDSS guided the doctors in diagnostics, history taking, physical examination, additional test taking and treatment.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Percentage of doctors who reported changes in their treatment strategies as a result of CDSS— Some change = 54% (n = 13) No change = 38% (n = 9) Large change = 0 Did not know = 0 - HCP satisfaction: NR - HCP use: Percentage of patients in which CDSS was used either partly or totally in treatment = 12% (104) - Implementation of CDSS/KMS: NR</p>	<p>General comments: Main outcome measures were changes in doctor's behavior, measured by registration of recommended variables in the Norwegian clinical guidelines. Other outcomes were related to impact on HCP use and implementation</p> <p>Quality assessment: Overall rating: Fair</p> <p>Applicability/generalizability: 20 of 24 GPs judged the recommended procedures to be too time consuming</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: N</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 			
<p>Hicks, Sequist, Ayanian, et al., 2008</p> <p>#1343</p>	<p>Geographical location: 14 sites in MA</p> <p>Study dates: July 1, 2003–February 1, 2005</p> <p>General setting: - Academic - Community</p> <p>Specific setting: - Outpatient - Chronic</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 18 months</p> <p>Sample type(s) (with</p>	<p>Authors' basic description of system: Integrated patient-specific electronic clinical reminder system for management of diabetes and coronary artery disease. In addition to the CDSS reminders, the study also included a nurse practitioner protocol.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Guideline adherent medication prescribing— I: 7%, C: 5%, $p < 0.0001$ Prescribing Joint National Committee adherent drug class within 1 week of visit Adjusted odds ratio 1.32 (1.09 to 1.61) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Racially diverse sample of primary care patients at hospital and community care clinics associated with a large urban academic medical center where use of electronic medical records was the norm</p> <p>Intervention integrated into existing EHR and into the workflow</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>N randomized for each):</p> <ul style="list-style-type: none"> - Patients: 2027 - Clinics: 14 <p>User level of expertise/ proficiency: NR</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N 		<p>6) Impact on HCP use and implementation: NR</p>	<p>without the need for additional input from physician</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
<p>Hobbs, Delaney, Carson, et al., 1996</p> <p>#6704</p>	<p>Geographical location: Birmingham, UK</p> <p>Study dates: January–October 2002</p> <p>General setting: Not clearly described</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of</p>	<p>Authors' basic description of system: Primed is a rule-based system that guides hyperlipidemia decisions in general practice.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i></p> <ul style="list-style-type: none"> - Diagnosis - Lab test ordering - Preventive care <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Mean rate of lipid testing was 4.4 tests/1000 population/month. No differences between practices during pre and post usage. - Increase in the number of patients receiving a full lipid profile and decrease in those having only partial investigation ($\chi^2 = 49.5$, $df = 3$, $P < 0.05$) - Data did not show distinction between control and intervention - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Uneven experimental group</p> <p>8 of 25 dropped out (1 dispute, 1 lost data, 3 failed to record data, 3 lost data due to upgrades)</p> <p>Blinding and</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): Clinics/practices/ hospitals: 25 (I = 21, C = 4)</p> <p>User level of expertise/proficiency: Practices with previous experience of DSS were excluded</p> <p>Staff attended a university training session ("Recruitment of the practices," page 134); no further information available</p>	<p>Information delivery: a) <i>Delivery format:</i> Standalone system</p> <p>b) <i>Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: a) <i>General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p>b) <i>Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p>c) <i>Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather</p>		<p>Practitioner knowledge of lipid disorders = 24 to 41.7% No distinction between control and intervention practices</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: Cost of lipid-lowering drugs = £49/1000 patients/month SD = £31.70 (£4.53 – 140.81/1000 patients/month) No difference between control and intervention period - Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: Referrals— Pre: 3 from control, 17 from intervention Post: 6 from control, 22 from intervention 55% decrease in expected referrals Analysis of usage (n = 14) Mean patients = 12 (range 0 to 47) Working days = 12 of 130 (range 2 to 91) for 50% of practices 50% of practices used the module less than 8 times (min 6, max of 41 and mean of 15) Data did not report distinction between</p>	<p>concealment not described</p> <p>Outcome data were not adequately reported</p> <p>Learning bias (Discussion section, paragraph 2)</p> <p>Applicability/generalizability: CDSS was built using legacy system; 6 months of intervention</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>than inaction: Can't tell</p> <ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i> Hypertext functioned as an educational tool</p>		<p>control and intervention</p> <ul style="list-style-type: none"> - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Holbrook, Thabane, Keshavjee, et al., 2009 #299	Geographical location: Ontario, Canada Study dates: Late 2002–End of 2003 General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Patient Duration of intervention: NR Sample type(s) (with N randomized for each): - Patients: 511 (I = 253, C = 258) - Individual HCPs: > MDs: 43 > PAs/NPs: 3 NPs User level of expertise/proficiency: NR	Authors' basic description of system: The CDSS is a web-based diabetes tracker of the Computerization of Medical Practices for the Enhancement of Therapeutic Effectiveness Study II, providing both physicians and patients updated tracker information and most recent laboratory results. Source/origin of system: Not clearly described Content: a) <i>Objective(s):</i> - Chronic disease management - Initiating discussion with patient b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: a) <i>Delivery format:</i> Online access b) <i>Delivery mode:</i> Not clearly described	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Total process composite score [maximum = 10] (SD)— Intervention (n = 253) Before: 5.19 (2.14) After: 6.52 (2.30) Control (n = 258) Before: 5.19 (2.16) After: 5.25 (2.52) Mean difference 95% CI 1.27 (0.79 to 1.75), P < 0.001 Patients with improvement for total composite score, n (%)— Intervention: 156 (61.7) Control: 110 (42.6) Difference 19.1% P < 0.001 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: Knowledge of diabetes target had improved = 16 of 33 (48%) 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: - Patient satisfaction: Intervention	General comments: Unable to retrieve supplemental data Quality assessment: Overall rating: Fair Comments: Used allocation concealment Computer generated randomization Outcome assessors were blinded to each patient's intervention status No information whether patients or physicians were blinded Attrition rate: I = 29 of 253 C = 37 of 258 > 10% Fairly similar baseline

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p>		<p>patients were more optimistic than those in the control group in terms of their daily productivity and ease of management of their diabetes, their relationship with their respective primary care providers, and the quality of their diabetes care.</p> <p>192 (75.9%) of the intervention patients were as satisfied or more satisfied with their care since starting to use the tracker system.</p> <p>There were no statistically significant changes in quality-of-life measures, SF-12 and Diabetes-39.</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Applicability/generalizability: Short intervention period (6 months)</p> <p>Use of surrogate outcomes</p> <p>Participants were already using an EMR in practice</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Holt, Thorogood, Griffiths, et al., 2010 #14579 AND Holt, Thorogood, Griffiths, et al., 2006	Geographical location: 19 practices in the West Midlands UK area Study dates: September 2006-September 2008 General setting: Community Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 24 months	Authors' basic description of system: A cardiovascular risk assessment tool to improve the identification of at-risk patients. Source/origin of system: Commercially available Content: <i>a) Objective(s):</i> - Diagnosis - Preventive care <i>b) Relationship to point of care:</i> - Synchronous - Asynchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Incidence of cardiovascular events—Rate ratio = 0.96, 95% CI = 0.85 to 1.10, P = 0.59 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and	General comments: Definition of cardiovascular event: - A new diagnosis of cardiovascular disease (i.e., entry onto the Coronary Heart Disease [CHD] Register or Stroke/Transient Ischaemic Attack [TIA] Register) - A new stroke or TIA (whether or not already on the Stroke/TIA Register) - A new myocardial infarction (whether or not

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Clinics/practices/hospitals: 19 - Patients: 38,147 <p>User level of expertise/proficiency: NR</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N 		<p>implementation: NR</p> <p>Other (clinical and process outcomes): Incidence of cardiovascular events: rate ratio = 0.96, 95% CI = 0.85 to 1.10, P = 0.59</p>	<p>already on the CHD Register)</p> <p>- Sudden death from cardiovascular disease</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Baseline characteristics of study population not described; blinding and concealment methods not reported</p> <p>Applicability/generalizability: Multicenter primary care practices across various locations and regions in UK; cannot determine the impact of the intervention for specific types of cardiovascular events</p> <p>Unable to</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			determine the impact of CDSS due to changes in the wording of the screen alerts

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Judge, Field, DeFlorio, et al., 2006 #2625	<p>Geographical location: Worcester, MA</p> <p>Study dates: March 2002–March 2003</p> <p>General setting: Academic</p> <p>Specific setting: Long-term care facility</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Resident care units of a long-term care facility</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomize) Clinics/practices/hospitals: 7 resident care units</p> <p>User level of expertise/proficiency: High</p>	<p>Authors' basic description of system: Computer-based clinical decision support system for the long-term care setting based on evidence derived from observational studies of preventable adverse drug events, consensus recommendations for the appropriate use of medications in geriatric patients, and known high-risk drug-drug interactions.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Intervention: Number of alerts = 1982 (%); appropriate action taken = 31% (n = 606) Control: Number of alerts = 1861 (%); appropriate action taken = 28% (n = 513) Relative risk = 1.1 , 95% CI (1.00,1.2)</p> <p>- HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR</p>	<p>General comments: Primary outcome was the effect of a prescription-related alert on physician behavior measured in terms of proportion of alerts that were followed by appropriate action in the intervention and control units</p> <p>Quality assessment: Overall rating: Fair</p> <p>Applicability/generalizability: Implemented in resident care facilities of a large academic hospital and incorporated into a CPOE system that had been in use for at least 4 years</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i> - Local user involvement in</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Kenealy, Arroll, and Petrie, 2005 #3200 Comparison 1 of 3	Geographical location: Auckland, New Zealand Study dates: NR General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Clinician Duration of intervention: 2 months Sample type(s) (with N randomized for	Authors' basic description of system: Two versions of reminders for diabetes screening were evaluated: (1) computerized reminders for physicians that flashed only for patients eligible for screening and (2) patient reminders using a diabetes risk self-assessment sheet. Source/origin of system: Commercially available Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: <i>a) Delivery format:</i>	Comparator(s): Usual care/no CDSS or KMS 1) Usual care 2) Patient reminder 3) Computerized reminder	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percentage of eligible screened for diabetes (total = 19,187 patients; eligible for screening = 5628 patients) I: Computerized reminder: 31.8% C: Usual Care: 15.5% Odds ratio 2.55, 95% CI 1.68, 3.88 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR	General comments: Short duration (2 months) Quality assessment: Overall rating: Good Comments: Methods used for randomization were adequate Applicability/generalizability: Implemented in a community-based, primary care practice setting in which the vast majority of the family practitioners used the same commercially available EHR

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>each): > MDs: 107 family practitioners > Practices: 66</p> <p>User level of expertise/proficiency: Family practitioners were instructed on using computer reminder as well as patient reminder form</p>	<p>Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of</p>		<p>6) Impact on HCP use and implementation: NR</p>	<p>software</p> <p>Additional stipulation was that the HCPs receive the laboratory glucose results electronically, which a vast majority of them did</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		reasoning: N - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y			
Kenealy, Arroll, and Petrie, 2005 #3200 Comparison 2 of 3	Geographical location: Auckland, New Zealand Study dates: NR General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Clinician	Authors' basic description of system: Two versions of reminders for diabetes screening were evaluated: (1) computerized reminders for physicians that flashed only for patients eligible for screening and (2) patient reminders using a diabetes risk self-assessment sheet. Source/origin of system: Commercially available Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous	Comparator(s): 1) Usual care 2) Patient reminder 3) Computerized reminder Patient reminder was a diabetes self-assessment form that was filled out by the patient prior to the visit and given to the doctor during the visit	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percentage of eligible screened for diabetes (total = 19,187 patients; eligible for screening = 5628 patients)— I: Computerized reminder: 31.8% C: Patient reminder: 23.9% Odds ratio 1.49, 95% CI 1.07, 2.07 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR	General comments: None Quality assessment: Overall rating: Good Methods used for randomization were adequate Applicability/generalizability: Implemented in a community-based, primary care practice setting in which the vast majority of the family

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 2 months</p> <p>Sample type(s) (with N randomized for each): - MDs: 107 family practitioners - Practices: 66</p> <p>User level of expertise/ proficiency: Family practitioners were instructed on using computer reminder as well as patient reminder form</p>	<p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <i>c) Communication content features:</i> - Provision of a</p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>practitioners used the same commercially available EHR software</p> <p>Additional stipulation was that the HCPs receive the laboratory glucose results electronically, which a vast majority of them did</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>recommendation, not just an assessment: Y</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
<p>Kenealy, Arroll, and Petrie, 2005</p> <p>#3200</p> <p>Comparison 3 of 3</p>	<p>Geographical location: Auckland, New Zealand</p> <p>Study dates: NR</p> <p>General setting: -Community</p> <p>Specific setting: - Outpatient - Chronic</p> <p>Study design:</p>	<p>Authors' basic description of system: Two versions of reminders for diabetes screening were evaluated: (1) computerized reminders for physicians that flashed only for patients eligible for screening and (2) patient reminders using a diabetes risk self-assessment sheet.</p> <p>Source/origin of system: Commercially available</p>	<p>Comparator(s):</p> <p>1) Usual care</p> <p>2) Patient reminder</p> <p>3) Computerized reminder</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Percentage of eligible screened for diabetes (total = 19,187patients; eligible for screening = 5628 patients) I: Computerized reminder: 31.8% C: Computerized reminder + patient reminder: 23.7% - Recommended clinical study ordered/completed: NR - Recommended treatment 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Methods used for randomization were adequate</p> <p>Applicability/generalizability:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 2 months</p> <p>Sample type(s) (with N randomized for each): - MDs: 107 family practitioners - Practices: 66</p> <p>User level of expertise/proficiency: Family practitioners were instructed on using computer reminder as well as patient reminder form</p>	<p>Content: <i>a) Objective(s):</i> Preventive care</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> - User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision</p>		<p>ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Implemented in a community-based, primary care practice setting in which the vast majority of the family practitioners used the same commercially available EHR software</p> <p>Additional stipulation was that the HCPs receive the laboratory glucose results electronically, which a vast majority of them did</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>making: Y</p> <ul style="list-style-type: none"> - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
<p>Khan, Maclean, and Littenberg, 2010</p> <p>#14627</p> <p>AND</p>	<p>Geographical location: 38 practices in Vermont and 26 in NY</p> <p>Study dates: Observed for at least 24 months</p>	<p>Authors' basic description of system: Decision support system designed to help primary care providers and their diabetes patients achieve guideline-based treatment targets.</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: All subjects: Inpatient length of stay (days) — Control: 1.1 Intervention: 0.99 P = 0.01 <p>Seniors (age 65 years and up):</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Maclean, Gagnon, Callas, et al., 2009	General setting: Community	Source/origin of system: Locally developed		Inpatient length of stays (days)— Control: 1.44 Intervention: 1.22 P = 0.002	Applicability/ generalizability: Locally developed intervention evaluated in a multisite trial across two states; some baseline differences between the control and intervention group
	Specific setting: Outpatient	Content: <i>a) Objective(s):</i> Chronic disease management		Age < 65 years: Inpatient length of stay (days)— Control: 0.84 Intervention: 0.79 P < 0.25	
	Study design: RCT, cluster randomization	<i>b) Relationship to point of care:</i> Asynchronous		Men: Inpatient length of stay (days)— Control: 1.10 Intervention: 0.94 P = 0.03	
	Unit of randomization: Clinic or team	Decision support: <i>Response requirement:</i> NR (assume no response requirement)		Women: Inpatient length of stay (days)— Control: 1.10 Intervention: 1.05 P = 0.15	
	Duration of intervention: NR	Information delivery: <i>a) Delivery format:</i> Paper-based		- Morbidity: All subjects: Number of inpatient admissions (hospitalization)— Control: 0.20 Intervention: 0.17 P = 0.01	
	Sample type(s) (with N randomized for each): - Patients: 7412 - Clinics/practices/ hospitals: 64 - Individual HCPs: 132 > MDs: family medicine: 65 - Internists: 35 - NPs: 18 - PAs: 14	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N		All subjects: Number of emergency department visits— Control: 0.36 Intervention: 0.27 P < 0.0001	
	User level of expertise/ proficiency: NR	<i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the		Seniors (age 65 years and up): Number of inpatient admissions— Control: 0.27 Intervention: 0.21	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		reason for not following CDSS recommendations: N		P = 0.001	
		- Provision of decision support at time and location of decision making: Can't tell		Seniors (age 65 years and up): Number of emergency department visits—	
		- Recommendations executed by noting agreement: N		Control: 0.36 Intervention: 0.21 P < 0.001	
		<i>c) Communication content features:</i>		Age < 65 years: Number of inpatient admissions—	
		- Provision of a recommendation, not just an assessment: Y		Control: 0.15 Intervention: 0.13 P < 0.31	
		- Promotion of action rather than inaction: N			
		- Justification of decision support via provision of reasoning: N		Age < 65 years: Number of emergency department visits—	
		- Justification of decision support via provision of research evidence: N		Control: 0.37 Intervention: 0.33 P < 0.11	
		<i>d) Auxiliary features:</i>		Men: Number of inpatient admissions—	
		- Local user involvement in development process: Can't tell		Control: 0.21 Intervention: 0.17 P = 0.02	
		- Provision of decision support results to patients as well as providers: Y		Men: Number of emergency department visits—	
		- CDSS accompanied by periodic performance feedback: Y		Control: 0.36 Intervention: 0.23 P < 0.0001	
		- CDSS accompanied by conventional education: N		Women: Number of inpatient admissions—	
				Control: 0.20 Intervention: 0.17 P = 0.15	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Women: Number of emergency department visits— Control: 0.37 Intervention: 0.30 P = 0.01</p> <p>- Mortality: NR</p> <p>- Validated measure of HRQOL or functional status: Functional status (n = 672)— SF-12 Physical (0-100) Control: 40.6 Intervention: 40.8 Unadjusted effect=+0.2 Adjusted effect = +0.2 (95% CI -0.9 to +1.3) P = 0.68</p> <p>SF-12 Mental (0-100) Control: 50.5 Intervention: 50.7 Unadjusted effect=+0.3 Adjusted effect=-0.4 (95% CI -1.6 to +0.8) P = 0.50</p> <p>Quality of life at followup survey (n = 658)— Audit of diabetes dependent quality of life (ADDQOL) (-9 to +9) Control: -1.4 Intervention: -1.2 Unadjusted effect: +0.23 Adjusted effect: +0.12 (95% CI -0.04 to +0.28) P = 0.13</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: Guideline-appropriate testing for A1C— Control: 55% Intervention: 56% Unadjusted OR = 1.06 Adjusted OR = 1.17 (95% CI 0.80 to 1.72) P = 0.43 Guideline-appropriate testing for lipids— Control: 71% Intervention: 74% Unadjusted OR = 1.17 Adjusted OR = 1.39 (95% CI 1.07, 1.80) P = 0.012 Guideline-appropriate testing for creatinine— Control: 80% Intervention: 84% Unadjusted OR = 1.26 Adjusted OR = 1.40 (95% CI 1.06 to 1.84) P = 0.018 Guideline-appropriate testing for urine protein:— Control: 32% Intervention: 40% Unadjusted OR = 1.41 Adjusted OR = 1.74 (95% CI 1.13 to 1.69) P = 0.012)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<ul style="list-style-type: none"> - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: All subjects: Inpatient charges— Control: \$3480.14 Intervention: \$3113.19 P = 0.02 All subjects: Emergency department charges — Control: \$414.30 Intervention: \$303.51 P < 0.0001 Seniors (age 65 years and up): Inpatient charges— Control: 4264.36 Intervention: \$3699.26 P = 0.004 Seniors (age 65 years and up): Emergency department charges— Control: \$443.27 Intervention: \$270.45 P < 0.0001 Age < 65 years: Inpatient charges— Control: \$2869.84 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Intervention: \$2572.14 P = 0.30</p> <p>Age < 65 years: Emergency department charges— Control: \$391.76 Intervention: \$334.03 P = 0.07</p> <p>Men: Inpatient charges— Control: \$3712.22 Intervention: \$3098.26 P = 0.03</p> <p>Men: Emergency department charges— Control: \$410.91 Intervention: \$299.18 P < 0.0001</p> <p>Women: Inpatient charges — Control: \$3265.12 Intervention: \$3128.00 P = 0.21</p> <p>Women: Emergency department charges— Control: \$417.45 Intervention: \$307.80 P < 0.009</p> <p>- Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	
Kline, Zeitouni, Hernandez-	Geographical location:	Authors' basic description of system:	Comparator(s): Usual care/no	<p>1) Impact on clinical outcomes: - Length of stay: Median length of</p>	General comments:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Nino, et al., 2009 #381	Charlotte, NC Study dates: Oct 17, 2005–Sep 18, 2007 General setting: Academic Specific setting: - Emergency department - Acute Patients with chest pain admitted to the emergency department Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 2 years Sample type(s) (with N randomized for each): Patients: 400 User level of expertise/proficiency: NR	Computer-based method to estimate the pretest probability of acute coronary syndrome using the method of attribute matching that produces a point estimate of pretest probability by obtaining 8 predictor variables from a patient undergoing evaluation for a possible acute coronary syndrome. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Diagnosis <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or	CDSS or KMS	stay— Control: 11.4 hours Intervention: 9.2 hours (95% CI for difference = -2.9, 7.6 hours; P = 0.36) - Morbidity: Admit/hospitalization— Control: N = 185 Intervention: N = 184 Significant cardiovascular diagnosis (n = 71): n (% of subgroup, % of group)— Control = 13 (36%, 7%) Intervention = 9 (26%, 5%) No significant cardiovascular diagnosis (n = 298) : n (% of subgroup, % of group)— Control = 20 (13%, 11%) Intervention = 10 (7%, 5%) P=0.059 Readmission within 7 days— Control = 20 of 185 (11%) Intervention = 6 of 184 (4%) 95% CI = 2.5% to 13.2% P=0.001 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR	None Quality assessment: Overall rating: Good Comments: Randomization adequate (computer-generated randomization sequence); assessors blind to group assignment Applicability/generalizability: Urban emergency department population known to have a high rate of cocaine use Full-time research coordinator required to gather the clinical variables and input them into the computerized interface to generate the pretest probability

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y 		<p>4) Impact on relationship-centered outcomes:</p> <ul style="list-style-type: none"> - Patient satisfaction: Satisfaction with clinician explanation of the problem— Control: 38% Intervention: 49% (95% CI for the difference = 0.9% to 21.0%) <p>5) Impact on economic outcomes:</p> <p>NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Krall, Traunweiser, and Towery, 2004 #4293	<p>Geographical location: Portland, OR</p> <p>Study dates: Jan 15–Feb 16, 2000</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 1 month</p> <p>Sample type(s) (with N randomized for each): - Patients: 10,972 - Individual HCPs: > MDs/DOs (family practice and internal medicine): 73 > PAs/NPs: 27</p>	<p>Authors' basic description of system: Low-dose aspirin therapy alert that notified the clinician at the point of care using offline data analysis instead of event monitoring.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Documentation of aspirin use for patients within the first month— Intervention: 54.3% (315 of 580) Control: 25.8% (128 of 496) ($p < 0.001$, OR 3.3) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: Short-term intervention—1 month</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Early adopter of CDSS; short study duration (1 month)</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>> Nurses</p> <p>User level of expertise/proficiency: Comprehensive EMR since 1994</p>	<p>Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y (clinician needed 2 extra clicks to complete recommended aspirin order) <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>development process: Y</p> <ul style="list-style-type: none"> - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N <p>e) Other:</p> <p>Two clicks were required for the clinicians to complete the recommended aspirin order</p>			
<p>Kucher, Koo, Quiroz, et al., 2005</p> <p>#3517</p>	<p>Geographical location: Boston, MA</p> <p>Study dates: 9/2000–1/2004</p> <p>General setting: Academic</p> <p>Specific setting: Inpatient medical and surgical services</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention:</p>	<p>Authors' basic description of system: A computer program linked to the patient database to identify consecutive hospitalized patients at risk for deep-vein thrombosis among high-risk hospitalized patients.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p>a) <i>Objective(s):</i> Preventive care—ordering DVT prophylactic measures</p> <p>b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p> <p>Design: eligible patients randomized to have alerts generated for their providers versus no such alerts</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: Clinically diagnosed DVT or PE at 90 days occurred in 61 patients in the intervention group (4.9%) compared with 103 patients (8.2%) in the control group. The Kaplan-Meier estimates of the likelihood of freedom from DVT or PE at 90 days were 94.1% (95% CI: 92.5 to 95.4%) and 90.6% (95% CI: 88.7 to 92.2%), respectively ($p < 0.001$) <p>30-day outcomes—</p> <p>DVT: Intervention: 3.3% Control: 5.7%, $p = 0.004$</p> <p>PE: Intervention: 0.8% Control: 1.7%, $p = 0.05$</p> <ul style="list-style-type: none"> - Mortality: Death at 90 days— Intervention: 22.5% Control: 22.3%, $p = 0.74$ <p>Death at 30 days—</p>	<p>General comments: Well-designed study with adequate intervention and followup periods</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Early adopter of CDDS</p> <p>Locally developed system</p> <p>Use of relevant,</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
	<p>40 months</p> <p>Sample type(s) (with N randomized for each): Patients: 2506</p> <p>User level of expertise/proficiency: Users already using CPOE/EHR</p>	<p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather</p>		<p>Intervention: 13.9% Control: 12.5%, $p = 0.56$ - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Prophylactic measures ordered— Intervention: 421 of 1255 patients (33.5%) Control: 182 of 1251 (14.5%) $p < 0.001$ - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>valid, and reproducible patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>than inaction: Y</p> <ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 			
<p>Kuperman, Teich, Tanasijevic, et al., 1999</p> <p>#5941</p>	<p>Geographical location: Boston, MA</p> <p>Study dates: 12/1/1994–1/31/1995 and 9/1/1995–10/30/1995</p> <p>General setting: Academic</p> <p>Specific setting: Inpatient–non-ICU</p> <p>Study design: RCT, parallel group</p>	<p>Authors' basic description of system: A computer system to detect critical conditions and automatically notify the responsible physician via the hospital's paging system.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i> Other—action in response to a critical laboratory value</p> <p><i>b) Relationship to point of care:</i> Synchronous</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: NR - Mortality: Control: 13 of 98 (13.3% per patient) Intervention: 7 of 94 (7.4% per patient), $p = 0.19$ - Validated measure of HRQOL or functional status: NR - Adverse events among alerting situations (including death)— Control: 27 of 98 (28% per patient) Intervention: 31 of 94 (33% per patient), $p = 0.41$ <p>2) Impact on health care process</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Academic setting</p> <p>Early adopter of DCSS</p> <p>Locally developed</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Unit of randomization: Patient</p> <p>Duration of intervention: 4 months</p> <p>Sample type(s) (with N randomized for each): Alerts: 192</p> <p>User level of expertise/proficiency: Clinical alerting system that had been in use since June 1994</p>	<p>Decision support: <i>Response requirement:</i> - Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> - Integrated with CPOE/EHR - Other—pager <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: N (action required)</p>		<p>outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Time until treatment ordered (in hours)— Intervention (n = 94): Median (IQR): 1.0 (0.2-2.6) Mean (SD): 4.1 (12.1) Control (n = 98): Median (IQR): 1.6 (0.6-4.2) Mean (SD): 4.6 (9.1) p = 0.003 - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	system

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 			
<p>Lee, Chen, Currie, et al., 2009</p> <p>#312</p>	<p>Geographical location: New York, NY</p> <p>Study dates: 1/1/2006–8/31/2006</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p>	<p>Authors' basic description of system: A personal digital assistant–based log with and without obesity decision support features.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i></p>	<p>Comparator(s): Another CDSS/KMS (no CDSS for obesity, but CDSS for smoking cessation)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Obesity-related diagnoses— Intervention: 91 of 807 (11.3%) Control: 10 of 997 (1%) ($p < 0.001$) 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Nonblinded participants and</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 8 months</p> <p>Sample type(s) (with N randomized for each): - Individual HCPs: > Training Nurses (acute and family): 29 - Other: 1874 patient encounters</p> <p>User level of expertise/proficiency: Participants received user training including basic use of personal digital assistant and clinical log system and overview of decision support features for obesity management and smoking cessation</p>	<p>Diagnosis</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> Not clearly described</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y</p>		<p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>outcome assessors; ambiguous reporting of methods</p> <p>Applicability/generalizability: Student nurses as participants</p> <p>Standalone PDA CDSS</p> <p>No patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Can't tell 			
Linder, Rigotti, Schneider, et al., 2009 #488	Geographical location: Boston, MA Study dates: 12/19/06–9/30/07 General setting:	Authors' basic description of system: In intervention practices, clinicians received 3 enhancements to the EMR: (1) First, two smoking status icons were added. If smoking	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR 	General comments: Apparent increase in smoking cessation rates might be due to improved

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Academically-affiliated community practices</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Practice</p> <p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 12,207 smokers of 132,630 patients for 315,962 visits - Practices: 26 - Individual HCPs: > Clinicians: 521 (314 control, 207 intervention)</p> <p>User level of expertise/ proficiency: Clinicians received an introductory email, one practice visit by an investigator, and periodic emails to</p>	<p>status was not documented in the EMR (e.g., not present in the problem list), a black icon of a cigarette and a question requested the clinician to update this status. If the EMR recognized the patient as a smoker, a scarlet icon appeared to guide the clinician to the Tobacco Smart Form.</p> <p>(2) Second, for smokers clinicians received various tobacco treatment reminders.</p> <p>(3) Third, the Tobacco Smart Form provided documentation-based clinical decision support. In particular, an order set facilitated the ordering of smoking cessation medications, documenting of cessation-related actions, and referrals to smoking cessation counselors who would then attempt to follow up with the patients.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Diagnosis - Pharmacotherapy - Chronic disease management <i>b) Relationship to point of care:</i></p>		<p>- Recommended treatment ordered/prescribed: Prescribed medication— Intervention: 2.0% Control: 2.0% $p = 0.40$ Referred to smoking cessation counseling— Intervention: 4.5% Control: 0.4% $p < 0.001$ Documentation of smoking status increased— Intervention: 37 to 54% Control: 35 to 46% in the ($p < 0.001$) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: 44% (90 of 207) of intervention clinicians used the Tobacco Smart Form at least once - Implementation of CDSS/KMS: NR</p>	<p>documentation. Even though the study was positive, the absolute magnitude of the impact of the intervention was relatively modest.</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: The practices had used an EMR for a number of years previously</p> <p>Included residents</p> <p>Portions of the intervention have been implemented into other EHRs</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	encourage use	<p>Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> - System-initiated (“push”) - User-initiated (“pull”) (icons were available to users, who then needed to take action in order to fully initiate the process)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y (reminders, Yes; form, Can’t tell)</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>the reason for not following CDSS recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Litzelman, Dittus, Miller, et al., 1993	Geographical location: Indianapolis, IN	Authors' basic description of system: Computerized reminder	Comparator(s): Another CDSS/KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process	General comments: None

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#7057	<p>Study dates: May 1–Oct 31, 1989</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Other—half-day practice session</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 5,407 - Individual HCPs: > MDs: 176; 31 internal medicine, 145 residents I = 92 (15 faculty + 77 residents) C = 84 (16 faculty + 68 residents) - Other—32 practice sessions (I = 16, C = 16)</p>	<p>system containing more than 1400 physician-authored rules to review information stored in the patients' electronic records. Computerized reminder system reviewed the records of all patients prior to scheduled visits to the general medicine practice and printed indicated tests in the "orders" section of each patient's outpatient encounter form.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Lab test ordering - Preventive care <i>b) Relationship to point of care:</i> - Synchronous</p> <p>Decision support: <i>Response requirement:</i> - Justification for not complying - Mandatory response (nurse/clerk will return incomplete form)</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features</p>	<p>1) CDSS prints out patient-specific data for each reminder with explanation</p> <p>2) The comparator is the same CDSS with modifications for the 3 prevention tests targeted for the study; FOBT, mammography, and pap test</p>	<p>outcomes: - Recommended preventive care ordered/completed: All tests— All physicians: I = 46% C = 38% P = 0.002 Residents only: I = 47% C = 37% P = 0.0004 Faculty only: I = 42% C = 44% P = 0.72</p> <p>FOBT— All physicians: I = 61% C = 49% P = 0.0007 Residents only: I = 63% C = 46% P < 0.0001 Faculty only: I = 57% C = 58% P = 0.81</p> <p>Mammography— All physicians: I = 54% C = 47% P = 0.036 Residents only: I = 55% C = 45% P = 0.013</p>	<p>Quality assessment: Overall rating: Fair</p> <p>Comments: Randomization by block (half-day practice sessions); possible contamination between physicians during change over</p> <p>New physicians may be added to the session</p> <p>Different practicing patterns between faculty and residents</p> <p>Applicability/generalizability: Regenstrief Medical Record System locally developed</p> <p>Experiment conducted in an academic environment; population may</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/proficiency: Computerized reminder system had been used for 14 years (1975–1989)	influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Can't tell <i>d) Auxiliary features:</i>		Faculty only: I = 50% C = 51% P = 0.87 Pap testing— All physicians: I = 21% C = 18% P = 0.20 Residents only: I = 22% C = 18% P = 0.136 Faculty only: I = 17% C = 18% P = 0.77 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Intervention physicians complied with target	be less generalizable to the community Form of delivery in paper may no longer apply

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Local user involvement in development process: Y (guideline design involved 35 faculty) - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i> Contains summary of the patient's recent study test results</p>		<p>reminders for cancer screening protocols for mammography, pap smear, and fecal occult blood testing more often than control physicians (46% vs 38%, $P = 0.002$)</p> <ul style="list-style-type: none"> - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Lo, Matheny, Seger, et al., 2009</p> <p>#748</p>	<p>Geographical location: Boston, MA</p> <p>Study dates: 7/21/03–1/20/04</p> <p>General setting: - Community - Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 2765 - Clinics: 22 - Individual HCPs: 366 (191 control, 175 intervention) - Events: 3673</p> <p>User level of expertise/</p>	<p>Authors' basic description of system: In an effort to avoid overloading physicians with alerts, a system for stratifying alerts into three tiers, with noninterruptive alerts falling into the category of least likely and least severe consequences was developed (with comment from physician and pharmacist expert panels).</p> <p>This study was limited to noninterruptive alerts. When the physician used the EMR to order a medication, the system was queried for the relevant lab tests. If such tests were not found, a notification was displayed in real time on the screen.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery:</p>	<p>Comparator(s): Usual care (usual care included access to the EMR, but without the alerts)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Proportion of laboratory tests that were appropriately ordered within 14 days of the visit— Intervention: 41% (689 of 1685) Control: 39% (771 of 1988) OR 1.048, CI 0.753 to 1.457, $p = 0.782$ - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: Quite likely the reason that this study was negative was that providers had to take the trouble to use a paper ordering system, rather than automatic order entry</p> <p>Quality assessment: Overall rating: Good</p> <p>Comments: The primary analysis was via logistic regression, which was necessary to control for baseline differences between the groups</p> <p>Applicability/generalizability: These practices had used an EMR for a number of years; included residents</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	proficiency: NR	<p><i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>support via provision of reasoning: N</p> <p>- Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Y</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: N</p>			
<p>Lobach and Hammond, 1994</p> <p>#7001</p>	<p>Geographical location: Durham, NC</p> <p>Study dates: 9/93–2/94</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient, chronic disease management</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p>	<p>Authors' basic description of system: A collaboratively developed guideline for outpatient diabetes management consisting of eight elements (e.g., Hgb1AC every 6 months) that were pulled from the EMR.</p> <p>At each encounter, the eight elements were listed, plus the date that each was last performed and a recommended followup date (this date could include "due now").</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p>	<p>Comparator(s): Usual care</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Provider compliance scores— Intervention: 32.0% Control: 15.6% P = 0.02 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered</p>	<p>General comments: The clinical meaning of the primary outcome variable is uncertain</p> <p>Quality assessment: Overall rating: Good</p> <p>Comments: Compliance was assessed using chart audit</p> <p>It was not clear precisely how the physician-level</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 497 - Clinics/practices/hospitals - Individual HCPs: > Training MDs: 10 > MDs: 20 - Events 1265</p> <p>User level of expertise/proficiency: NR</p>	<p><i>a) Objective(s):</i> - Lab test ordering - Chronic disease management - Preventive care</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following</p>		<p>outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>compliance scores, which were reported as percent compliance, were calculated</p> <p>Each encounter generated 8 potential elements, not all of which required immediate attention; did the authors take the percent compliance out of those actions that were recommended as immediate?</p> <p>Applicability/generalizability: The idea could be used elsewhere, but the implementation was dependent on the peculiarities of this particular EMR</p> <p>Guideline recommendations based on the American Diabetes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>CDSS recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i></p> <p>Providers could enter data elements that were not automatically captured by the EMR (e.g., foot exams, laboratory tests performed)</p>			<p>Association</p> <p>Single clinic</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		elsewhere)			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Locatelli, Covic, Macdougall, et al., 2009</p> <p>#220</p>	<p>Geographical location: 53 centers in 8 European countries (Bulgaria, Croatia, Germany, Italy, Latvia, Poland, Romania and Serbia, Montenegro)</p> <p>Study dates: Enrollment was completed in 9/2005</p> <p>General setting: - Academic - Community</p> <p>Specific setting: - Outpatient (nephrology care centers) - Chronic care</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Center</p> <p>Duration of intervention: 6 to 8 months</p> <p>Sample type(s) (with N randomized for each):</p>	<p>Authors' basic description of system: This is a central database, plus a CDS system that uses the response to data collection prompts to generate guideline-based recommendations customized for each patient, with arguments for and against the option.</p> <p>Source/origin of system: NR</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management (primary, the description of the system was too sketchy to determine whether the system had other objectives)</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> Can't tell</p> <p>Contextual factors/features influencing the</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Proportion of adherence to the guideline-based reminders— Intervention patients: 40% Control: 48% - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: This paper is extremely sketchy regarding the details of the intervention and somewhat sketchy about how the statistical analyses were performed</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Details about the intervention were uncertain.</p> <p>No blinding</p> <p>Uncertain how patients with missing values were analyzed</p> <p>The funding sponsor identified the selection of centers and was responsible for data collection and data management</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>- Patients: 599 - Clinics: 53</p> <p>User level of expertise/proficiency: NR</p>	<p>implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: N</p>			<p>Interpretation of data was performed with close collaboration between the steering committee and the sponsor</p> <p>Applicability/generalizability: These clinics are unlikely to reflect practice in the US; recommendations were based on the European Best Practices Guidelines</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Manotti, Moia, Palareti, et al., 2001 #5240	Geographical location: 5 sites in Italy Study dates: 1996–1998 General setting: Community Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: NR Sample type(s) (with N randomized for each): Patients: 345 in induction phase (145 intervention, 190 control), and 916 in maintenance phase (458 intervention, 458 maintenance) User level of expertise/ proficiency: High; these are	Authors' basic description of system: The environment is a standalone computerized system for managing anticoagulation. The intervention group adds a computer-aided dosing module that proposes the next dose and the next followup interval. Final decision about the prescription and the schedule of followup appointments was left to the physician, who was free to accept or to modify the computer suggestion. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Pharmacotherapy - Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Standalone system	Comparator(s): 2 study arms: 1) Group C: Computer-aided dosing 2) Group M: Manual dosing by physician	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Patients in Group C spent significantly more time within the therapeutic range than patients in Group M (71.2% vs 68.2%). There was also a significant difference in the percentage of time spent within the therapeutic range for each of the drug groups. All these differences were highly significant ($p < 0.001$) at the statistical level. - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	General comments: This study is assessing only a tiny component of CDS but one that is nevertheless important for the practice of anticoagulation Quality assessment: Overall rating: Good Applicability/generalizability: Although outside the US, these results could likely be generalized to any anticoagulation clinic that is organized around an EMR

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	experienced anticoagulation providers that already use a computerized anticoagulation management system	<p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		support via provision of research evidence: N d) <i>Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Marco, Sedano, Bermudez, et al., 2003 #4674	Geographical location: Santander, Spain Study dates: 12/98–8/99 General setting: Academic Specific setting: Outpatient (anticoagulation unit of a university hospital) Study design: RCT, crossover Unit of randomization: Patient Duration of	Authors' basic description of system: The software was used in parallel with traditional management; the software proposes a dose and the next visit time, but these recommendations are reviewed by the provider before action is taken. Source/origin of system: Commercially available Content: a) <i>Objective(s):</i> Pharmacotherapy b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i>	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: The computer matched the traditional dosing, achieving a small but statistically significant greater efficacy in maintaining patients within the INR target range. The percentage of INR determinations over 5.5 was very low in both groups. Results validated the computerized acenocoumarol dosing in the center, achieving at least similar levels of effectiveness and safety compared with traditional dosage by medical	General comments: The design was a crossover but analyzed as parallel groups; contamination seems quite likely Quality assessment: Overall rating: Fair Comments: The intervention was not well described, and contamination was likely Applicability/generalizability:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	intervention: 20 weeks Sample type(s) (with N randomized for each): Patients: 1882 User level of expertise/proficiency: NR	NR (assume no response requirement) Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i> User-initiated (“pull”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an		staff. - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	Single site Study conducted in Spain

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>assessment: Y</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p>d) Auxiliary features:</p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
<p>Martens, van der Aa, Panis, et al., 2006</p> <p>#3066</p> <p>AND</p> <p>Martens, van der Weijden, Severens, et al., 2007</p> <p>#1633</p>	<p>Geographical location: Netherlands</p> <p>Study dates: 10/03–4/04</p> <p>General setting:</p> <ul style="list-style-type: none"> - Academic - Community <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster</p>	<p>Authors' basic description of system:</p> <p>This is a real-time automated reminder system that contains reminders regarding alternative type of drug, other doses, alternative drug administration, specific indication, other duration of prescribing, not prescribing, referring to a specialist. It uses if-then logic derived from guidelines and is activated whenever the physician enters a prescription in the computerized prescriptions module that is not</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: No differences between groups were found for indicators and volumes related to recommendations advocating certain drugs <p>Although there was a tendency toward</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Lots of providers and practices were ultimately excluded</p> <p>Study was</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	randomization	consistent with guidelines.		clinically relevant results for prescription volumes that were supposed to drop, the difference in sum score between the groups was not significant.	underpowered
	Unit of randomization: Clinic or team (practice)	Not explicitly stated whether the reminders could be ignored, or how well the system was integrated with the existing EMR.			Applicability/generalizability: A somewhat awkward and probably poorly integrated intervention, tested outside the US
	Duration of intervention: NR	Source/origin of system: Locally developed		For antibiotic prescriptions that were supposed to drop, the sum score for the intervention group was 28.2 (95% CI: 20.8 to 44.5) prescriptions per 1000 patients per GP, while this was 39.7 (95% CI: 29.7 to 64.1) for the control group.	
	Sample type(s) (with N randomized for each): - Practices: 23 - Individual HCPs: > MDs: 53 general practitioners	Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous		Cholesterol sum score prescriptions per 1000 patients per GP: All nonsignificant	Physicians were already experienced users of an EHR
	User level of expertise/proficiency: Physicians received individual instruction when the system was installed in the practice	Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")		- Impact on user knowledge: NR	Prescribing guidelines were set by a regional multidisciplinary committee of opinion leaders (pharmacists, GPs, hospital staff) and prevailing EBM
		Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y		3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: Halfway during the intervention year, a written questionnaire was sent to a specially selected sample of GPs asking about their experiences with and opinion on the feasibility of working with the	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance 		<p>clinical reminder system. From that, it was asserted that respondents valued the guidelines that were used as the basis for the reminders, accepted the content in part because of their input into the development process, and appreciated that reminders were only generated when prescription was outside the guidelines.</p> <ul style="list-style-type: none"> - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		feedback: N - CDSS accompanied by conventional education: N			
Matheny, Sequist, Seger, et al., 2008 #1157	<p>Geographical location: Boston, MA</p> <p>Study dates: 1/1/04–6/30/04</p> <p>General setting: - Academic - Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 1922 - Clinics: 20 - MDs: 303 - Other: 2507 clinic visits</p>	<p>Authors' basic description of system: In clinics that already use an EMR, the intervention appended reminders for potassium, creatinine, liver function, thyroid function, and therapeutic drug levels for appropriate medications (10 total reminders) to the main patient summary screen when lab testing associated with chronic medication use was late.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS (usual care includes a general EMR)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Rates of appropriate laboratory monitoring within 14 days of an office visit ranged from 14% (therapeutic drug levels) to 64% (potassium monitoring with potassium-sparing diuretic use).</p> <p>Reminders for appropriate laboratory monitoring had no impact on rates of receiving appropriate testing for creatinine, potassium, liver function, renal function, or therapeutic drug level monitoring.</p> <p>- Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Comments: The authors partially attribute the negative results to a ceiling effect, the passive nature of the reminders, and guideline overload</p> <p>Applicability/generalizability: Participants were already experienced users of the EMR</p> <p>Practices were part of a health system that has historically been an early adopter of health IT</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/ proficiency: NR	<p>System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N- Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of</p>		6) Impact on HCP use and implementation: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Maviglia, Yoon, Bates, et al., 2006 #3030	Geographical location: Boston, MA Study dates: 1/8/03–1/7/04 General setting: Academic Specific setting: Outpatient Study design: RCT, cluster randomization Unit of randomization: Clinic Duration of intervention: 12 months	Authors' basic description of system: The EMR at Partners was enhanced to include an infobutton that provides patient-specific and context-sensitive links to help providers efficiently research questions about the drugs that they prescribe. Two versions were of the infobutton application were evaluated, one that linked to information from Micromedex® and the other to information from SkolarMD®. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i>	Comparator(s): Another CDSS/KMS One version of KnowledgeLink included links to information provided from Micromedex (KL/MDX) and the other version provided content from SkolarMD (KL/SKL)	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Postuse survey—289 completed surveys returned from 89 distinct users (29% response rate); 83.8% of queries were successfully answered (86.0% for KL/MDX, 72.5% for KL/SKL, $p = 0.1$) and 14.9% of the time the queries caused providers to	General comments: Although framed as a RCT, and although one of the links was preferred to the other, the ultimate impact of this work is not in comparing the two links, but rather in demonstrating how well context-sensitive help was received Quality assessment: Overall rating: Good Applicability/

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each): - Clinics: 18</p> <p>User level of expertise/ proficiency: NR</p>	<p>Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content</i></p>		<p>change their decision (15.2% KL/MDX, 13.7% KL/SKL, $p = 0.7$)</p> <p>- HCP satisfaction: Poststudy survey—72 of 389 returned (19%); 80% of providers rated the system overall as positively on scales of ease of use, relevance, speed, and improvement in patient care, and 70% or more had positive impressions of the target reference, either Micromedex or SkolarMD</p> <p>Poststudy survey—KL/MDX respondents tended to be more satisfied than their KL/SLK counterparts (87% versus 54%, $p = 0.05$); not so much in how often users reported that they could find answers to their questions but more related to how quickly and easily the answers could be found</p> <p>- HCP use: Clinicians used KnowledgeLink on average 2.3 times per month; range, 0.1–100; median, 0.5 and during an average of 1.2% patient encounters</p> <p>Usage was statistically significantly higher among those randomized to Micromedex compared to SkolarMD (median 0.56 versus 0.42 uses/month, $p = 0.01$)</p> <p>- Implementation of CDSS/KMS: NR</p>	<p>generalizability: Academic setting</p> <p>Early adopters of CDSS</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Y <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N			
Mc Donald, 1976 #7448	Geographical location: Indianapolis, IN Study dates: NR General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group	Authors' basic description of system: The EMR normally produced a summary report and a patient encounter form (this paper form then being used for all ordering of tests, drugs, etc.). The intervention added a surveillance report, which reminded the provider about appropriate tests to order. Source/origin of system: Locally developed	Comparator(s): Another CDSS/KMS The comparator is the base CDS package without the surveillance report	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: - Recommended clinical study ordered/completed: Clinician response to order a test when due to an obsolete value— Intervention: 36% (144 of 390) Control: 11% (45 of 402) $p < 0.00001$	General comments: None Quality assessment: Overall rating: Good Comments: A classic study in the development of the field

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Unit of randomization: Patient</p> <p>Duration of intervention: 8 month(s)</p> <p>Sample type(s) (with N randomized for each): - Patients: 226 - Visits: 601</p> <p>User level of expertise/proficiency: NR</p>	<p>Content: <i>a) Objective(s):</i> - Lab test ordering - Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Asynchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N- Request documentation of the reason for not following CDSS</p>		<p>- Recommended treatment ordered/prescribed: Clinicians appropriately changed drug regimen— Intervention: 28% (31 of 110) Control: 13% (9 of 68) $p = 0.026$</p> <p>If including either a repeat of the index measurement or the suggested change in medication— Intervention: 57% (63 of 110) Control: 23% (16 of 68) $p < 0.0001$</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Applicability/generalizability: Good applicability, with pertinent findings</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
McCowan, Neville, Ricketts, et al., 2001	Geographical location: United Kingdom	Authors' basic description of system: This standalone system requires clinicians to input	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: Hospital contacts for asthma— 	General comments: None

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#5320	<p>Study dates: Circa 2000</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster</p> <p>Unit of randomization: Practice</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Patients: 477 - Practices: 46</p> <p>User level of expertise/ proficiency: NR</p>	<p>information during the clinic visit and then refers to a database in order to generate recommendations. It can also print self-management plans and educational materials for patients.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p>		<p>Admissions Control (n = 330): 4 (1%) Intervention (n = 147): 0 OR = 0 (0 to 3.44)</p> <p>- Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Acute prescribing (# of patients)— Exacerbations of asthma: Intervention: 8% (12 of 147) Control: 17% (57 of 330) OR 0.43 (0.21 to 0.85) Received oral corticosteroids: Intervention: 5% (7 of 147) Control: 11% (35 of 330) OR 0.42 (0.14 to 1.29) Received emergency nebulisations: Intervention: 1% (1 of 147) Control: 5% (17 of 330) 0.13 (0.01 to 0.91)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p>	<p>Quality assessment: Overall rating: Fair</p> <p>Comments: Only 17 of 46 practices completed the study, with greater dropout in the intervention group</p> <p>Applicability/generalizability: A rudimentary standalone system tested outside the US</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N 		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: In response to a survey of intervention practices, clinicians said that the software increased consultation times slightly, that the data collection was reasonably comprehensive, and that the reminders were appropriate. <p>The software also had a risk prediction function that was not well received. Clinicians also reported that the printed management plans were of use and seemed to be of value to the patients.</p> <ul style="list-style-type: none"> - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- CDSS accompanied by conventional education: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
McDonald, Hui, Smith, et al., 1984 #7411	<p>Geographical location: Indianapolis, IN</p> <p>Study dates: 1980</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Team</p> <p>Duration of intervention: 2 years</p> <p>Sample type(s) (with N randomized for each): - Patients: 12,467 - Teams: 27 - Individual HCPs: 115 residents, 11 faculty members, 4 nurse-clinicians</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: On top of the existing EMR, intervention patients received computer-based reminders regarding testing and treatment. The reminders were based on information available the day before a scheduled clinic visit and were provided in printed form.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Immunization - Pharmacotherapy - Lab test ordering - Chronic disease management - Preventive care</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Noncommittal acknowledgement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p>	<p>Comparator(s): Another CDSS/KMS</p> <p>Same EMR but with reminders turned off</p>	<p>1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Hospitalization—Patients cared by study physicians eligible for pneumococcal or influenza vaccine had fewer hospitalizations and emergency room visits than control ($p < 0.02$) - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: The mean per-patient response rate for residents—Intervention: 49% Control: 29% for ($P < 0.001$)</p> <p>The effect of the computer reminder messages on the residents' response rate was significant ($p < 0.0001$). The effect of the resident's team was not ($p = 0.1$, intraclass correlation = 0.1).</p> <p>The response rate for the 11 faculty members who served as their own controls was 44% and 29% in the study and control states respectively ($p < 0.01$).</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p>	<p>General comments: Intervention included 1491 rules that could generate 751 unique reminder messages</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Good, despite the passage of time</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y 		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: The attitude of the residents in the study groups about the computer system in general and the reminder messages in particular predicted their response rate, accounting for 15% of the variance ($p < 0.001$). <p>The degree to which residents read the reports (as shown by their initials) predicted their response to a similar degree, explaining 15% ($p < 0.001$) of the variance. These two predictive variables were correlated ($r = 0.42$, $p < 0.001$); physicians who were positive about the computer were more likely to read the reports and vice versa.</p> <p>Among study residents, the physicians' intentions predicted their behavior, explaining 33% of the variance in response rate across the various actions ($p < 0.03$, $r^2 = 0.33$).</p> <ul style="list-style-type: none"> - HCP satisfaction: NR - HCP use: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 		- Implementation of CDSS/KMS: NR	
<p>McDonald, Hui, and Tierney, 1992</p> <p>#7115</p>	<p>Geographical location: Indianapolis, IN</p> <p>Study dates: Winters from 1978 to 1981</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention:</p>	<p>Authors' basic description of system: On top of the EMR, computerized reminders regarding influenza vaccinations were appended.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Immunization</p> <p><i>b) Relationship to point of care:</i> Asynchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i></p>	<p>Comparator(s): Another CDSS/KMS</p> <p>The comparator was the EMR but without the reminders regarding preventive care, specifically influenza vaccination</p>	<p>1) Impact on clinical outcomes: The difference in linear trends between the patients in the intervention group (whose physicians received reminders) and those in the control group was significant for emergency room visits ($P < 0.05$), hospitalizations ($P < 0.01$), and blood gas determinations ($P < 0.001$).</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: Hospitalization— <p>Winter months in years with access: 1978–1979 (N = 1000) Control: 5.0% Intervention: 6.6% 1979–1980 (N = 33,451) Control: 9.3% Intervention: 7.9% 1980–1981 (N = 71,075) Control: 9.0% Intervention: 6.2%</p>	<p>General comments: This is a report of some of the results of a larger trial. This larger trial is dated but nevertheless well-known and fundamental to the development of the field.</p> <p>Quality assessment: Overall rating: Good.</p> <p>Applicability/generalizability: Academic setting</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	3 years Sample type(s) (with N randomized for each): Patients: 4555 User level of expertise/proficiency: NR	Paper-based <i>b) Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can’t tell - Justification of decision		Nonwinter months in years with access: 1978–1979 (N = 1000) Control: 10.9% Intervention: 10.5% 1979–1980 (N = 33,451) Control: 14.0% Intervention: 17.1% 1980–1981 (N = 71,075) Control: 14.9% Intervention: 15.7% Winter months in years without access: 1978–1979 (N = 1000) Control: 3.2% Intervention: 3.5% 1979–1980 (N = 33,451) Control: 4.7% Intervention: 6.4% 1980–1981 (N = 71,075) Control: 4.4% Intervention: 2.9% Winter months (linear difference), P = < 0.01 Nonwinter months (constant difference), P = not significant Winter (no fall visit) (linear difference), P = not significant - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>support via provision of reasoning: N</p> <p>- Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Can't tell</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: N</p>		<p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: The cumulative incidence of influenza vaccination— 1978–1979: Control: 17.4% Intervention: 35.3% 1979–1980: Control: 19.7% Intervention: 34.5% 1980–1981: Control: 25.5% Intervention: 42.9% ($p < 0.001$)</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
McDowell, Newell, and Rosser, 1986 #7366 Comparison 1 of 3	Geographical location: 6 sites in Ontario, Canada Study dates: Oct 23, 1984–Dec 31, 1984 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Family Duration of intervention: 10 weeks Sample type(s) (with N randomized for each): - Patients: 1420 - Clinics/practices/hospitals: 6 User level of expertise/proficiency: NR	Authors' basic description of system: The computerized medical record system identifies patients for whom preventive procedures are due and automatically generates reminders for them using three mechanisms: reminder by mailed letter, telephone reminder by nurse, personal reminder by physician. Source/origin of system: Not clearly described Content: <i>a) Objective(s):</i> - Immunization - Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the	Comparator(s): Usual care/no CDSS or KMS <u>1) Intervention 1 = Reminder by letter</u> 2) Intervention 2 = Telephone reminder by nurse 3) Intervention 3 = Personal reminder by physician (CDSS) Control 1 = Randomized control group Control 2 = Control practices	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Rates of vaccination, n (%)— Intervention 1: 84 of 239 (35.1%) Control 1: 21 of 215 (9.8%) Control 2: 17 of 444 (3.8%) 3 intervention groups differed from randomized control group ($\chi^2 = 40.7$, 1df, $p < 0.001$) Difference among 3 intervention groups ($\chi^2 = 11.1$, 1df, $p < 0.005$) Personal reminder by physician versus control ($z = 3.4$, $p < 0.005$) Rates of vaccination for patients contacted who had not been vaccinated before the trial— Intervention 1: 84 of 237 (35.4%) - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: - Cost: NR	General comments: None Quality assessment: Overall rating: Fair Comments: Learning bias in physicians; vaccination rate in randomized controlled group was significantly higher than control practices Baseline was measured based on individual patient instead of family Blinding, randomization method, and concealment were not reported Applicability/generalizability: Academic medical center Short study duration

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i> - Local user involvement in</p>		<p>- Cost-effectiveness: The cost of letter rises slowly as the physician's salary increases. Telephone method is more cost-effective than letter if nurse is paid less than \$16 per hour. Personal contact by physicians is more cost-effective than letter if physician's salary is \$50 per hour or less.</p> <p>6) Impact on HCP use and implementation: NR</p>	Varying cost in other institutions

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
McDowell, Newell, and Rosser, 1986 #7366 Comparison 2 of 3	Geographical location: 6 sites in Ontario, Canada Study dates: Oct 23, 1984–Dec 31, 1984 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Family Duration of intervention: 10 weeks Sample type(s) (with N randomized for	Authors' basic description of system: The computerized medical record system identifies patients for whom preventive procedures are due and automatically generates reminders for them using three mechanisms: reminder by mailed letter, telephone reminder by nurse, personal reminder by physician. Source/origin of system: Not clearly described Content: <i>a) Objective(s):</i> - Immunization - Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)	Comparator(s): Usual care/no CDSS or KMS 1) Intervention 1 = Reminder by letter <u>2) Intervention 2 = Telephone reminder by nurse</u> 3) Intervention 3 = Personal reminder by physician (CDSS) Control 1 = Randomized control group Control 2 = Control practices	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Rates of vaccination, n (%)— Intervention 2: 77 of 208 (37.0%) Control 1: 21 of 215 (9.8%) Control 2: 17 of 444 (3.8%) 3 intervention groups differed from randomized control group ($\chi^2 = 40.7$, 1df, $p < 0.001$) Difference among 3 intervention groups ($\chi^2 = 11.1$, 1df, $p < 0.005$) Personal reminder by physician vs control ($z = 3.4$, $p < 0.005$) Rates of vaccination for patients contacted who had not been vaccinated before the trial— Intervention 2: 77 of 177 (43.5%) - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	General comments: None Quality assessment: Overall rating: Fair Comments: Learning bias in physicians; vaccination rate in randomized controlled group was significantly higher than control practices Baseline was measured based on individual patient instead of family Blinding, randomization method, and

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>each):</p> <ul style="list-style-type: none"> - Patients: 1,420 - Clinics/practices/hospitals: 6 <p>User level of expertise/proficiency: NR</p>	<p>Information delivery:</p> <p><i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather 		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: NR - Cost-effectiveness: The cost of letter rises slowly as the physician’s salary increases. Telephone method is more cost-effective than letter if nurse is paid less than \$16 per hour. Personal contact by physicians is more cost-effective than letter if physician’s salary is \$50 per hour or less. <p>6) Impact on HCP use and implementation: NR</p>	<p>concealment were not reported</p> <p>Applicability/generalizability: Academic medical center</p> <p>Short study duration</p> <p>Varying cost in other institutions</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>than inaction: N</p> <ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
<p>McDowell, Newell, and Rosser, 1986</p> <p>#7366</p> <p>Comparison 3 of 3</p>	<p>Geographical location: 6 sites in Ontario, Canada</p> <p>Study dates: Oct 23, 1984–Dec 31, 1984</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p>	<p>Authors' basic description of system: The computerized medical record system identifies patients for whom preventive procedures are due and automatically generates reminders for them using three mechanisms: reminder by mailed letter, telephone reminder by nurse, personal reminder by physician.</p> <p>Source/origin of system: Not clearly described</p> <p>Content: <i>a) Objective(s):</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p> <p>1) Intervention 1 = Reminder by letter</p> <p>2) Intervention 2 = Telephone reminder by nurse</p> <p><u>3) Intervention 3 = Personal reminder by physician (CDSS)</u></p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Rates of vaccination, n (%)— Intervention 3: 46 of 201 (22.9%) Control 1: 21 of 215 (9.8%) Control 2: 17 of 444 (3.8%) 3 intervention groups differed from randomized control group ($\chi^2 = 40.7$, 1df, $p < 0.001$) Difference among 3 intervention groups ($\chi^2 = 11.1$, 1df, $p < 0.005$) Personal reminder by physician vs control ($z = 3.4$, $p < 0.005$) 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Learning bias in physicians; vaccination rate in randomized controlled group was significantly higher than control practices</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Unit of randomization: Family</p> <p>Duration of intervention: 10 weeks</p> <p>Sample type(s) (with N randomized for each): - Patients: 1,420 - Clinics/practices/hospitals: 6</p> <p>User level of expertise/proficiency: NR</p>	<p>- Immunization - Preventive care</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision</p>	<p>Control 1 = Randomized control group</p> <p>Control 2 = Control practices</p>	<p>Rates of vaccination for patients contacted who had not been vaccinated before the trial— Intervention 3: 46 of 102 (45.1%)</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: NR - Cost-effectiveness: The cost of letter rises slowly as the physician's salary increases. Telephone method is more cost-effective than letter if nurse is paid less than \$16 per hour. Personal contact by physicians is more cost-effective than letter if physician's salary is \$50 per hour or less.</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Baseline was measured based on individual patient instead of family</p> <p>Blinding, randomization method, and concealment were not reported</p> <p>Applicability/generalizability: Academic medical center</p> <p>Short study duration</p> <p>Varying cost in other institutions</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>making: Y</p> <ul style="list-style-type: none"> - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
McDowell, Newell, and Rosser, 1989A #7290	<p>Geographical location: 6 sites in Ottawa, Canada</p> <p>Study dates: 1985</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel-group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): - Patients: 1406 - Clinics: 4</p> <p>User level of expertise/ proficiency: NR</p>	<p>Authors' basic description of system: Center uses a computerized record. In the physician group, the computer printed a message to the physician to recommend cervical cancer screening; repeat reminders were generated for subsequent visits until a test was done.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Preventive care <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p> <p>4 arms:</p> <p>1) Physician reminder (n = 332)</p> <p>2) Letter reminder (n = 367)</p> <p>3) Telephone reminder (n = 377)</p> <p>4) No intervention control (n = 330)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Pap smears for those due— Physician reminder: 41 of 255 = 16.1% Letter reminder: 76 of 293 = 25.9% Telephone reminder: 60 of 300 = 20% Control: 35 of 255 = 13.7%</p> <p>Physician reminders added only 2.4% to the screening rate; telephone reminder added 6.3%, whereas the letter was the most effective, increasing the screening rate by 12.2%. The difference among the four random groups was statistically significant ($p < 0.005$). The results for the physician intervention, however, were not significantly better than those of randomized control ($z = 0.62$, NS).</p> <p>Effectiveness of the reminders, contacted, # (%); screening done, # (%)— Physician reminder: 94 of 255 (36.9); 41 (43.6%) Letter reminder: 188 of 287 (65.5); 64 (34.0) Telephone reminder: 124 of 291 (30.4); 54 (36.7) Control: 101 of 255 (39.6); 35 (34.7%)</p>	<p>General comments: 4 arms but only one aimed at MD and one control</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Possible contamination, inadequate reporting of methods and results, inadequate statistical analysis</p> <p>Applicability/generalizability: Multiple interventions aimed at patients and nurses; Canadian practices</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as 		<ul style="list-style-type: none"> - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: NR - Cost-effectiveness: Cost including staff and material costs— <p>Cost per screening gained was \$11.75 for an MD salary of \$60 per hour; \$5.88 for an MD salary of \$30 per hour</p> <p>Letter reminder cost (including stationery, stamps, prepaid replies, 158 followup letters, and clerical staff to assemble the letters was \$444.06</p> <p>Telephone reminder cost was \$196 to call 280 women (salary of \$15 an hour);</p> <p>Cost per screening gained was \$11.26 for a nurse salary \$10 per hour; \$4.38 for a nurse salary \$5 per hour</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: N (not in physician reminder group) - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell			
McDowell, Newell, and Rosser, 1989B #7291	Geographical location: 6 sites in Ottawa, Canada Study dates: March 1985–June 1986 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Other—family Duration of intervention: 15 month(s) Sample type(s) (with N randomized for each):	Authors' basic description of system: Computer printed a "check blood pressure" note to MD at time of patient visit until a reading was recorded; the computer continued to generate reminders on subsequent visits. Source/origin of system: Locally developed Content: a) <i>Objective(s):</i> Diagnosis b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: a) <i>Delivery format:</i> Paper-based b) <i>Delivery mode:</i>	Comparator(s): Usual care/no CDSS or KMS 4 arms: 1) Physician reminder (n = 1423) 2) Letter reminder (n = 1508) 3) Telephone reminder (n = 1433) 4) No intervention control (n = 1371)	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study completed: Blood pressure check— Physician reminder: 325 of 1059 = 30.7% Letter reminder: 391 of 1094 = 35.7% Telephone reminder: 251 of 1042 = 24.1% Control: 210 of 996 = 21.1% Efficacy of reminders: Outcomes after reminder week— Physician reminder: 173 of 294 = 65.5% Letter reminder: 302 of 886 = 34.1% Telephone reminder: 154 of 637 = 24.2% Control: 130 of 305 = 42.6% - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	General comments: 4 groups: only 1 aimed at physician and 1 control Similar study but different outcome measures as McDowell, Newell, and Rosser, 1989A; possible contamination across these two studies Quality assessment: Overall rating: Fair Comments: Possible contamination, inadequate reporting of methods and

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>- Patients: 6167 families; 8298 patients</p> <p>- Practices: 6</p> <p>User level of expertise/proficiency: NR</p>	<p>System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of 		<p>3) Impact on workload, efficiency, and organization of health care delivery:</p> <ul style="list-style-type: none"> - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: NR <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: NR - Cost-effectiveness: Cost per reading gained for physician reminder was \$1.70 or \$1.33 according to salary level Cost per reading gained for letter reminder was \$14.37 Cost per reading gained for telephone reminder was \$31.27 or \$22.47 according to salary level <p>6) Impact on HCP use and implementation: NR</p>	<p>results, inadequate statistical analysis</p> <p>Applicability/generalizability: Multiple interventions aimed at patients and nurses; Canadian practices</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N (not in physician reminder group) - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell			
McGregor, Weekes, Forrest, et al., 2006 #2627	Geographical location: Baltimore, MD Study dates: May 10–August 3, 2004 General setting: Academic Specific setting: - Inpatient–ICU - Inpatient–non-ICU Study design: RCT, parallel group Unit of randomization: Patient	Authors' basic description of system: PharmWatch decision support designed to assist in the management of antimicrobial utilization. Alerts were designed to detect scenarios of potentially inappropriate or inadequate antimicrobial use. Source/origin of system: Commercially available Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous Decision support:	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: Intervention: 3.84 (2.12 to 7.57) Control: 3.99 (2.19 to 7.57) p = 0.38 - Morbidity: NR - Mortality: Intervention: 73 of 2237 = 3.26% Control: 67 of 2270 = 2.95% p = 0.55 - Validated measure of HRQOL or functional status: NR - Adverse events: Testing for C. difficile— Intervention: 127 of 2237 = 5.7% Control: 150 of 2270 = 6.6% p = 0.21 2) Impact on health care process outcomes: - Recommended preventive care	General comments: CDSS aimed at antimicrobial team Quality assessment: Overall rating: Good Comments: Intervention was blinded Applicability/generalizability: Randomized by even/odd # MRN Would only work

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 12 weeks</p> <p>Sample type(s) (with N randomized for each): Patients: 4507 patient admissions; 2237 to intervention and 2270 to control</p> <p>User level of expertise/proficiency: High</p>	<p><i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i></p>		<p>ordered/completed: NR</p> <ul style="list-style-type: none"> - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Team intervention— Intervention: 359 of 1315 = 16% Control: 180 of 1325 = 7.9% - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery:</p> <ul style="list-style-type: none"> - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: The antimicrobial management team spent an average of 4.1 person-hours per day making interventions on the control arm and 3.2 person-hours per day on the intervention arm. Thus, the team spent roughly one hour less each day intervening on the intervention arm than the control arm of the trial. <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Antimicrobials— Intervention: \$285,812 Control: \$370,006 Cost savings of \$84,194 (22.8%) - Cost of restricted antimicrobials— Intervention: \$131,660 Control: \$191,948 Cost savings of \$60,288 (31%) - Cost-effectiveness: NR 	in large academic setting that has an antimicrobial team

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 		6) Impact on HCP use and implementation: NR	
McLaughlin, Hayes, and Kelleher, 2010 #15296	<p>Geographical location: 6 clinics in the US</p> <p>Study dates: NR</p> <p>General setting: NR</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster</p>	<p>Authors' basic description of system: PDA application to calculate a blood pressure (BP) percentile or percentile range for each BP value entered. If the BP was \geq 95th percentile, then "AB" was displayed next to the value as an abnormal flag.</p> <p>Source/origin of system: Locally developed</p>	<p>Comparator(s): Group 1: Paper normative pediatric BP table affixed to the growth chart</p> <p>Group 2: PDA</p> <p>Group 3: Usual care</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: 4 clinics dropped from study.</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): Patients: 176 patients with abnormal blood pressure Clinics/practices/hospitals: 6 Individual HCPs: 40 [Training MDs and attending MDs]</p> <p>User level of expertise/proficiency: The PDA intervention was also explained to physicians working at these clinics to ensure their understanding and to make them aware the PDA receipt would be placed in their patients' records at future visits.</p>	<p>Content: <i>a) Objective(s):</i> Preventive care</p> <p><i>b) Relationship to point of care:</i> -Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support</p>		<p>NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Intervention compliance— Group 1 (BP table) Compliance: 18% Noncompliance: 12% Group 2 (PDA) Compliance: 33% Noncompliance: 26% Group 3 (Usual care) Compliance: 18% P = 0.27</p> <p>- HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR</p>	<p>Unknown number of pediatricians (from 40) left in the pool of clinicians accepted for randomization.</p> <p>Missing outcome data; no discussion of randomization, blinding, or allocation concealment process</p> <p>Applicability/generalizability: Multisite trial across pediatric clinics</p> <p>Locally developed PDA application</p> <p>Included residents, but exact number was unclear</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>at time and location of decision making: Y</p> <p>- Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i></p> <p>- Provision of a recommendation, not just an assessment: Can't tell</p> <p>- Promotion of action rather than inaction: N</p> <p>- Justification of decision support via provision of reasoning: N</p> <p>- Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: N</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: N</p>			
Montgomery, Fahey, Peters, et al., 2000 #5769 Comparison 1	Geographical location: 27 sites in Avon, UK Study dates: Sept 1996–Sept 1998	Authors' basic description of system: A computer-based CDSS was written for the two most commonly used practice computing systems (EMIS and AAH Meditel) so that it could	Comparator(s): Usual care/no CDSS or KMS <u>1) Intervention 1 = CDSS + cardiovascular</u>	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study	General comments: None Quality assessment: Overall rating:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
of 2	<p>General setting: Community</p> <p>Specific setting: - Outpatient - Chronic</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Patients: 614 - Clinics/practices/hospitals: 27 - Individual HCPs: > MDs: 74 GP > Practice nurse: 11</p> <p>User level of expertise/proficiency: GPs and nurses were trained to use the computer-based CDSS by one of the authors</p>	<p>be incorporated into routine clinical care. The system is identical to the New Zealand guidelines for the management of hypertension, except that absolute risk is presented numerically rather than pictorially.</p> <p>The following patient information is required to ascertain absolute cardiovascular risk: sex, age, diabetes, smoking, blood pressure, cholesterol, body mass index, symptomatic cardiovascular disease, family history of ischaemic heart disease, and familial hypercholesterolaemia. The system then calculates the patient's 5-year risk of a fatal or nonfatal cardiovascular event.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> - Diagnosis - Pharmacotherapy <i>b) Relationship to point of care:</i> Not clearly described</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response)</p>	<p><u>risk chart</u></p> <p>2) Intervention 2 = cardiovascular risk chart</p> <p>Control = usual care</p>	<p>ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Number (%) of patients prescribed different numbers of cardiovascular drugs at baseline and 6-month followup—</p> <p>0-1 classes of drugs: Intervention 1 (n = 207): 81 (39) Control (n = 137): 50 (37)</p> <p>2 classes of drugs: Intervention 1: 74 (36) Control: 47 (34)</p> <p>More than 3 classes of drugs: Intervention 1: 52 (25) Control: 40 (29)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Fair</p> <p>Comments: Simple randomization using table random numbers.</p> <p>GPs, nurses, and patients were not blinded</p> <p>Greater than 10% attrition rate at 12-month followup</p> <p>Outcomes not consistently reported</p> <p>Applicability/generalizability: The use of New Zealand guidelines may affect adoption in other care providers</p> <p>Only involved general practice</p> <p>Only older patients involved in the study (60 to 80 years old)</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: N</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y/N/Can't tell Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Montgomery, Fahey, Peters, et al., 2000 #5769 Comparison 2 of 2	Geographical location: 27 sites in Avon, UK Study dates: Sept 1996–Sept 1998 General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster	Authors' basic description of system: A computer-based CDSS was written for the two most commonly used practice computing systems (EMIS and AAH Meditel) so that it could be incorporated into routine clinical care. The system is identical to the New Zealand guidelines for the management of hypertension, except that absolute risk is presented numerically rather than pictorially.	Comparator(s): Usual care/no CDSS or KMS 1) Intervention 1 = CDSS + cardiovascular risk chart <u>2) Intervention 2 = cardiovascular risk chart</u> Control = usual care	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Number (%) of patients prescribed different numbers of cardiovascular drugs at baseline and 6-month followup— Intervention 2 (n = 208): 68 (33) Control (n = 137): 50 (37)	General comments: None Quality assessment: Overall rating: Fair Comments: Simple randomization using table random numbers GPs, nurses, and

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Patients: 614 - Clinics/practices/hospitals: 27 - Individual HCPs: > MDs; 74 GP > Practice nurse: 11</p> <p>User level of expertise/proficiency: GPs and nurses were trained to use the computer based CDSS by one of the authors.</p>	<p>The following patient information is required to ascertain absolute cardiovascular risk: sex, age, diabetes, smoking, blood pressure, cholesterol, body mass index, symptomatic cardiovascular disease, family history of ischaemic heart disease, and familial hypercholesterolaemia. The system then calculates the patient's five year risk of a fatal or nonfatal cardiovascular event.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> - Diagnosis - Pharmacotherapy <i>b) Relationship to point of care:</i> Not clearly described</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> User-initiated ("pull")</p>		<p>2 classes of drugs: Intervention 2: 67 (32) Control: 47 (34)</p> <p>More than 3 classes of drugs: Intervention 2: 73 (35) Control: 40 (29)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>patients were not blinded</p> <p>Greater than 10% attrition rate at 12-month followup</p> <p>Outcomes not consistently reported</p> <p>Applicability/generalizability: The use of New Zealand guidelines may affect adoption in other care providers</p> <p>Only involved general practice.</p> <p>Only older patients involved in the study (60 to 80 years old)</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning N - Justification of decision support via provision of research evidence: N 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Murray, Harris, Overhage, et al., 2004 #4153 Comparison 1 of 3	Geographical location: Indianapolis, IN Study dates: January 1, 1994–May 1, 1996 (patients recruited) General setting: Academic Specific setting: Outpatient Study design: RCT, 2 x 2 factorial design Unit of randomization: Clinic or team Duration of intervention: 1 year	<u>Physician intervention</u> Authors' basic description of system: Computer-based physician order-entry for hypertension management. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management (hypertension) <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: <i>a) Delivery format:</i>	Comparator(s): Usual care/no CDSS or KMS 2 x 2 factorial design: 1) Control (n = 171) 2) <u>Physician intervention (n = 181)</u> 3) Pharmacist intervention (n = 180) 4) Dual intervention [physician + pharmacist] (n = 180)	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity (all hospitalizations)— Control: 0.25 ± 0.89 Physician: 0.25 ± 0.69 Pharmacist: 0.25 ± 0.62 Dual: 0.19 ± 0.74 Morbidity (heart disease–specific hospitalizations)— Control: 0.02 ± 0.13 Physician: 0.01 ± 0.10 Pharmacist: 0.01 ± 0.07 Dual: 0.01 ± 0.11 - Mortality: NR - Validated measure of HRQOL or functional status: Bulpitts overall score, mean \pm SD— Control (n = 127): 36 ± 21 Physician Intervention (n = 124): 35 ± 20 Pharmacist intervention (n = 116): 37 ± 21	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Comments: Potential for contamination, one academic site Well-established health IT infrastructure; EMR in place for 25+ years; residents

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each): Patients: 712</p> <p>User level of expertise/proficiency: NR</p>	<p>Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><u>Physician Intervention:</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y</p>		<p>Dual intervention (n = 116): 38 ± 22</p> <p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed— Control: n = 171 Physician intervention: n = 181 Pharmacist intervention: n = 180 Dual intervention: n = 180</p> <p>All antihypertensive drug suggestions, # (%) of patients with any suggestion: Control: 114 (67) Physician: 123 (68) Pharmacist: 117 (65) Dual: 125 (69)</p> <p># of suggestions (mean #/patient ± SD): Control: 245 (2.1 ± 1.1) Pharmacist: 234 (2.0 ± 1.1) Physician: 255 (2.1 ± 1.1) Dual: 243 (1.9 ± 1.0)</p> <p>Mean patient adherence score ± SD: Control: 26 ± 33 Physician: 29 ± 36 Pharmacist: 25 ± 33 Dual: 35 ± 39</p> <p>Start or increase ACE inhibitor, # (%) of patients with any suggestion:</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 		<p>Control: 91 (53) Physician: 92 (51) Pharmacist: 89 (42) Dual: 96 (53)</p> <p>Mean patient adherence score \pm SD: Start or increase ACE inhibitor: Control: 30 \pm 46 Physician: 44 \pm 50 Pharmacist: 33 \pm 47 Dual: 41 \pm 49</p> <p>Start diuretic, # (%) of patients with any suggestion: Control: 58 (34) Physician: 55 (30) Pharmacist: 54 (30) Dual: 52 (29)</p> <p>Mean patient adherence score \pm SD: Control: 31 \pm 47 Physician: 22 \pm 42 Pharmacist: 22 \pm 42 Dual: 25 \pm 44</p> <p>Start or increase calcium channel blocker, # (%) of patients with any suggestion: Control: 51 (30) Physician: 56 (31) Pharmacist: 38 (21) Dual: 46 (26)</p> <p>Mean patient adherence score \pm SD: Control: 49 \pm 51 Physician: 34 \pm 48 Pharmacist: 47 \pm 51 Dual: 39 \pm 49</p> <p>Start or increase β-blocker, # (%) of patients with any suggestion: Control: 20 (12)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Physician: 31 (17) Pharmacist: 35 (14) Dual: 34 (19)</p> <p>Mean patient adherence score \pm SD: Control: 45 \pm 51 Physician: 45 \pm 51 Pharmacist: 29 \pm 46 Dual: 47 \pm 51</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <p>- Cost (mean \pm SD): Total charges— Control (n = 171): 5149 \pm 11,756 Physician Intervention (n = 181): 6200 \pm 18,947 Pharmacist intervention (n = 180): 5445 \pm 9612 Dual intervention (n = 180): 3122 \pm 4633</p> <p>Outpatient charges— Control: 3005 \pm 4318 Physician: 2681 \pm 3520 Pharmacist: 2868 \pm 3553 Dual: 2229 \pm 2137</p> <p>Inpatient charges— Control: 2145 \pm 9805 Physician: 3519 \pm 17830 Pharmacist: 2577 \pm 7709 Dual: 893 \pm 3450</p> <p>- Cost-effectiveness: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
6) Impact on HCP use and implementation: NR					
Murray, Harris, Overhage, et al., 2004 #4153 Comparison 2 of 3	Geographical location: Indianapolis, IN	Pharmacist intervention Authors' basic description of system: Computer-based pharmacist intervention for hypertension management.	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity (all hospitalizations)— Control: 0.25 ± 0.89 Physician: 0.25 ± 0.69 Pharmacist: 0.25 ± 0.62 Dual: 0.19 ± 0.74	General comments: None
	Study dates: January 1, 1994–May 1, 1996 (patients recruited) General setting: Academic Specific setting: Outpatient Study design: RCT, 2 x 2 factorial design Unit of randomization: Clinic or team Duration of intervention: 1 year Sample type(s) (with N randomized for each): Patients: 712 User level of expertise/proficiency: NR	Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management (hypertension) <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of CDSS/KMS:	2 x 2 factorial design: 1) Control (n = 171) 2) Physician intervention (n = 181) <u>3) Pharmacist intervention (n = 180)</u> 4) Dual intervention [physician + pharmacist] (n = 180)	Morbidity (heart disease–specific hospitalizations)— Control: 0.02 ± 0.13 Physician: 0.01 ± 0.10 Pharmacist: 0.01 ± 0.07 Dual: 0.01 ± 0.11 - Mortality: NR - Validated measure of HRQOL or functional status: Bulpitts overall score, mean \pm SD— Control (n = 127): 36 ± 21 Physician Intervention (n = 124): 35 ± 20 Pharmacist intervention (n = 116): 37 ± 21 Dual intervention (n = 116): 38 ± 22 - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR	Quality assessment: Overall rating: Good Comments: Potential for contamination, one academic site Applicability/generalizability: Well-established health IT infrastructure; EMR in place for 25+ years; residents

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Pharmacist Intervention:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y</p> <p><i>d) Auxiliary features:</i> - Local user involvement in</p>		<p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed— Control: n = 171 Physician intervention: n = 181 Pharmacist intervention: n = 180 Dual intervention: n = 180</p> <p>All antihypertensive drug suggestions, # (%) of patients with any suggestion: Control: 114 (67) Physician: 123 (68) Pharmacist: 117 (65) Dual: 125 (69)</p> <p># of suggestions (mean #/patient ± SD): Control: 245 (2.1 ± 1.1) Pharmacist: 234 (2.0 ± 1.1) Physician: 255 (2.1 ± 1.1) Dual: 243 (1.9 ± 1.0)</p> <p>Mean patient adherence score ± SD: Control: 26 ± 33 Physician: 29 ± 36 Pharmacist: 25 ± 33 Dual: 35 ± 39</p> <p>Start or increase ACE inhibitor, # (%) of patients with any suggestion: Control: 91 (53) Physician: 92 (51) Pharmacist: 89 (42) Dual: 96 (53)</p> <p>Mean patient adherence score ± SD: Control: 30 ± 46 Physician: 44 ± 50 Pharmacist: 33 ± 47 Dual: 41 ± 49</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell		<p>Start diuretic, # (%) of patients with any suggestion: Control: 58 (34) Physician: 55 (30) Pharmacist: 54 (30) Dual: 52 (29)</p> <p>Mean patient adherence score \pm SD: Control: 31 \pm 47 Physician: 22 \pm 42 Pharmacist: 22 \pm 42 Dual: 25 \pm 44</p> <p>Start or increase calcium channel blocker, # (%) of patients with any suggestion: Control: 51 (30) Physician: 56 (31) Pharmacist: 38 (21) Dual: 46 (26)</p> <p>Mean patient adherence score \pm SD: Control: 49 \pm 51 Physician: 34 \pm 48 Pharmacist: 47 \pm 51 Dual: 39 \pm 49</p> <p>Start or increase β-blocker, # (%) of patients with any suggestion: Control: 20 (12) Physician: 31 (17) Pharmacist: 35 (14) Dual: 34 (19)</p> <p>Mean patient adherence score \pm SD: Control: 45 \pm 51 Physician: 45 \pm 51 Pharmacist: 29 \pm 46 Dual: 47 \pm 51</p> <p>- Impact on user knowledge: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost (mean \pm SD): Total charges— Control (n = 171): 5149 \pm 11,756 Physician Intervention (n = 181): 6200 \pm 18,947 Pharmacist intervention (n = 180): 5445 \pm 9612 Dual intervention (n = 180): 3122 \pm 4633 Outpatient charges— Control: 3005 \pm 4318 Physician: 2681 \pm 3520 Pharmacist: 2868 \pm 3553 Dual: 2229 \pm 2137 Inpatient charges— Control: 2145 \pm 9805 Physician: 3519 \pm 17830 Pharmacist: 2577 \pm 7709 Dual: 893 \pm 3450 - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation: NR</p>	
Murray, Harris, Overhage, et al., 2004	Geographical location: Indianapolis, IN	<u>Dual intervention</u> Authors' basic description of system: Computer-based physician and pharmacist (dual) order-entry	Comparator(s): Usual care/no CDSS or KMS 2 x 2 factorial design:	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity (all hospitalizations)— Control: 0.25 \pm 0.89 Physician: 0.25 \pm 0.69 	<p>General comments: None</p> <p>Quality assessment:</p>
#4153	Study dates: January 1, 1994–May				

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Comparison 3 of 3	1, 1996 (patients recruited)	for hypertension management.		Pharmacist: 0.25 ± 0.62 Dual: 0.19 ± 0.74	Overall rating: Good
	<p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, 2 x 2 factorial design</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): Patients: 712</p> <p>User level of expertise/proficiency: NR</p>	<p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Chronic disease management (hypertension)</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Noncommittal acknowledgement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><u>Dual Intervention:</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of</p>	<p>1) Control (n = 171)</p> <p>2) Physician intervention (n = 181)</p> <p>3) Pharmacist intervention (n = 180)</p> <p>4) <u>Dual intervention [physician + pharmacist] (n = 180)</u></p>	<p>Morbidity (heart disease–specific hospitalizations)— Control: 0.02 ± 0.13 Physician: 0.01 ± 0.10 Pharmacist: 0.01 ± 0.07 Dual: 0.01 ± 0.11</p> <p>- Mortality: NR</p> <p>- Validated measure of HRQOL or functional status: Bulpitts overall score, mean \pm SD— Control (n = 127): 36 ± 21 Physician Intervention (n = 124): 35 ± 20 Pharmacist intervention (n = 116): 37 ± 21 Dual intervention (n = 116): 38 ± 22</p> <p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed— Control: n = 171 Physician intervention: n = 181 Pharmacist intervention: n = 180 Dual intervention: n = 180</p>	<p>Comments: Potential for contamination, 1 academic site</p> <p>Applicability/generalizability: Well-established health IT infrastructure; EMR in place for 25+ years; residents</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell		All antihypertensive drug suggestions, # (%) of patients with any suggestion: Control: 114 (67) Physician: 123 (68) Pharmacist: 117 (65) Dual: 125 (69) # of suggestions (mean #/patient \pm SD): Control: 245 (2.1 \pm 1.1) Pharmacist: 234 (2.0 \pm 1.1) Physician: 255 (2.1 \pm 1.1) Dual: 243 (1.9 \pm 1.0) Mean patient adherence score \pm SD: Control: 26 \pm 33 Physician: 29 \pm 36 Pharmacist: 25 \pm 33 Dual: 35 \pm 39 Start or increase ACE inhibitor, # (%) of patients with any suggestion: Control: 91 (53) Physician: 92 (51) Pharmacist: 89 (42) Dual: 96 (53) Mean patient adherence score \pm SD: Control: 30 \pm 46 Physician: 44 \pm 50 Pharmacist: 33 \pm 47 Dual: 41 \pm 49 Start diuretic, # (%) of patients with any suggestion: Control: 58 (34) Physician: 55 (30) Pharmacist: 54 (30) Dual: 52 (29) Mean patient adherence score \pm SD: Control: 31 \pm 47 Physician: 22 \pm 42	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Pharmacist: 22 ± 42 Dual: 25 ± 44</p> <p>Start or increase calcium channel blocker, # (%) of patients with any suggestion: Control: 51 (30) Physician: 56 (31) Pharmacist: 38 (21) Dual: 46 (26)</p> <p>Mean patient adherence score ± SD: Control: 49 ± 51 Physician: 34 ± 48 Pharmacist: 47 ± 51 Dual: 39 ± 49</p> <p>Start or increase β-blocker, # (%) of patients with any suggestion: Control: 20 (12) Physician: 31 (17) Pharmacist: 35 (14) Dual: 34 (19)</p> <p>Mean patient adherence score ± SD: Control: 45 ± 51 Physician: 45 ± 51 Pharmacist: 29 ± 46 Dual: 47 ± 51</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost (mean ± SD): Total charges—</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				Control (n = 171): 5149 ± 11,756 Physician Intervention (n = 181): 6200 ± 18,947 Pharmacist intervention (n = 180): 5445 ± 9612 Dual intervention (n = 180): 3122 ± 4633 Outpatient charges— Control: 3005 ± 4318 Physician: 2681 ± 3520 Pharmacist: 2868 ± 3553 Dual: 2229 ± 2137 Inpatient charges— Control: 2145 ± 9805 Physician: 3519 ± 17830 Pharmacist: 2577 ± 7709 Dual: 893 ± 3450 - Cost-effectiveness: NR 6) Impact on HCP use and implementation: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Ornstein, Garr, Jenkins, et al., 1991	Geographical location: Charleston, SC	Authors' basic description of system: Computer-generated reminders for five preventive services by scanning each patient record for deficient preventive services. Reminder forms were generated for physicians and letters for patients.	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percentage change (95% CI) between study period— Cholesterol: Control (n = 1422): 9.1 (8.0 to 10.1) Intervention 1 (n = 1826): 12.3 (11.3 to 13.2) All P < 0.0001 Fecal occult blood test (FOBT): Control (n = 618): 8.1 (4.7 to 11.5), P < 0.0001 Intervention 1 (n = 818): 5.1 (1.8 to 8.5), P = 0.0030 Mammography: Control (n = 266): 15.7 (10.7 to 20.9), P < 0.0001 Intervention 1 (n = 345): 10.7 (4.7 to 16.8), P = 0.0009 Pap smear: Control (n = 843) = -0.9 (-4.0 to 2.1), P = 0.54 Intervention 1 (n = 1111): -4.5 (-7.1 to -1.9), P = 0.001 Tetanus: Control (n = 1576): 3.8 (3.1 to 4.4) Intervention 1 (n = 1988): 10.5 (9.8 to 11.3) All P < 0.0001	General comments: None Quality assessment: Overall rating: Fair Comments: 4 of 49 physicians left during study period; replaced by other physicians Statistically significant difference exists between baseline groups (race, insurance coverage, and visit frequency) History and learning bias/Hawthorne effect in physicians during intervention period (same building) Applicability/generalizability: Academic
#7209	Study dates: July 1, 1988–July 1, 1989	Source/origin of system: Not clearly described	Control		
Comparison 1 of 3	General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: - Clinician - Patient Duration of intervention: 1 year Sample type(s) (with N randomized for each): - Patients: 7397 - Individual HCPs (family medicine): > MDs: 6 > Trainees: 43 User level of expertise/proficiency: NR	Content: <i>a) Objective(s):</i> - Lab test ordering - Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Justification for not complying Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i>	1) <u>Intervention 1</u> = MD reminders 2) Intervention 2 = MD+PT reminders 3) Intervention 3 = PT reminders		

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		Integration with charting or order entry system to support workflow integration: Can't tell		- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	medical center Single site Clinical settings with patient or physicians better educated about preventive services might not respond as favorably to computer-based prompts
		<i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N		3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Disposition of physician reminders— Cholesterol, n = 1883 FOBT, n = 1817 Mammography, n = 1038 Pap smear, n = 1103 Tetanus, n = 2317 Total = 8158 Physician response, n (%): Ordered test— Cholesterol = 646 (34) FOBT = 765 (42) Mammography = 212 (20) Pap smear = 247 (22) Tetanus = 470 (20) Total = 2340 (29) Rescheduled— Cholesterol = 182 (10) FOBT = 172 (9)	
		<i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N			
		<i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		<p>Mammography = 148 (14) Pap Smear = 248 (22) Tetanus = 281 (12) Total = 1027 (13)</p> <p>Not indicated— Cholesterol = 472 (25) FOBT = 320 (18) Mammography = 183 (18) Pap smear = 356 (32) Tetanus = 646 (28) Total = 1977 (24)</p> <p>Patient refused— Cholesterol = 44 (2) FOBT = 48 (3) Mammography = 183 (18) Pap smear = 32 (3) Tetanus = 135 (6) Total = 442 (5)</p> <p>Did not discuss— Cholesterol = 394 (21) FOBT = 379 (21) Mammography = 251 (24) Pap smear = 158 (14) Tetanus = 593 (26) Total = 1775 (22)</p> <p>Blank— Cholesterol = 145 (8) FOBT = 133 (7) Mammography = 61 (6) Pap smear = 66 (6) Tetanus = 192 (8) Total = 597 (7)</p> <p>- HCP satisfaction: NR - HCP use: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
- Implementation of CDSS/KMS: NR					
Ornstein, Garr, Jenkins, et al., 1991 #7209 Comparison 2 of 3	Geographical location: Charleston, SC Study dates: July 1, 1988–July 1, 1989 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: - Clinician - Patient Duration of intervention: 1 year Sample type(s) (with N randomized for each): - Patients: 7397 - Individual HCPs (family medicine) > MDs: 6 > Trainee: 43 User level of expertise/	Authors' basic description of system: Computer-generated reminders for five preventive services by scanning each patient record for deficient preventive services. Reminder forms were generated for physicians and letters for patients. Source/origin of system: Not clearly described Content: a) <i>Objective(s):</i> - Lab test ordering - Preventive care b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Justification for not complying Information delivery: a) <i>Delivery format:</i> Paper-based b) <i>Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of CDSS/KMS:	Comparator(s): Usual care/no CDSS or KMS Control 1) Intervention 1 = MD reminders <u>2) Intervention 2 = MD+PT reminders</u> 3) Intervention 3 = PT reminders	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percentage change (95% CI) between study period— Cholesterol: Control (n = 1422): 9.1 (8.0 to 10.1) Intervention 2 (n = 1732): 18.6 (17.8 to 19.5) All P < 0.0001 Fecal occult blood test (FOBT): Control (n = 618): 8.1 (4.7 to 11.5), P < 0.0001 Intervention 2 (n = 815): 17.7 (14.9 to 20.4), P < 0.0001 Mammography: Control (n = 266): 15.7 (10.7 to 20.9), P < 0.0001 Intervention 2 (n = 332): 15.7 (11.1 to 20.2), P < 0.0001 Pap smear: Control (n = 843): -0.9 (-4.0 to 2.1), P = 0.54 Intervention 2 (n = 1006): -0.8 (-3.7 to 2.1), P = 0.60 Tetanus: Control (n = 1,576): 3.8 (3.1 to 4.4) Intervention 2 (n = 1908): 12.0 (11.2 to 12.8) All P < 0.0001	General comments: None Quality assessment: Overall rating: Fair Comments: 4 of 49 physicians left during study period; replaced by other physicians Statistically significant difference exists between baseline groups (race, insurance coverage, and visit frequency) History and learning bias/Hawthorne effect in physicians during intervention period (same building) Applicability/generalizability:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	proficiency: NR	<p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: NY - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support</p>		<p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Disposition of physician reminders— Cholesterol, n = 1883 FOBT, n = 1817 Mammography, n = 1038 Pap smear, n = 1103 Tetanus, n = 2317 Total = 8158</p> <p>Physician response, n (%) Ordered test— Cholesterol = 646 (34) FOBT = 765 (42) Mammography = 212 (20) Pap smear = 247 (22) Tetanus = 470 (20) Total = 2340 (29)</p> <p>Rescheduled— Cholesterol = 182 (10)</p>	<p>Academic medical center</p> <p>Single site</p> <p>Clinical settings with patient or physicians better educated about preventive services might not respond as favorably to computer-based prompts</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		<p>FOBT = 172 (9) Mammography = 148 (14) Pap Smear = 248 (22) Tetanus = 281 (12) Total = 1027 (13)</p> <p>Not indicated— Cholesterol = 472 (25) FOBT = 320 (18) Mammography = 183 (18) Pap smear = 356 (32) Tetanus = 646 (28) Total = 1977 (24)</p> <p>Patient refused— Cholesterol = 44 (2) FOBT = 48 (3) Mammography = 183 (18) Pap smear = 32 (3) Tetanus = 135 (6) Total = 442 (5)</p> <p>Did not discuss— Cholesterol = 394 (21) FOBT = 379 (21) Mammography = 251 (24) Pap smear = 158 (14) Tetanus = 593 (26) Total = 1775 (22)</p> <p>Blank— Cholesterol = 145 (8) FOBT = 133 (7) Mammography = 61 (6) Pap smear = 66 (6) Tetanus = 192 (8) Total = 597 (7)</p> <p>- HCP satisfaction: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				- HCP use: NR - Implementation of CDSS/KMS: NR	
Ornstein, Garr, Jenkins, et al., 1991 #7209 Comparison 3 of 3	Geographical location: Charleston, SC Study dates: July 1, 1988–July 1, 1989 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: - Clinician - Patient Duration of intervention: 1 year Sample type(s) (with N randomized for each): - Patients: 7397 - Individual HCPs (family medicine): > MDs: 6 > Trainees: 43	Authors' basic description of system: Computer-generated reminders for five preventive services by scanning each patient record for deficient preventive services. Reminder forms were generated for physicians and letters for patients. Source/origin of system: Not clearly described Content: <i>a) Objective(s):</i> - Lab test ordering - Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Justification for not complying Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the	Comparator(s): Usual care/no CDSS or KMS Control 1) Intervention 1 = MD reminders 2) Intervention 2 = MD+PT reminders <u>3) Intervention 3 = PT reminders</u>	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percentage change (95% CI) between study period— Cholesterol: Control (n = 1422): 9.1 (8.0 to 10.1) Intervention 3 (n = 1768): 13.6 (13.0 to 14.3) All P < 0.0001 Fecal occult blood test (FOBT): Control (n = 618): 8.1 (4.7 to 11.5), P < 0.0001 Intervention 3 (n = 782): 8.7 (5.8 to 11.6), P < 0.0001 Mammography: Control (n = 266): 15.7 (10.7 to 20.9), P < 0.0001 Intervention 3 (n = 329): 2.8 (-3.0 to 8.5), P < 0.35 Pap smear: Control (n = 843): -0.9 (-4.0 to 2.1), P = 0.54 Intervention 3 (n = 1054): -2.1 (-4.7 to 0.5), P = 12 Tetanus: Control (n = 1576): 3.8 (3.1 to 4.4)	General comments: None Quality assessment: Overall rating: Fair Comments: 4 of 49 physicians left during study period; replaced by other physicians Statistically significant difference exists between baseline groups (race, insurance coverage, and visit frequency) History and learning bias/Hawthorne effect in physicians during intervention period (same building)

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/proficiency: NR	implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: NY - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in		Intervention 3 (n = 1925): 9.5 (8.9 to 10.1) All P < 0.0001 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Disposition of physician reminders— Cholesterol, n = 1883 FOBT, n = 1817 Mammography, n = 1038 Pap smear, n = 1103 Tetanus, n = 2317 Total = 8158 Physician response, n (%) Ordered test— Cholesterol = 646 (34) FOBT = 765 (42) Mammography = 212 (20) Pap smear = 247 (22) Tetanus = 470 (20) Total = 2340 (29)	Applicability/generalizability: Academic medical center Single site Clinical settings with patient or physicians better educated about preventive services might not respond as favorably to computer-based prompts

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		<p>Rescheduled— Cholesterol = 182 (10) FOBT = 172 (9) Mammography = 148 (14) Pap Smear = 248 (22) Tetanus = 281 (12) Total = 1027 (13)</p> <p>Not indicated— Cholesterol = 472 (25) FOBT = 320 (18) Mammography = 183 (18) Pap smear = 356 (32) Tetanus = 646 (28) Total = 1977 (24)</p> <p>Patient refused— Cholesterol = 44 (2) FOBT = 48 (3) Mammography = 183 (18) Pap smear = 32 (3) Tetanus = 135 (6) Total = 442 (5)</p> <p>Did not discuss— Cholesterol = 394 (21) FOBT = 379 (21) Mammography = 251 (24) Pap smear = 158 (14) Tetanus = 593 (26) Total = 1775 (22)</p> <p>Blank— Cholesterol = 145 (8) FOBT = 133 (7) Mammography = 61 (6) Pap smear = 66 (6) Tetanus = 192 (8)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
				Total = 597 (7)	
				- HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	
Overhage, Tierney, and McDonald, 1996 #6674	Geographical location: Indianapolis, IN Study dates: Oct 26, 1992–April 1993 General setting: Academic Specific setting: Inpatient–non-ICU Study design: RCT, cluster group Unit of randomization: Clinic or team Duration of intervention: 6 months Sample type(s) (with N randomized for each): - Patients: 1929 (of which 1622 were eligible) - Training MDs: 78	Authors' basic description of system: Twenty-two preventive care reminders derived from USPTF recommendations were printed on reports that the physicians received. Source/origin of system: Locally developed Content: a) <i>Objective(s):</i> Preventive care b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: a) <i>Delivery format:</i> - Integrated with CPOE/EHR - Paper-based b) <i>Delivery mode:</i> System-initiated ("push") Contextual factors/features	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Complied with preventive care— Intervention: 23% Control: 24% P = 0.78 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Preventive care for hospitalized Patients in one academic center Well-established health IT infrastructure and historically an early adopter of health IT

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	User level of expertise/ proficiency: NR	<p>influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 			
Overhage, Tierney, Zhou, et al., 1997 #6468	Geographical location: Indianapolis, IN Study dates: Oct 1992–July 1993 General setting: Academic Specific setting: Inpatient–non-ICU Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 30 weeks Sample type(s) (with N randomized for	Authors' basic description of system: Corollary orders alert system to get MDs to order tests or treatments needed to monitor the effects of other tests or treatments. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> <ul style="list-style-type: none"> - Pharmacotherapy - Lab test ordering <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: <ul style="list-style-type: none"> - Length of stay: Average— Intervention: 7.62 days Control: 8.12 days Difference of -0.5 days (95% CI -0.17, 1.19; $p = 0.94$) - Morbidity: NR - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: 24 hour compliance— Intervention 46.3% Control 21.9% $P < 0.0001$ 24-hour compliance— Intervention: 50.4% Control: 29.0% 	General comments: 87 target orders Quality assessment: Overall rating: Good Applicability/generalizability: One academic medical center; well-established health IT infrastructure and history of being an early adopter of health IT; physicians had been using computer workstations to enter orders for more than 12 months; residents wrote orders

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>each):</p> <ul style="list-style-type: none"> - Patients: 2181 (for which 1686 had at least one order written) - Training MDs, internal medicine: 86 <p>User level of expertise/proficiency: NR</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y 		<p>P < 0.0001</p> <p>Hospital stay compliance— Intervention: 55.9% Control: 37.1% P < 0.0001</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Average hospital charges— Intervention: \$8,073 Control: \$8,589 Difference of -\$515.95 (95% CI -\$828.41, \$1316.58; p = 0.68) - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>- Justification of decision support via provision of research evidence: Y</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Y</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: Can't tell</p> <p>- CDSS accompanied by conventional education: Can't tell</p>			
<p>Palen, Price, Snyder, et al., 2010</p> <p>#14780</p>	<p>Geographical location: 8 sites in Denver, Colorado</p> <p>Study dates: January 2005-September 2007</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization:</p>	<p>Authors' basic description of system: Age-specific alert implemented in an EHR targeted to a specific condition to reduce D-dimer testing in the elderly population.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed:</p> <p>- Recommended clinical study ordered/completed:</p> <p>Rate of completed D-dimer tests per 1000 visits among patients 65 years and older—</p> <p>Intervention clinics: Prealert: 5.02 Postalert: 1.52 (95% CI -4.20 to -2.80; P < 0.001)</p> <p>Control clinics: Prealert: 2.11 Postalert: 0.81 (95% CI -1.79 to -0.80; P < .001).</p>	<p>General comments: Single crossover cluster randomization was the actual study type</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Some patient baseline differences</p> <p>Outcome assessors not blind to</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Clinic or team	requirement)		Rate of completed D-dimer tests per 1000 visits among patients < 65 years— Intervention clinics: Prealert: 4.15 Postalert: 4.29 (95% CI -0.34 to -0.61)	intervention status
	Duration of intervention: 19 month(s)	Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR		Control clinics: Prealert: 3.84 Postalert: 4.35 (95% CI, -0.460 to 0.460)	Simple cluster by assigning half to control and intervention—not true randomization
	Sample type(s) (with N randomized for each): Clinics/practices/hospitals: 8	<i>b) Delivery mode:</i> System-initiated (“push”)		- Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	Applicability/generalizability: Large multisite trial
	User level of expertise/proficiency: NR	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y		3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	No patient-centered outcomes Well-established health IT infrastructure and history of being an early adopter of health IT

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
Palen, Raebel, Lyons, et al., 2006 #2607	Geographical location: Colorado, US Study dates: Nov 1, 2002–Oct 31, 2003 General setting: NR Specific setting: Outpatient Study design: RCT, parallel group Unit of	Authors' basic description of system: Nonintrusive physician alerts were linked to specific medication orders. When physicians ordered these medications, guidelines for laboratory tests monitoring were suggested. Source/origin of system: Commercially developed Content: <i>a) Objective(s):</i> Lab test ordering	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Lab testing performed as recommended— Intervention: 56.6% Control: 57% (8957 of 15,686), $P = 0.31$ - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency,	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Nonintrusive alerts too weak Robust health IT infrastructure

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>randomization: Clinician</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 26,586 - Individual HCPs, internal medicine and family practice: 207</p> <p>User level of expertise/proficiency: Intervention physicians received one-on-one training</p>	<p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Noncommittal acknowledgement (nonintrusive alerts)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed</p>		<p>and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
		by noting agreement: N c) <i>Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y d) <i>Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y			
Paul, Andreassen, Tacconelli, et al., 2006 #2377	Geographical location: - Israel - Freiburg, Germany - Rome, Italy Study dates: May 2004–November 2004	Authors' basic description of system: The TREAT output includes the probability of infection and its severity, source of infection, pathogen distribution, mortality, and antibiotic coverage. TREAT recommends treatment by highlighting the top 3 antibiotic	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: Duration of hospital stay, median/mean (SD) (N = 2326)— Control: 6/9.45 (11.52) Intervention: 6/8.83 (11.29) P value = 0.055 Duration of hospital stay among patients surviving 30 days median/mean (SD) (N = 1837)— Control: 5/9.4 (12.2)	General comments: None Quality assessment: Overall rating: Good Comments:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	General setting: Academic Specific setting: - Inpatient–ICU - Inpatient–non-ICU Study design: RCT, cluster randomized Unit of randomization: Hospital wards Duration of intervention: 7 months Sample type(s) (with N randomized for each): Patients: 2,326 User level of expertise/ proficiency: NR	regimens with the highest cost- benefit difference and include no antibiotic treatment. Source/origin of system: Locally developed Content: a) <i>Objective(s):</i> - Diagnosis - Pharmacotherapy b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: a) <i>Delivery format:</i> Standalone system b) <i>Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: a) <i>General system features:</i> Integration with charting or order entry system to support workflow integration: Y b) <i>Clinician-system interaction features:</i> - Automatic provision of decision support as part of		Intervention: 5/8.8 (11.9) P value = 0.128 - Morbidity: Duration of fever, median/mean (SD) (N = 2326)— Control: 1/2.5 (4.5) Intervention: 1/2.4 (3.9) P value = 0.253 - Mortality: 30 day mortality intention to treat, n (%)— Control: 145 of 1012 (14.3%) Intervention: 149 of 1153 (12.9) P value = 0.61 30 day mortality per protocol, n (%)— Control: 44 of 371 (11.9) Intervention: 49 of 503 (9.7) P value = 0.719 - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Control: 176 of 273 (64.5%) Intervention: 216 of 297 (72.7%) OR (95% CI) P value 1.48 (1.03 to 2.11) 0.033 1.48 (0.95 to 2.29) 0.082 (adjuncted)	Blinded assessments to patient assignment; cluster randomization design to minimize contamination Applicability/ generalizability: International academic settings Locally developed system implemented in three different hospitals

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>clinician workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y, did preliminary cohort study - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't 		<ul style="list-style-type: none"> - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Direct costs in Euros, mean (SD) per patient— <ul style="list-style-type: none"> Control: 37.9 (54.2) Intervention: 40.2 (57.6) P value: 0.473 Overall side effect costs in Euros, mean (SD) per patient— <ul style="list-style-type: none"> Control: 99.5 (1154.0) Intervention: 100.1 (1085.1) P value: 0.960 Ecological costs in Euros, mean (SD) per patient— <ul style="list-style-type: none"> Control: 499.3 (414.1) Intervention: 439.5 (388.4) P value: 0.002 Total antibiotic costs in Euros, mean (SD) per patient— <ul style="list-style-type: none"> Control: 623.2 (502.2) Intervention: 565.4 (483.4) P value: 0.007 - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		tell			
		e) Other: TREAT system was optional for physicians			
Peterson, Radosevich, O'Connor, et al., 2008 #830	Geographical location: 24 sites in a single geographic region recruited through the Minnesota Academy of Physicians Research Network Study dates: June 2003–June 2004 General setting: Community Specific setting: Outpatient Study design: RCT, cluster randomization Unit of randomization: Clinic Duration of intervention: 12 months Sample type(s) (with N randomized for each):	Authors' basic description of system: A multicomponent intervention (TRANSLATE) that includes implementation of a diabetes registry, visit reminders, and patient-specific physician alerts for diabetes management. Source/origin of system: Not clearly described Content: a) <i>Objective(s):</i> Chronic disease management: b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (assume no response requirement) Information delivery: a) <i>Delivery format:</i> Paper-based b) <i>Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percentage of patients meeting diabetes performance measures at baseline and after intervention (means \pm SEM)— Blood pressure monitoring: Baseline IMPACT clinics: 95.1 ± 0.8 Control clinics: 94.3 ± 1.1 Intervention period IMPACT clinics: 96.4 ± 0.6 Control clinics: 92.2 ± 1.2 $P = 0.050$ Renal testing: Baseline IMPACT clinics: 40.9 ± 4.4 Control clinics: 37.1 ± 4.3 Intervention period IMPACT clinics: 64.1 ± 4.2 Control clinics: 31.8 ± 4.0 $P < 0.001$ Annual eye examination: Baseline IMPACT clinics: 35.5 ± 3.0 Control clinics: 24.8 ± 2.5	General comments: Combined intervention aimed at MDs and patients Quality assessment: Overall rating: Good Applicability/generalizability: Included only practices that did not have electronic medical records Required a lot of work by site coordinator Multiple components to intervention, including a site coordinator, local physician champion, education, admin support, etc.

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	- Patients: 7101 - Practices: 24 User level of expertise/ proficiency: NR	implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <i>d) Auxiliary features:</i>		Intervention period IMPACT clinics: 62.5 ± 3.1 Control clinics: 26.0 ± 2.6 P < 0.001 Foot examination: Baseline IMPACT clinics: 39.4 ± 4.2 Control clinics: 39.1 ± 4.2 Intervention period IMPACT clinics: 68.8 ± 3.8 Control clinics: 33.5 ± 3.9 P < 0.001 A1c testing: Baseline IMPACT clinics: 88.2 ± 1.5 Control clinics: 87.5 ± 1.5 Intervention Period IMPACT clinics: 90.1 ± 1.1 Control clinics: 82.3 ± 1.9 P < 0.001 LDL cholesterol testing: Baseline IMPACT clinics: 69.6 ± 3.0 Control clinics: 64.3 ± 3.2 Intervention period IMPACT clinics: 78.0 ± 2.4 Control clinics: 64.6 ± 3.2 P < 0.001 % of mean eligible patients achieving recommended values— A1c < 7 Intervention: 49% Control: 43.8% P < 0.001	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Can't tell - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 		<p>SBP < 130 Intervention: 45% Control: 40.6% P < 0.001</p> <p>LDL < 100 Intervention: 43% Control: 35.5% P < 0.001</p> <ul style="list-style-type: none"> - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	
Peterson, Rosenbaum, Waitman, et al., 2007 #2332	Geographical location: Nashville, TN Study dates: 12/8/2005–8/31/2006 General setting: Academic	Authors' basic description of system: The CPOE-based text message displayed along with study dosing information communicated titration strategies, possible adverse effects, and key monitoring parameters. Geriatric dosing	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment 	General comments: None Quality assessment: Overall rating: Poor

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Specific setting: - Inpatient–ICU - Inpatient–non-ICU</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 2987 - Individual HCPs: 778</p> <p>User level of expertise/proficiency: NR</p>	<p>advisor follows guidelines for elderly patients.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Noncommittal acknowledgement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y</p>		<p>ordered/prescribed: Physicians used recommended doses— Intervention: 28.6% Control: 24.1% P < 0.001 - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Comments: Poor description of control group, contamination, low use by MD, inadequate reporting of methods and results</p> <p>Applicability/generalizability: One academic center</p> <p>Proxy decisionmakers existed</p> <p>Well-established health IT infrastructure</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Phillips, Ziemer, Doyle, et al., 2005 #3189 AND Ziemer, Doyle, Barnes, et al., 2006 #2821 Comparison 1 of 2	Geographical location: Atlanta, GA Study dates: January 1, 2000–December 31, 2002 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group, 2 x 2 factorial design Unit of randomization: Clinician Duration of intervention: 3 years Sample type(s) (with N randomized for each): - Individual HCPs: > Training MDs: 345 residents User level of expertise/ proficiency: Orientation yearly	Authors' basic description of system: The (computerized) reminders included both a flowsheet section—to show laboratory values, weight, blood pressure, and use of medications over a period of 6 to 18 months—and a recommendations section. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Pharmacotherapy - Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS:	Comparator(s): 2 x 2 factorial design: 1) Control 2) Reminders only 3) Feedback only 4) Reminders + feedback	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Impact of therapy Intensification on change in HbA1c levels (regression coefficient, P-value)— Baseline HbA1c: 0.4348, < 0.001 Reminders only: -0.0667, 0.39 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Effect of the intervention on therapy intensification (regression coefficient, P-value)— Reminders group at baseline: -0.0718, 0.77 Reminders group during intervention period: 0.0908, 0.18 From the text: At baseline, there were no significant differences in health care provider behavior among the intervention groups ($P > 0.70$). After 1 year of the intervention, intensification of therapy increased in all 4 groups. However, the increases were significantly greater in both the feedback only and	General comments: None Quality assessment: Overall rating: Fair Comments: High likelihood of contamination; inadequate reporting of methods Applicability/generalizability: Population was primarily African American and economically disadvantaged Did not use patient-centered outcomes Included residents

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	about the trial	<p><u>Computerized reminders-only group:</u></p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i></p>		<p>feedback + reminders group than among controls ($P < 0.001$ for both), but not in the reminders-only group compared with controls ($P = 0.06$).</p> <p>During the intervention period, residents with more experience tended to intensify therapy more ($P = 0.005$ for PGY). Residents also intensified therapy more with younger patients ($P = 0.001$) and patients with higher BMI ($P = 0.01$). However, after adjusting for other factors, the feedback intervention significantly and independently increased the likelihood of intensification of therapy; in contrast, reminders had no significant independent impact and did not affect the impact of feedback (interaction term nonsignificant).</p> <p>Over an average patient followup of 15 months within the intervention site, improvements in and final HbA1c (A1C) with feedback + reminders (ΔA1C 0.6%, final A1C 7.46%) were significantly better than control (ΔA1C 0.2%, final A1C 7.84%, $P_{\Delta} 0.02$).</p> <p>Changes were smaller with feedback only and reminders only (P_{Δ} NS versus control). Trends were similar but not significant with systolic blood pressure (sBP) and LDL cholesterol. Multivariable analysis showed that the feedback intervention independently facilitated attainment of American Diabetes Association goals for both A1C and sBP. Over a 2-year period,</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N (for reminders only group) - CDSS accompanied by conventional education: Y (yearly) 		<p>overall glycemic control improved in the intervention site but did not change in other primary care sites (final A1C 7.5 vs. 8.2%, $P = 0.001$).</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Phillips, Ziemer, Doyle, et al., 2005</p> <p>#3189</p> <p>AND</p> <p>Ziemer, Doyle, Barnes, et al., 2006</p> <p>#2821</p> <p>Comparison 2 of 2</p>	<p>Geographical location: Atlanta, GA</p> <p>Study dates: January 1, 2000–December 31, 2002</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group, 2 x 2 factorial design</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 3 years</p> <p>Sample type(s) (with N randomized for each): - Individual HCPs: > Training MDs: 345 residents</p> <p>User level of expertise/proficiency: Orientation yearly about the trial</p>	<p>Authors' basic description of system: The (computerized) reminders included both a flowsheet section—to show laboratory values, weight, blood pressure, and use of medications over a period of 6 to 18 months—and a recommendations section.</p> <p>Feedback sessions between one of the endocrinologists and a resident were approximately 5 minutes in duration and scheduled every 2 weeks. Feedback was based on IPCAAD report cards that showed individual provider actions or outcomes of the patients seen by that provider. Emphasis was placed on achieving ADA goals.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Pharmacotherapy - Chronic disease management <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p>	<p>Comparator(s): 2 x 2 factorial design:</p> <p>1) Control</p> <p>2) Reminders only</p> <p>3) Feedback only</p> <p><u>4) Reminders + feedback</u></p>	<p>1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Impact of therapy intensification on change in HbA1c levels (regression coefficient, P-value) Baseline HbA1c: 0.4348, < 0.001 Reminders + feedback: -0.0808, 0.46 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Effect of the intervention on therapy intensification (regression coefficient, P-value)— Reminders + feedback group at baseline: -0.0204, 0.95 Reminders + feedback group during intervention period: 0.0125, 0.89</p> <p><u>From the text:</u> At baseline, there were no significant differences in health care provider behavior among the intervention groups ($P > 0.70$). After 1 year of the intervention, intensification of therapy increased in all 4 groups. However, the increases were significantly greater in both the feedback only and feedback + reminders group than</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: High likelihood of contamination; inadequate reporting of methods</p> <p>Applicability/generalizability: Population was primarily African American and economically disadvantaged</p> <p>Did not use patient-centered outcomes</p> <p>Included residents</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><u>Computerized reminders + feedback group:</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell</p> <p><i>c) Communication content features:</i> - Provision of a</p>		<p>among controls ($P < 0.001$ for both), but not in the reminders-only group compared with controls ($P = 0.06$).</p> <p>During the intervention period, residents with more experience tended to intensify therapy more ($P = 0.005$ for PGY). Residents also intensified therapy more with younger patients ($P = 0.001$) and patients with higher BMI ($P = 0.01$). However, after adjusting for other factors, the feedback intervention significantly and independently increased the likelihood of intensification of therapy; in contrast, reminders had no significant independent impact and did not affect the impact of feedback (interaction term nonsignificant).</p> <p>Over an average patient followup of 15 months within the intervention site, improvements in and final HbA1c (A1C) with feedback + reminders (_A1C 0.6%, final A1C 7.46%) were significantly better than control (_A1C 0.2%, final A1C 7.84%, $P = 0.02$).</p> <p>Changes were smaller with feedback only and reminders only ($P = NS$ versus control). Trends were similar but not significant with systolic blood pressure (sBP) and LDL cholesterol. Multivariable analysis showed that the feedback intervention independently facilitated attainment of American Diabetes Association goals for both A1C and sBP. Over a 2-year period, overall glycemic control improved in</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>recommendation, not just an assessment: Y</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y (yearly) 		<p>the intervention site but did not change in other primary care sites (final A1C 7.5 vs. 8.2%, $P = 0.001$).</p> <ul style="list-style-type: none"> - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	
<p>Player, Gill, Mainous et al., 2010</p> <p>#14814</p>	<p>Geographical location: 27 sites in US States not reported</p> <p>Study dates: NR</p> <p>General setting: NR</p> <p>Specific setting:</p> <ul style="list-style-type: none"> - Outpatient - Chronic <p>Study design:</p>	<p>Authors' basic description of system: An EMR-based tool incorporating decision support for diagnosis and treatment of Gastro-esophageal reflux disease (GERD).</p> <p>Source/origin of system: Commercial</p> <p>Content:</p> <p><i>a) Objective(s):</i></p> <ul style="list-style-type: none"> - Diagnosis 	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Percentage of total patients newly diagnosed with GERD— Intervention ($n = 24,111$): 3.06% Control ($n = 29,926$): 2.33% $P < 0.01$ 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: No concealment and blinding information</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>- RCT, cluster randomization</p> <p>Unit of randomization: - Clinic or team</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Patients 67,543 - Clinics/practices/hospitals 27 - Individual HCPs: 119 > MDs [family medicine, internal medicine, or general practice] > PAs/NPs</p> <p>User level of expertise/proficiency: NR</p>	<p>- Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of</p>		<p>Odds ratio (CI 95%): 1.33 (1.13 to 1.56)</p> <p>Percentage of patients newly diagnosed with GERD among those experiencing atypical symptoms without prior GERD diagnosis— Intervention (n = 2532): 4.70% Control (n = 3725): 2.39% P < 0.01 Odds ratio (CI 95%): 2.02 (1.41 to 2.88)</p> <p>- Recommended treatment ordered/prescribed: Percentage of total patients newly prescribed medication for GERD— Intervention (n = 24,111): 1.52% Control (n = 29,926): 1.10% P = 0.32 Odds ratio (CI 95%): 1.11 (0.86 to 1.43)</p> <p>Percentage of patients with a GERD diagnosis (past or present) and no prescribed GERD medication prior to study start that were prescribed GERD medication during study period— Intervention (n = 3225): 24.25% Control (n = 3669): 18.95% P < 0.01 Odds ratio (CI 95%): 1.37 (1.12 to 1.68)</p> <p>Percentage of patients newly prescribed GERD medications among those experiencing atypical symptoms without prior GERD prescription— Intervention (n = 2532): 8.81%</p>	<p>No baseline information</p> <p>>10 % of patients were not followed up</p> <p>Applicability/generalizability: Large sample of patient population</p> <p>Large number of study sites including rural, suburban, and urban practices</p> <p>Study clinics had been using the Centricity office EMR for at least one year</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		decision making: Y - Recommendations executed by noting agreement: Can't tell <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <i>d) Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		Control (n = 3725): 6.44% P < 0.01 Odds ratio (CI 95%): 1.40 (1.08 to 1.83) Percentage of patients newly prescribed GERD medications and newly diagnosed with GERD among those experiencing atypical symptoms without prior GERD diagnosis and GERD prescription— Intervention (n = 2532): 2.33% Control (n = 3725): 1.29% P < 0.01 Odds ratio (CI 95%): 1.83(1.19 to 2.82) - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	
Price, 2005 #3135	Geographical location: Vancouver, BC Study dates:	Authors' basic description of system: PDA designed to improve adherence to 5 preventive measures in primary care.	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care	General comments: None Quality

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	2/02–4/02			ordered/completed:	assessment: Overall rating: Poor
	General setting: NR	Source/origin of system: Commercially available (Palm OS PDA)		<u>Control: n = 40</u> <u>Intervention: n = 39</u>	
	Specific setting: Outpatient	Content: <i>a) Objective(s):</i> Preventive care		Cervical cancer: 88% 100%	Comments: Small;
	Study design: RCT, parallel group	<i>b) Relationship to point of care:</i> Synchronous		Hyperlipidemia: 64% 94%	nonblinded;
	Unit of randomization: Clinician	Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)		Colorectal cancer: 38% 65%	contamination;
	Duration of intervention: 2 months	Information delivery: <i>a) Delivery format:</i> Standalone system (Palm Pilot)		Prophylaxis with aspirin: 33% 81%	physicians selected patients
	Sample type(s) (with N randomized for each): - Patients: 80 - Individual HCPs: 8	<i>b) Delivery mode:</i> User-initiated ("pull")		Hypertension: 97% 94%	nonrandomly; nonrandom, selected subset of users
	User level of expertise/proficiency: High	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N		- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	Applicability/generalizability: Highly motivated group of MDs that already had a PDA on site

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Raebel, Charles, Dugan, et al., 2007 #1932	<p>Geographical location: Denver, CO</p> <p>Study dates: 5/18/05–5/17/06</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): Patients: 59,680</p> <p>User level of expertise/ proficiency: NR</p>	<p>Authors' basic description of system: Computerized pharmacy alert system plus collaboration between health care professionals in decreasing potentially inappropriate medication dispensing in elderly.</p> <p>Source/origin of system: Not clearly described</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Intervention 543 of 29,840 (1.8%) prescribed inappropriate medication Usual care 644 of 29,840 (2.2%) prescribed inappropriate medication P = 0.002 - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR:</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: Monitored 11 medications inappropriate for elderly patients</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: One Kaiser group, all patients older than age 65</p> <p>Very low rate of inappropriate medications used</p> <p>Only looked at prescriptions written and not sold</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		periodic performance feedback: N - CDSS accompanied by conventional education: N			
Raebel, Chester, Newsom, et al., 2006 #2748	Geographical location: Denver, CO Study dates: 11/25/02–12/31/03 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 14 months Sample type(s) (with N randomized for each): Patients: 9139 User level of expertise/ proficiency: NR	Authors' basic description of system: When a patient was dispensed a target medication, the lab test was electronically assessed as completed or not. Not completed lab tests were sent to a clinical pharmacology call center that worked with patents to get lab testing. Abnormalities were sent to physician for decisionmaking designed to minimize physician burden completion within 14 days of dispensing medication. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Intervention: completed lab tests, 64% (3114 of 4871) Usual care: 58% (2773 of 4780) P < 0.001 - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	General comments: Started with 14 medications and excluded 2 Quality assessment: Overall rating: Good Comments: Overlap with Raebel, Lyons, Chester, et al., 2005 Applicability/ generalizability: Blinded one Kaiser group

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: Y <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can’t tell 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>- Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Y</p> <p>- Provision of decision support results to patients as well as providers: Y</p> <p>- CDSS accompanied by periodic performance feedback: Can't tell</p> <p>- CDSS accompanied by conventional education: Can't tell</p>			
<p>Raebel, Lyons, Chester, et al., 2005</p> <p>#3125</p>	<p>Geographical location: Denver, CO</p> <p>Study dates: 9/9/02–12/31/03</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of</p>	<p>Authors' basic description of system: When a patient was dispensed a target medication, the lab test was electronically assessed as completed or not. Not completed lab tests were sent to a clinical pharmacology call center that worked with patents to get lab testing. Abnormalities were sent to physician for decisionmaking designed to minimize physician burden.</p> <p>Source/origin of system: Not clearly described</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: Recommended lab tests completed— Intervention: 79.1% (n = 4076; 95% CI 78.0%-80.2%) Usual care: 70.25% (n = 3522; 95% CI, 68.9%-71.5%) P < 0.001</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p>	<p>General comments: Studied 15 medications</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Physicians, patients, and pharmacists blinded to study group</p> <p>One Kaiser group</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>intervention: 16 months</p> <p>Sample type(s) (with N randomized for each): Patients: 10,169</p> <p>User level of expertise/proficiency: NR</p>	<p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: Y</p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			
Reeve, Tenni, and Peterson, 2008 #1379	<p>Geographical location: Melbourne, Australia</p> <p>Study dates: NR</p> <p>General setting: Academic</p> <p>Specific setting:</p>	<p>Authors' basic description of system: Pharmacists were presented with an electronic prompt each time they dispensed an oral hypoglycemic agent. The prompt identified a patient potentially eligible for low-dose aspirin to prevent heart disease.</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Overall documented clinical intervention rate— Intervention: 1.74 per 100 patients (95% CI 1.55, 1.93) Control: 0.91 (0.77, 1.05) 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Pharmacy</p> <p>Duration of intervention: 6 weeks</p> <p>Sample type(s) (with N randomized for each): - Pharmacies: 15 Intervention: 31 pharmacies Usual care: 21 pharmacies - Pharmacists: 150</p> <p>User level of expertise/ proficiency: NR</p>	<p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system-pharmacy system <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional</p>		<p>Mann–Whitney U-test, $P < 0.001$</p> <p>Intervention— 2.55 aspirin treatment per 100 diabetic patients</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>generalizability: Community-based pharmacies not linked to medical record; not blinded</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>clinician data entry: Y- Request documentation of the reason for not following CDSS recommendations: Can't tell</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y- Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			
Rollman, Hanusa, Gilbert,	Geographical location:	Authors' basic description of system:	Comparator(s): Usual care/no	1) Impact on clinical outcomes: NR	General comments:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
et al., 2001 #5453	<p>Pittsburgh, PA</p> <p>Study dates: NR; recruitment started between April 1997 and December 1998</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 20 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 212 - Individual HCPs: > MDs: 16 internists</p> <p>User level of expertise/ proficiency: NR</p>	<p>EMR system generates interactive email alert (flag) to notify PCPs when the mood module identifies a patient as having major depression.</p> <p>Source/origin of system: Commercially available</p> <p>Content: <i>a) Objective(s):</i> Diagnosis <i>b) Relationship to point of care:</i> Asynchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> - Integrated with CPOE/EHR - Email <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i></p>	<p>CDSS or KMS</p> <p>All received email alert “flag”—</p> <p>1) Intervention 1 (active): Reminder plus patient-specific recommendation on paper/online encounter form; also, electronic prompts to schedule followup appointment</p> <p>2) Intervention 2 (passive): Reminder on paper encounter form; no other intervention prompts</p> <p>3) Control: usual care</p> <p>Note that the analysis did not compare findings across groups, so only a single evidence table was prepared for this study</p>	<p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: 3 days after notification— Agree: 120 of 186 (65%) Disagree: 24 of 186 (13%) Uncertain: 42 of 186 (23%)</p> <p>1 month after notification— Agree: 147 of 186 (71%) Disagree: 34 of 186 (16%) Uncertain: 27 of 186 (13%)</p> <p>154 days after notification— Agree: 166 of 186 (78%) Disagree: 36 of 186 (17%) Uncertain: 10 of 186 (5%)</p> <p>“There were no differences in the agreement rate or treatments provided across guideline exposure conditions.”</p> <p>Stratification of results by intervention groups were done in graph format; actual value not available</p>	<p>The email alert flag required a response (per procedure paragraph 1); justification via interactive email sent after the initial response (per procedure paragraph 2)</p> <p>The email alert flag was asynchronous; the reminder plus patient-specific recommendation (active) on paper/online encounter form was synchronous</p> <p>Authors’ description seems to suggest that email alerts and paper encounter forms were used to remind physicians</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: N <p>(Note: researcher has to enter "major depression" manually into the problem list and forward a flag to the clinic's scheduling secretary; page 190).</p> <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support 		<ul style="list-style-type: none"> - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR 	<p>Interviewer (outcome assessor) masked to randomization status of a patient's PCP.</p> <p>PCPs were not blinded to their assignment condition</p> <p>Small sample size (physicians)</p> <p>Some baseline differences (age, male gender, single marital status, Hamilton depression rating scale score, SF-12 mental health composite score and MOS social support scale score)</p> <p>15 of 227 (7%) patients dropped out.</p> <p>Did not adequately report outcome according to intervention groups</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			Inadequate analysis and reporting of findings. Applicability/generalizability: Small sample size Study conducted in an academic medical center
Rood, Bosman, van der Spoel, et al., 2005 #3549	Geographical location: Amsterdam, Netherlands Study dates: NR General setting: Academic Specific setting: Inpatient – ICU Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 10 weeks	Authors' basic description of system: System that notifies clinicians (nurses) of recommend insulin dosage and glucose-level monitoring. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> No response requirement Information delivery: <i>a) Delivery format:</i>	Comparator(s): Another CDSS/KMS, paper-based version	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: 1) Glucose in target range— Intervention: 40.2% Paper-based: 35.5% 2) Insulin guidelines— Intervention: 77.3% Paper-based: 64.2% - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered	General comments: For nurses, not MDs Quality assessment: Overall rating: Good Comments: Only second phase randomized Applicability/generalizability: Not all patients had diabetes; study conducted in the Netherlands

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Patients: <ul style="list-style-type: none"> > Computerized decision support intervention: 66 patients > Paper-based: 54 patients - Individual HCPs: <ul style="list-style-type: none"> > Training MDs: 6 fellows > MDs: 5 intensive care > Nurses: 93 <p>User level of expertise/proficiency: Trained very well</p>	<p>Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision 		<p>outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>support via provision of reasoning: Can't tell</p> <p>- Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Can't tell</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: N</p>			
<p>Rosser, Hutchison, McDowell, et al., 1992</p> <p>#7131</p>	<p>Geographical location: Ottawa, Ontario, Canada</p> <p>Study dates: 4/1/85–3/1/86</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p>	<p>Authors' basic description of system:</p> <p>A computer-generated reminder to ask the patient about tetanus vaccination was included on the routinely printed encounter form used for billing purposes. Until information about the procedure was recorded, the computer continued to generate reminders at subsequent visits.</p> <p>Source/origin of system:</p> <p>Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i></p>	<p>Comparator(s):</p> <p>Usual care/ no CDSS or KMS</p> <p>4 arms, 3 of which involved computerized reminder systems:</p> <p>1) Control</p> <p>2) Physician reminders</p> <p>3) Telephone reminders</p> <p>4) Letter</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: Vaccination rates were 3.2% in the randomized controls (2.3% in nonrandomized controls); the difference in the recorded vaccination rate between control and the three reminder groups—19.6% in the physician reminder group (95% CI 17.1%, 22.2%) $P < 0.00001$, 20.8% in the telephone reminder group (95% CI 18.3%, 23.5%), $P < 0.00001$ 27.4% in the letter reminder group (95% CI 24.8%, 30.2%), $P < 0.00001$</p>	<p>General comments:</p> <p>After adjusting for multiple comparisons, the intervention groups differed from the randomized controls but not from each other</p> <p>Quality assessment:</p> <p>Overall rating: Poor</p> <p>Comments:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 5589 - Clinics: 4 - Individual HCPs: > Training: 12 to 16 > MDs: 4 > Nurses: 4</p> <p>User level of expertise/proficiency: NR</p>	<p>Immunization</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed</p>	<p>reminders</p> <p>Data from a nonrandomized sample were reported as well</p>	<p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: NR - Cost-effectiveness: Physician reminder group— The cost per additional vaccination was \$0.43 at a physician salary of \$60 per hour and 0.22 at \$30 per hour.</p> <p>Telephone reminder group— The cost of an additional vaccination was \$5.43 at a salary of \$15 per hour and \$4.43 at \$10 per hour.</p> <p>Letter reminder group— The cost for each additional vaccination recorded was \$6.05.</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Incomplete reporting of methods and results; potential for contamination across intervention arms</p> <p>Applicability/generalizability: Study conducted in Canada in 1985</p> <p>Patient computer database since 1976</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		by noting agreement: N c) <i>Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Can't tell d) <i>Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Rosser, McDowell, and Newell, 1991 #7172	Geographical location: Ottawa, Ontario, Canada Study dates: 10/1984–01/1985; 4/1/85–3/1/86 General setting: Academic	Authors' basic description of system: Two interventions to improve rates of 5 preventive procedures were compared to a usual care control. In the physician intervention group, a reminder was generated from the EMR and placed in the preprinted encounter form. In	Comparator(s): Usual care/ no CDSS or KMS 4 arms, 3 of which involved computerized reminder systems:	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Procedure (% of procedures performed)— Administer influenza vaccine: Nonrandomized control: 3.8 Randomized control: 9.8	General comments: After adjusting for multiple comparisons, the intervention groups differed from the randomized controls but not

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 5589 - Clinics: 4 - Individual HCPs: > Training: 12 to 16 > MDs: 4 > Nurses: 4</p> <p>User level of expertise/proficiency: NR</p>	<p>the patient intervention groups, patients were either contacted by telephone (practice nurse attempted a maximum of 5 calls) or by letter.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Immunization - Preventive care <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i></p>	<p>1) Control</p> <p>2) Physician reminders</p> <p>3) Telephone reminders</p> <p>4) Letter reminders</p> <p>Data from a nonrandomized sample were reported as well</p>	<p>Physician reminder 22.9 Letter reminder: 35.2 Telephone reminder: 37.0</p> <p>Measure blood pressure: Nonrandomized control: 18.6 Randomized control: 21.1 Physician reminder 30.7 Letter reminder: 40.5 Telephone reminder: 37.2</p> <p>Assess smoking status: Nonrandomized control: 9.5 Randomized control: 11.9 Physician reminder 37.9 Letter reminder: 49.1 Telephone reminder: 55.8</p> <p>Obtain Papanicolaou smear: Nonrandomized control: 11.2 Randomized control: 13.7 Physician reminder 16.5 Letter reminder: 29.7 Telephone reminder: 30.0</p> <p>Administer tetanus vaccine: Nonrandomized control: 2.3 Randomized control: 3.2 Physician reminder 22.8 Letter reminder: 30.6 Telephone reminder: 24.0</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency,</p>	<p>from each other</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Incomplete reporting of methods and results; potential for contamination across intervention arms</p> <p>Applicability/generalizability: Study conducted in Canada in 1985</p> <p>Patient computer database since 1976</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Can't tell N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Rossi and Every, 1997 #6440	<p>Geographical location: - Puget Sound VA - Seattle, WA</p> <p>Study dates: 3/96–8/96</p> <p>General setting: VA</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 719 - Individual HCPs: > General internal medicine: 71 > Training MDs: 44 > MDs: 15 > NPs : 12</p> <p>User level of</p>	<p>Authors' basic description of system: In order to decrease the use of calcium channel blockers for patients with hypertension, the EMR was used to identify patients receiving these medications putatively for hypertension. A one-page computer-generated guideline reminder was placed in the clinic chart by the clinical pharmacist and collected by the ward clerk at the end of the visit.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> - Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push")</p>	<p>Comparator(s): Usual care (although usual care at this site involved a sophisticated EMR)</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prescription change from calcium channel blockers to other medication: Control: < 1% (1 of 373) Intervention: 11.3% (39 of 346) ($p < 0.001$) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Reasons for unchanged calcium channel blockers therapy— Prescribed for angina: 71 (23%) No hypertension: 48 (14%) Failed blood pressure control with first-line therapy: 48 (14%) Adverse effects on first-line therapy:</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Comments: An excellent study in all its elements. The authors provide some informal cost and cost-effectiveness numbers in the discussion section.</p> <p>Applicability/generalizability: Participants had to already be successful users of a sophisticated EMR</p> <p>VA setting</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	expertise/ proficiency: NR	<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Y</p>		<p>33 (10%)</p> <ul style="list-style-type: none"> - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N <p><i>e) Other:</i> The reminder cited national guidelines, recommended alternative medications, facilitated ordering those alternative medications, and requested that the physician justify the choice of calcium channel blocker if the medication was left unchanged</p>			
<p>Rothschild, McGurk, Honour, et al., 2007</p> <p>#2216</p>	<p>Geographical location: Boston, MA</p> <p>Study dates: April 2003–June 2004</p> <p>General setting: Academic</p> <p>Specific setting: Inpatient</p> <p>Study design: RCT, cluster</p>	<p>Authors' basic description of system:</p> <p>Within the context of an existing EMR, transfusion orders in the intervention group were compared against guidelines. If inappropriate, physicians had to either change their order or state their reason for disagreement.</p> <p>Source/origin of system:</p> <p>Locally developed</p>	<p>Comparator(s):</p> <p>Usual care</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Transfusion guideline adherence, decision support-evaluated orders— Final total appropriateness ratings, appropriate (%): 	<p>General comments:</p> <p>Very stringent criteria were used to classify orders as appropriate.</p> <p>Study also included a posteducation phase; table only presents data for the DS intervention</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 4 months</p> <p>Sample type(s) (with N randomized for each): - Patients (DS intervention): 1607 - Individual HCPs: > Staff MDs (fourth-year to seventh-year residents, fellows, and attending physicians): 961 > Trainee MDs: 453 PG YR 1: 175 PG YR 2: 156 PG YR 3: 122</p> <p>User level of expertise/proficiency: NR</p>	<p>Content: <i>a) Objective(s):</i> Transfusion ordering</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision</p>		<p>Assigned staff: 343 (32.6) Housestaff control: 503 (32.5) Housestaff intervention: 546 (40.4)</p> <p>Final total appropriateness ratings, inappropriate (%): Assigned staff: 708 (67.4) Housestaff control: 1043 (67.5) Housestaff intervention: 804 (59.6)</p> <p>DS-agree orders: Assigned staff: 321 Housestaff control: 470 Housestaff intervention: 411</p> <p>Chart review confirms DS-agree: Assigned staff: 238 Housestaff control: 349 Housestaff intervention: 305</p> <p>Chart review changes to DS-disagree: Assigned staff: 83 Housestaff control: 121 Housestaff intervention: 106</p> <p>DS-disagree orders: Assigned staff: 730 Housestaff control: 1,076 Housestaff intervention: 939</p> <p>Chart review changes to DS-agree appropriate (%): Assigned staff: 105 (14.4) Housestaff control: 154 (14.3) Housestaff intervention: 108 (11.5)</p> <p>Chart review confirms DS-disagree inappropriate (%): Assigned staff: 625 (85.6)</p>	<p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Well-established health IT infrastructure and historically an early adopter of health IT</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>making: Y</p> <p>- Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i></p> <p>- Provision of a recommendation, not just an assessment: Y</p> <p>- Promotion of action rather than inaction: Can't tell</p> <p>- Justification of decision support via provision of reasoning: Can't tell</p> <p>- Justification of decision support via provision of research evidence: Y</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Y</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: N (although the trial was preceded by an education period)</p>		<p>Housestaff control: 922 (85.7)</p> <p>Housestaff intervention: 698 (74.3)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <p>- HCP acceptance: Physicians accepted 14% (133 of 939) of new DS-recommended orders, especially recommendations to increase transfusion doses (73%)</p> <p>- HCP satisfaction: NR</p> <p>- HCP use: NR</p> <p>- Implementation of CDSS/KMS: NR</p>	
Roukema, Steyerberg, van der Lei, et al., 2008	<p>Geographical location: Rotterdam, Netherlands</p> <p>Study dates:</p>	<p>Authors' basic description of system:</p> <p>All patients were followed with the basic CDS, which required approximately 2 minutes for</p>	<p>Comparator(s):</p> <p>Usual care (with the other components of the CDS)</p>	<p>1) Impact on clinical outcomes:</p> <p>- Length of stay: Children in the intervention group had a median (25th to 75th percentile) length of stay at the ED of 138 (104–181) minutes. The</p>	<p>General comments:</p> <p>None</p> <p>Quality</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#1540	<p>9/1/03–12/31/05</p> <p>General setting: NR</p> <p>Specific setting: Emergency department</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 28 months</p> <p>Sample type(s) (with N randomized for each): Patients: 164</p> <p>User level of expertise/ proficiency: Nurses received training on how to use system</p>	<p>the nurse to input information from the history and physical examination. For children with fever without known cause that were classified as being at high risk, intervention patients had the recommendation to order lab tests turned on while control patients did not.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i></p> <ul style="list-style-type: none"> - Diagnosis (or risk assessment preliminary to a diagnosis) - Lab test ordering <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery:</p> <p><i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p>	working)	<p>median length of stay at the ED in the control group was 123 (83–179) minutes.</p> <ul style="list-style-type: none"> - Morbidity: NR - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Adherence to the advice to order laboratory tests— Intervention: 82% (61 of 74) Control: 44% (40 of 90) $p < 0.001$, χ^2 test - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>assessment: Overall rating: Good</p> <p>Comments: This small, and perhaps underpowered, study is testing a rather minor point since there is little reason to use the CDS with the recommendation to order lab tests turned off</p> <p>Applicability/ generalizability: Study conducted in the Netherlands</p> <p>Study aim is of limited applicability in the U.S.</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Roumie, Elasy, Greevy, et al., 2006 #2556 Comparison 1 of 2	Geographical location: Tennessee, US Study dates: Patients identified: 7/03–12/03 Interventions performed: 6/14/04–6/18/04 Followup until: 12/31/04 General setting: Academic and community Specific setting: Outpatient Study design: RCT, cluster randomization Unit of randomization: Clinician Duration of intervention: 6 months Sample type(s) (with N randomized for each): - Patients: 1827 randomized, 1341	Authors' basic description of system: The provider education and alert intervention was a one-time reminder for every patient with uncontrolled hypertension, including guideline-based recommendations. The patient intervention was a letter discussing behavioral strategies and noting that many patients require more than one medication. The provider education (control group) intervention included an email to providers containing a web link to the JNC 7 guidelines (intervention groups also received the email). Source/origin of system: Locally developed Content: a) <i>Objective(s):</i> - Chronic disease management - Pharmacotherapy b) <i>Relationship to point of care:</i> Not clearly described Decision support: <i>Response requirement:</i> NR (assume no response requirement)	Comparator(s): Usual care (included an EMR) Three groups were compared, including two interventions: 1) Provider education (control) 2) <u>Provider education + alert</u> 3) Provider education + alert + patient education	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: n = 1341 Hospitalizations, n (%): Provider education group: 12 of 324 (3.7) Provider education + alert group: 16 of 547 (2.9) Provider education + alert + patient education: 25 of 470 (5.3) - Mortality: n = 1341 Deaths, n (%): Provider education group: 8 of 324 (2.5) Provider education + alert group: 3 of 547 (0.6) Provider education + alert + patient education: 4 of 470 (0.9) - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Any changes in antihypertensive drugs, n (%)— Provider education group: 104 of 324 (32.4), RR (95% CI): 0.88 (0.72, 1.08) Provider education + alert group: 156 of 547 (28.5), RR (95% CI) 0.90 (0.73,	General comments: While pairs of groups were not specifically subjected to formal statistical comparison, the pattern of the results suggests that, for the primary outcome, the provider education + alert + patient education group outperformed the other 2 groups, the results from these latter 2 groups being effectively similar Quality assessment: Overall rating: Good Applicability/generalizability: Academic and community setting Compares a DSS to a DSS enhanced by patient education

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>assigned to groups - Individual HCPs: 205 randomized, 182 included (101 staff physicians, 36 residents, 45 NPs/PAs)</p> <p>User level of expertise/proficiency: High; must already be users of a sophisticated EMR</p>	<p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><u>Provider education + alert group:</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: Can’t tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an</p>		<p>1.11) Provider education + alert + patient education: 137 of 470 (29.1) Mean medication adherence (SD), n = 948— Provider education group: 0.89 (0.14) Provider education + alert group: 0.89 (0.14) Provider education + alert + patient education: 0.88 (0.16)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>assessment: Y</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
<p>Roumie, Elasy, Greevy, et al., 2006</p> <p>#2556</p> <p>Comparison 2 of 2</p>	<p>Geographical location: Tennessee, US</p> <p>Study dates: Patients identified: 7/03–12/03</p> <p>Interventions performed: 6/14/04–6/18/04</p> <p>Followup until: 12/31/04</p> <p>General setting:</p>	<p>Authors' basic description of system:</p> <p>The provider education and alert intervention was a one-time reminder for every patient with uncontrolled hypertension, including guideline-based recommendations.</p> <p>The patient intervention was a letter discussing behavioral strategies and noting that many patients require more than one medication. The provider education (control</p>	<p>Comparator(s):</p> <p>Usual care (included an EMR)</p> <p>Three groups were compared, including two interventions:</p> <p>1) Provider education (control)</p> <p>2) Provider</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: n = 1341 Hospitalizations, n (%): <ul style="list-style-type: none"> Provider education group: 12 of 324 (3.7) Provider education + alert group: 16 of 547 (2.9) Provider education + alert + patient education: 25 of 470 (5.3) - Mortality: n = 1341 Deaths, n (%): <ul style="list-style-type: none"> Provider education group: 8 of 324 	<p>General comments:</p> <p>While pairs of groups were not specifically subjected to formal statistical comparison, the pattern of the results suggests that, for the primary outcome, the provider education + alert + patient</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Academic and community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 1827 randomized, 1341 assigned to groups - Individual HCPs: 205 randomized, 182 included (101 staff physicians, 36 residents, 45 NPs/PAs)</p> <p>User level of expertise/proficiency: High; must already be users of a sophisticated EMR</p>	<p>group) intervention included an email to providers containing a web link to the JNC 7 guidelines (intervention groups also received the email).</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Chronic disease management - Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Not clearly described</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p>	<p>education + alert</p> <p><u>3) Provider education + alert + patient education</u></p>	<p>(2.5) Provider education + alert group: 3 of 547 (0.6) Provider education + alert + patient education: 4 of 470 (0.9)</p> <p>- Validated measure of HRQOL or functional status: NR - Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Any changes in antihypertensive drugs, n (%)— Provider education group: 104 of 324 (32.4), RR (95% CI): 0.88 (0.72, 1.08) Provider education + alert group: 156 of 547 (28.5), RR (95% CI) 0.90 (0.73, 1.11) Provider education + alert + patient education: 137 of 470 (29.1) Mean medication adherence (SD), n = 948— Provider education group: 0.89 (0.14) Provider education + alert group: 0.89 (0.14) Provider education + alert + patient education: 0.88 (0.16)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p>	<p>education group outperformed the other 2 groups, the results from these latter 2 groups being effectively similar</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Academic and community setting</p> <p>Compares a DSS to a DSS enhanced by patient education</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><u>Provider education + alert + patient education group:</u></p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Y</p> <p><i>d) Auxiliary features:</i></p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			
Roy, Durieux, Gillaizeau, et al., 2009 #89	Geographical location: 20 sites in France Study dates: 6/1/05–6/30/06 General setting: Community Specific setting: Emergency department Study design: RCT, cluster randomization Unit of randomization: Clinic or team (facility) Duration of intervention: 7 months Sample type(s) (with	Authors' basic description of system: After introducing hand-held devices for data collection during a run-in period, intervention physicians received CDS through those same devices. First, they were asked to provide clinical data as input to a Geneva score, which estimates the probability of pulmonary embolism. The device then recommends tests that could potentially lead to a decision of diagnose/exclude PE. Test results are input into the device, the pretest probability of PE revised, and the process iterates. Source/origin of system: Locally developed Content: a) <i>Objective(s):</i> Diagnosis	Comparator(s): Usual care (but with continued data collection using hand-held devices)	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Appropriate diagnostic strategy applied (adjusted absolute change, %)— Control: 10.9 Intervention: 30.2 Adjusted difference in change (95% CI), percentage points: 19.3 (2.9 to 35.6 p = 0.023) - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR	General comments: None Quality assessment: Overall rating: Good Comments: In the absence of receiving feedback from the device, control physicians used the device much less, introducing a potential bias of unknown magnitude. Nevertheless, the conclusion that the CDS improved process of care seems

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>N randomized for each): - Patients: 1768 patients enrolled, 1645 patients analyzed - Clinics/practices: 20</p> <p>User level of expertise/proficiency: NR</p>	<p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed</p>		<p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: Data were input in real time for 80% of intervention patients and 39% of controls - Implementation of CDSS/KMS: NR</p>	<p>sound.</p> <p>Applicability/generalizability: This is not an intervention that is likely to be used in the U.S.</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		by noting agreement: N			
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Samore, Bateman, Alder, et al., 2005 #3127	<p>Geographical location: 12 rural areas of Utah and Idaho</p> <p>Study dates: 1/01–9/03</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Community</p> <p>Duration of intervention: 2 years</p> <p>Sample type(s) (with N randomized for each): 12 communities</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: Practitioners could choose a paper- or PDA-based support tool to increase appropriateness (especially, to decrease inappropriate use) of antimicrobial agents. The PDA-based CDSS generated diagnostic and therapeutic recommendations on the basis of patient-specific information that was input about the suspected diagnosis or absence of specific symptoms and signs.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Diagnosis - Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i></p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Rates of antimicrobial prescribing did not change significantly during the first intervention year. In CDSS and community intervention-alone communities, a nonsignificant decrease of 1% and an increase of 3% from baseline were observed. In nonstudy communities, prescribing rates decreased by 3% compared with baseline.</p> <p>During the second intervention year, prescribing rates in CDSS communities decreased 10% from baseline, whereas in the community intervention-alone communities and nonstudy communities, prescribing rates in 2003 increased by 1% and 6%, respectively.</p> <p>Within CDSS communities, the overall antimicrobial prescribing rate declined by an absolute amount of 0.09 prescriptions per person-year between baseline and the second-intervention year. This translated to an expected reduction of 93 antimicrobial prescriptions per month in a rural</p>	<p>General comments: The study also had a community intervention that is not relevant for our purposes</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: The complex and difficult-to-follow statistical analyses probably do not help get around the fact that there were only 12 communities studied</p> <p>Applicability/generalizability: It is doubtful that an intervention that is not integrated into clinical workflow and which requires additional time for data entry would be generally</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can’t tell - Justification of decision support via provision of reasoning: Can’t tell - Justification of decision support via provision of</p>		<p>community with a population size equal to the mean of the CDSS group.</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: 71% of physicians in the intervention communities used the decision support system - Implementation of CDSS/KMS: NR</p>	<p>acceptable, even for underresourced rural practices</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i> Therapeutic recommendations included over-the-counter medications for symptom control as well as prescription antimicrobials. For pediatric patients, the advice was customized to the patient's weight and age. For cases of pneumonia, the system also calculated the patient's pneumonia severity index score.</p>			
<p>Schriefer, Landis, Turbow, et al., 2009</p> <p>#326</p>	<p>Geographical location: Western NC</p> <p>Study dates: Early 2006</p> <p>General setting: Academic</p>	<p>Authors' basic description of system: In addition to height and weight, for intervention patients the EMR additionally calculated BMI.</p> <p>Source/origin of system: NR</p> <p>Content:</p>	<p>Comparator(s): Usual care</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Obese patients in the intervention group were more likely than controls to receive a diagnosis of 	<p>General comments: The methods did not mention that physicians were prompted to take any action as a result of a high BMI</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Team</p> <p>Duration of intervention: 2 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 846 - Individual HCPs: > Family medicine: 37 (13 faculty, 24 residents)</p> <p>User level of expertise/proficiency: NR</p>	<p><i>a) Objective(s):</i> - Diagnosis - Chronic disease management</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N</p>		<p>obesity (16.6% vs 10.7%, $p = 0.016$), be referred for dietary treatment (14.0% vs 7.3%, $p = 0.002$), and be referred for exercise (12.1% vs 7.1%, $p = 0.016$)</p> <p>- Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Quality assessment: Overall rating: Good</p> <p>Comments: Not knowing whether the intervention prompted physicians into action limits the ability to interpret the results</p> <p>Applicability/generalizability: A single practice, plus an intervention that could easily be strengthened by adding some recommendations</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
		<ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Sequist, Gandhi, Karson, et al., 2005 #3343	<p>Geographical location: 20 sites in MA</p> <p>Study dates: October 2002–April</p>	<p>Authors' basic description of system: An integrated, patient-specific electronic clinical reminder system on diabetes and coronary artery disease (CAD).</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Diabetes—</p>	<p>General comments: Both groups received paper-based reminders</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	2003				
	General setting: - Academic - Community	Source/origin of system: Locally developed		Annual cholesterol exam: Baseline = 4957 (58%) Enrolled = 1185 (14%) Hazard ratio (95% CI) = 1.41 (1.15-1.72) P < 0.001	Quality assessment: Overall rating: Poor
	Specific setting: - Outpatient - Chronic	Content: <i>a) Objective(s):</i> - Pharmacotherapy - Lab test ordering - Preventive care		Biennial hemoglobin A1c exam: Baseline = 4868 (57%) Enrolled = 2245 (26%) Hazard ratio (95% CI) = 1.14 (0.89-1.46) P = 0.29	Comments: Clinically significant difference in baseline (race and insurance status)
	Study design: RCT, cluster randomization	<i>b) Relationship to point of care:</i> Synchronous		Annual dilated eye exam: Baseline = 1464 (17%) Enrolled = 4049 (47%) Hazard Ratio (95% CI) = 1.38 (0.81-2.32) P = 0.23	Table 2 contains results that combine both intervention and control arms
	Unit of randomization: Clinic or team	Decision support: <i>Response requirement:</i> No response requirement			
	Duration of intervention: 6 months	Information delivery: <i>a) Delivery format:</i> - Integrated with CPOE/EHR - Paper-based		CAD— Annual cholesterol exam: Baseline = 5039 (53%) enrolled = 1151 (12%) Hazard Ratio (95% CI) = 0.99 (0.75-1.29) P = 0.92	255 PCPs were surveyed: 159 (62%) responded (Intervention, 78; Control, 81)
	Sample type(s) (with N randomized for each): - Patients 6243 (4549 patients with diabetes, 2199 patients with coronary artery disease [CAD]) - Clinics/practices/hospitals: 20 - Individual HCPs: > MDs: 194 primary care physicians	<i>b) Delivery mode:</i> System-initiated (“push”)		- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Adherence rates in the entire population and in the enrolled population for diabetes and CAD care, # (% of total population)— Diabetes: Hypertension/ACE inhibitor use: Baseline = 2761 (62%) Enrolled = 711 (16%) Hazard Ratio (95% CI) = 1.42 (0.94-2.14)	Applicability/generalizability: Locally developed system Primary care physicians practicing at all 20 centers received electronic reminders in their practice
	User level of expertise/proficiency: NR	Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N		P = 0.10 Statin use for LDL cholesterol $\geq 130\text{mg/dL}$: Baseline = 476 (31%) Enrolled = 595 (38%) Hazard Ratio (95% CI) = 1.10 (0.65-1.85) P = 0.73 CAD: Aspirin use: Baseline = 2883 (41%) Enrolled = 669 (9%) Hazard Ratio (95% CI) = 2.36 (1.37-4.07) P = 0.002 Beta-blocker use: Baseline = 2701 (38%) Enrolled = 808 (11%) Hazard Ratio (95% CI) = 1.09 (0.72-1.63) P = 0.69	previously Well-established health IT infrastructure and historically an early adopter of health IT
		c) <i>Communication content features</i> : - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N d) <i>Auxiliary features</i> : - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N		Statin use for LDL cholesterol $\geq 130\text{mg/dL}$: Baseline = 495 (28%) Enrolled = 385 (21%) Hazard Ratio (95% CI) = 1.51 (1.05-2.17) P = 0.03 - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR	
		e) <i>Other</i> :			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Reminders displayed on the main patient summary screen along with patient medication list and problem list - Succinct messages - Passive reminders (do not require physician acknowledgement) 		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: Electronic reminders useful for diabetes disease management = 53 (68%) Electronic reminders useful for CAD management = 41 (53%) Electronic reminders improve quality of patient care = 121 (76%) - HCP use: Lack of awareness of guidelines existence = 61 (38%) Notice electronic reminders during patient encounter = 60 (38%) Electronic reminders prompt physician to take specific action = 55 (35%) - Implementation of CDSS/KMS: NR 	
<p>Sequist, Zaslavsky, Marshall, et al., 2009</p> <p>#616</p>	<p>Geographical location: 11 sites in MA</p> <p>Study dates: April 200 –June 2007</p> <p>General setting: Community</p> <p>Specific setting:</p>	<p>Authors' basic description of system: Physicians received active and passive electronic reminders during office visits with patients overdue for colorectal cancer screening; passive alerts were present at any point within the electronic visit summary, and active alerts required acknowledgement from the</p>	<p>Comparator(s): Usual care/no CDSS or KMS; patient mailing intervention group</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: Physician reminder intervention, pathologic findings— Colonic adenoma: Intervention (I): 650 (6.0%) Control (C): 540 (4.9%) Percentage point difference (95% CI) = 1.0 (-0.1 to 2.2) P = 0.09 Colorectal cancer: 	<p>General comments: Two types of intervention: patient mailing and physician electronic reminders</p> <p>Results of patient intervention are</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Outpatient	user when placing orders.		I: 17 (0.2%) C: 17 (0.2%) Percentage point difference (95% CI) = 0.0 (-0.1 to 0.1) P = 0.99	not included in this abstraction
	Study design: RCT, parallel group	Source/origin of system: Commercially available		Positive FOBT (among those patients who performed FOBT) I: 27 (1.1%) C: 32 (1.3%) Percentage point difference (95% CI) = -0.2 (-0.8 to 0.4) P = 0.52	43 of 55 physicians in the intervention group surveyed; only 33 responded
	Unit of randomization: Clinician	Content: <i>a) Objective(s):</i> - Lab test ordering - Preventive care			
	Duration of intervention: 15 months	<i>b) Relationship to point of care:</i> Synchronous			Quality assessment: Overall rating: Fair
	Sample type(s) (with N randomized for each): - Patients: 21,860 - Clinics/practices/hospitals: 11 - Individual HCPs: > MDs: 110 primary care physicians	Decision support: <i>Response requirement:</i> Mandatory response (active)		Patient mailing intervention, pathologic findings— Colonic adenoma: I: 622 (5.7%) C: 568 (5.2%) Percentage point difference (95% CI) = 0.5 (-0.1 to 1.1) P = 0.10	Comments: Patients in the intervention group and control group were similar for both the patient-level and physician-level randomizations
	User level of expertise/proficiency: Physicians in both intervention and control groups were educated about electronic reminders via a 1-hour presentation and discussion	Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")		Colorectal cancer: I: 19 (0.2%) C: 15 (0.2%) Percentage point difference (95% CI) = 0.0 (-0.1 to 0.1) P = 0.43	Interaction of patient and physician intervention status possibly affecting outcomes (results indicated that it is not statistically significant)
		Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional		Positive FOBT (among those patients who performed FOBT): I: 47 (1.7%) C: 12 (0.5%) Percentage point difference (95% CI) = 1.2 (0.6 to 1.7) P < 0.001 - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR	No important baseline

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>clinician data entry: Y</p> <ul style="list-style-type: none"> - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y (active) <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N <p><i>e) Other:</i> Passive and active alerts are available</p>		<p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: Receipt of colorectal cancer screening by intervention status (all patients: N = 21,860)— <p>Physician reminder group:</p> <p>I: 41.9%</p> <p>C: 40.2%</p> <p>Percentage point difference (95% CI) = 1.6 (-2.7 to 5.9)</p> <p>P = 0.47</p> <p>0 primary care visits, N = 7643:</p> <p>I: 19.1%</p> <p>C: 16.0%</p> <p>Percentage point difference (95% CI) = 3.0 (-1.1 to 7.2)</p> <p>P = 0.15</p> <p>1 to 2 primary care visits, N = 9011:</p> <p>I: 53.2%</p> <p>C: 51.5%</p> <p>Percentage point difference (95% CI) = 1.6 (-3.8 to 7.1)</p> <p>P = 0.56</p> <p>More than 3 primary care visits, N = 5206:</p> <p>I: 59.5%</p> <p>C: 52.7%</p> <p>Percentage point difference (95% CI) = 6.0 (-0.5 to 12.5)</p> <p>P = 0.07</p> <p>Patient mailing intervention group:</p> <p>I: 44%</p> <p>C: 38.1%</p> <p>Percentage point difference: 5.8 (4.5, 7.1)</p>	<p>differences</p> <p>Applicability/generalizability:</p> <p>Integrated medical groups using advanced electronic health record</p> <p>Use of EHR in ambulatory settings since 1997</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>P < 0.001</p> <p>0 primary care visits, N = 7643:</p> <p>I: 19.6%</p> <p>C: 15.6%</p> <p>Percentage point difference (95% CI) = 3.9(2.2 to 5.6)</p> <p>P < 0.001</p> <p>1 to 2 primary care visits, N = 9011:</p> <p>I: 55.6%</p> <p>C: 49.0%</p> <p>Percentage point difference (95% CI) = 6.6 (4.7 to 8.4)</p> <p>P <0.001</p> <p>More than 3 primary care visits, N = 5206:</p> <p>I: 59.5%</p> <p>C: 52.3%</p> <p>Percentage point difference (95% CI) = 7.1 (4.4 to 9.8)</p> <p>P < 0.001</p> <p>Types of colorectal cancer screening tests</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				NR	
				6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: Perceived proportion of electronic reminders that accurately reflected patients' screening status—50% (IQR 30% to 80%) Perceived effectiveness of electronic reminders in increasing the colorectal screening rate among patients (poststudy survey of 43 eligible physicians, n = 33 intervention group)— Electronic reminders were very effective: 9% Somewhat effective: 47% - HCP use: NR - Implementation of CDSS/KMS: NR	
Shojania, Yokoe, Platt, et al., 1998 #6206	Geographical location: Boston, MA Study dates: 6/20/96–3/30/97 General setting: Academic Specific setting: - Inpatient–ICU - Inpatient–non-ICU - Acute	Authors' basic description of system: Computer screen displaying, at the time of physician order entry, an adaptation of the Centers for Disease Control and Prevention guidelines for appropriate vancomycin use. Source/origin of system: Locally developed Content: a) <i>Objective(s):</i>	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Total orders per prescriber ($P = 0.04$)— #, \pm SD, mean (25-75% quartiles): Control (n = 1911): 16.7, \pm 29.2, 5.0 (1.0-15)	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Study set at Women and Brigham's

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 7 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 1798 - Individual HCPs: 396 MDs - Events: 5536</p> <p>User level of expertise/ proficiency: All users familiar with CPOE</p>	<p>Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed</p>		<p>Intervention (n = 1345): 11.3, \pm 19.9, 3.0 (1.0-11) - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	No patient-centered outcomes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		by noting agreement: Can't tell			
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Simon, Smith, Feldstein, et al., 2006 #14023	<p>Geographical location: Oregon and Washington</p> <p>Study dates: November 2000–June 2004</p>	<p>Authors' basic description of system: The computerized age-specific alerts occurred at the time of prescribing a targeted, potentially inappropriate medication and suggested an alternative medication.</p>	<p>Comparator(s): Another CDSS/KMS</p> <p>1) Control is drug-specific computerized alert system</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: Designed as cluster RCT, but data not analyzed as such</p> <p>Unit of randomization: Practice</p> <p>Duration of intervention: 18 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 30,924 - Clinics/practices/hospitals: 15 - Individual HCPs: 126 MDs</p> <p>User level of expertise/proficiency: Familiar with CPOE</p>	<p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following</p>	<p>2) Intervention is age/drug-specific computerized alert system</p>	<p>ordered/prescribed: Alerts per prescriber (average)— Control: 18 (14 [82%] false positive) Intervention: 4 (0 false positive) The transition in January 2003 from drug-specific alerts to patient-specific alerts for the same target medications resulted in a continuation of the established downward trend without apparent change in the level ($P = 0.75$) or slope ($P = 0.22$) of the time series - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Comments: Data not analyzed and reported according to a priori analytic plan</p> <p>Applicability/generalizability: Locally developed system</p> <p>Control arm was a previously implemented CDSS</p> <p>No patient-centered results</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>CDSS recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y 			
Smith, Feldstein, Perrin, et al., 2009	<p>Geographical location: NR</p> <p>Study dates: NR</p>	<p>Authors' basic description of system:</p> <p>In the EMR intervention, a patient-specific electronic</p>	<p>Comparator(s):</p> <p>Another CDSS/KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: NR</p>	<p>General comments:</p> <p>None</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#440	<p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 25 days</p> <p>Sample type(s) (with N randomized for each): Patients: 961</p> <p>User level of expertise/proficiency: Users were familiar with EMS system used to deliver alerts</p>	<p>message was sent to the primary care clinician from the chair of the HMO's patient-safety committee stating that computer records indicated the patient had received a new medication, that laboratory monitoring was recommended, and that the patient had not received the test(s) between 6 months before and 5 days after the dispensing.</p> <p>Source/origin of system: Locally developed</p> <p>Content: a) <i>Objective(s):</i> Lab test ordering b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: a) <i>Delivery format:</i> Integrated with CPOE/EHR b) <i>Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: a) <i>General system features:</i></p>	<p>4 groups:</p> <p>1) EMR reminder to PCP</p> <p>2) Automated voice message to patients</p> <p>3) Pharmacy team outreach</p> <p>4) Usual care</p>	<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: Cost and cases with all recommended baseline laboratory tests completed by arm per 100 patients (total cases completed, total cost)— Usual Care: 22, \$2092 EMR Intervention: 48, \$3748 - Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: No patient-centered outcomes</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell			
Smith, Shah, Bryant, et al., 2008 #1172	Geographical location: Rochester, MN Study dates: July 1, 2001–December 31, 2003 General setting: Community Specific setting: - Outpatient - Chronic Study design: RCT, cluster randomization Unit of randomization: Clinician Duration of intervention: 30 months Sample type(s) (with N randomized for each):	Authors' basic description of system: Telemedicine intervention of specialty advice and evidence-based messages regarding medication management for cardiovascular risk. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Pharmacotherapy - Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> - Online access - Email <i>b) Delivery mode:</i>	Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Process of diabetes care, ADA-NCQA provider score, median (range); $P = 0.41$ — Control ($n = 277$): 58 (5 to 80) Intervention ($n = 358$): 56 (0 to 80) - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: The average time for completing a specialty review was 4.4 minutes; only 68 (5%) of reviews took longer than 10 minutes to complete 4) Impact on relationship-centered outcomes: NR	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Setting was Mayo Clinic Was locally developed

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<ul style="list-style-type: none"> - Patients: 639 - Clinics/practices/hospitals: 6 - Individual HCPs: <ul style="list-style-type: none"> > MDs: 97 internists and family medicine <p>User level of expertise/proficiency: New system for users</p>	<p>System-initiated (“push”) (email messages)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y </p> <p><i>c) Communication content features:</i> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can’t tell - Justification of decision </p>		<p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Estimate of total costs for 1 year (\$), mean (bootstrap 95% CI); $P = 0.02$ Control ($n = 277$): 8564 (6628 to 10,763) Intervention ($n = 358$): 6252 (5105 to 7640) - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: In 438 (59%) instances, endocrinologists considered the reminder message and the advice useful, and in 364 (49%) instances, they reported using the message to manage the patient. - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		support via provision of research evidence: Y d) <i>Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Can't tell			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Stiell, Clement, Grimshaw, et al., 2009 #135	<p>Geographical location: Canada (12 hospitals in several provinces)</p> <p>Study dates: NR</p> <p>General setting: - Academic - Community</p> <p>Specific setting: Emergency department</p> <p>Study design: RCT, matched pair cluster randomization</p> <p>Unit of randomization: Hospitals</p> <p>Duration of intervention: 2 years</p> <p>Sample type(s) (with N randomized for each): - Patients: 11,824 - Clinics/practices/hospitals: 12</p> <p>User level of expertise/proficiency: Users familiar with CPOE system used for</p>	<p>Authors' basic description of system: A mandatory real-time reminder of the Canadian C-Spine Rule at the point of requisition for imaging was implemented. Any cervical spine imaging that was ordered required the doctor to check the rule criteria or to indicate the reason for overriding the rule before the diagnostic imaging department processed the request.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Diagnostic imaging rates of 11,824 participants with injury of the cervical spine during 12 months before and after periods (# of patients [mean % (SD)] imaged)— Before period: Control: 2413 (52.8 [8.6]) Intervention: 3267 (61.7 [15.0]) After period: Control: 2516 (58.9 [7.0]) Intervention: 3628 (53.3 [13.5]) - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Study conducted in Canada</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	intervention	<p>implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell			
Strom, Schinnar, Aberra, et al., 2010 #14937	Geographical location: 2 sites in Pennsylvania Study dates: 8/9/2006–2/13/2007 General setting: Academic Specific setting: Inpatient Study design: RCT, parallel group Unit of randomization: Clinician Duration of intervention: 6 months Sample type(s) (with N randomized for each):	Authors' basic description of system: An automatic hard-stop pop-up alert implemented into the CPOE to prevent concomitant orders of trimethoprim-sulfamethoxazole and warfarin. Source/origin of system: Locally developed (customized) Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Alert adherence of not reordering the alert- triggering drug within 10 minutes of firing (correct ordering decisions): Control: 13.5% (20 of 148) alerts Intervention: 57.2% (111 of 194) alerts Adjusted odds ratio: 0.12 (95% CI 0.045-0.33) Mean number of alerts per provider: Intervention = 3.53 Control = 3.29 - Impact on user knowledge: NR 3) Impact on workload, efficiency,	General comments: None Quality assessment: Overall rating: Fair Comments: Valid outcome measures; limited details of baseline characteristics providers Applicability/generalizability: Large sample size of clinicians, but alert was triggered by only 100 providers and involved only 96 patients

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Patients: 96 Individual HCPs: 1971 Training MDs: 1872 NPs: 99</p> <p>User level of expertise/proficiency: NR</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision 		<p>and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: NR - HCP use: Intervention group was less likely than the control group to reorder the alert-triggering drug after adjusting for provider type (resident physician or nurse practitioner) as a confounder and accounting for clustering by provider Adjusted odds ratio: 0.12 (95% CI 0.045 to 0.33) Unadjusted odds ratio: 0.12 (95% CI 0.07 to 0.20) - Implementation of CDSS/KMS: NR 	Academic setting and thus intervention was primarily used by residents

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		support via provision of research evidence: N d) <i>Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Strom, Schinnar, Bilker, et al., 2010 #14938	Geographical location: 2 sites in Pennsylvania Study dates: 8/2/2006–12/15/2007 General setting: Academic Specific setting: Inpatient Study design: RCT, parallel group Unit of randomization: Clinician Duration of intervention: 15 months	Authors' basic description of system: A pop-up alert implemented into the CPOE to prevent concomitant orders of warfarin and NSAIDs. Source/origin of system: Commercially available Content: a) <i>Objective(s):</i> Pharmacotherapy b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: a) <i>Delivery format:</i>	Comparator(s): Another CDSS/KMS (commercially available passive alert in CPOE that warned provider not to prescribe the combination of drugs with no response requirement)	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: - Recommended clinical study ordered/completed: - Recommended treatment ordered/prescribed: Alert adherence of not reordering the alert- triggering drug within 10 minutes of firing— Control: 28% (154 of 560) alerts Intervention group 25% (114 of 464) alerts Adjusted OR of inappropriate ordering: 1.22 (95% CI 0.69 to 2.16) P = 0.48 Mean number of alerts per provider: Intervention = 3.5	General comments: Customized alert Quality assessment: Overall rating: Fair Comments: Valid outcome measures; limited details of baseline characteristics or providers Applicability/generalizability: Large study implemented for 15 months in two academic

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each): Patients: 528 Individual HCPs: 1963 > Training MDs: 1865 > NPs: 98</p> <p>User level of expertise/proficiency: NR</p>	<p>Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of</p>		<p>Control = 4.5</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	settings

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>reasoning: Y</p> <ul style="list-style-type: none"> - Justification of decision support via provision of research evidence: N <p>d) <i>Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
<p>Subramanian, Fihn, Weinberger, et al., 2004</p> <p>#4111</p>	<p>Geographical location: Indianapolis, IN Seattle, WA</p> <p>Study dates: NR</p> <p>General setting: VA</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p>	<p>Authors' basic description of system: Physicians were randomly assigned to receive either (1) care suggestions generated with electronic medical record data and symptom data obtained from questionnaires mailed to patients within 2 weeks of scheduled outpatient visits (intervention group) or (2) suggestions generated with electronic medical record data alone (control group).</p> <p>Source/origin of system: Locally developed</p> <p>Content: a) <i>Objective(s):</i> Chronic disease management</p>	<p>Comparator(s): Another CDSS/KMS; this study compares EMR-based suggestions (control) with EMR and symptom-based suggestions (intervention)</p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: Hospitalization at 6 and 12 months (mean \pm SD)— At 6 months (P = 0.0002): Control (n = 365): 0.7 \pm 0.4 Intervention (n = 355): 1.5 \pm 1.1 At 12 months (P = 0.05): Control (n = 365): 1.7 \pm 0.7 Intervention (n = 355): 2.3 \pm 1.2 - Mortality: NR - Validated measure of HRQOL or functional status: SF-36: Physical component scale (mean \pm SD)— Change from enrollment to 6 months (P = 0.2): Control (n = 319): 1.8 \pm 1.8 Intervention (n = 311): 0.8 \pm 1.9 	<p>General comments: In this study, the clinic is already using a CDSS for chronic heart failure care decision support (baseline), and the investigators are examining the impact of adding symptom information from a manual survey</p> <p>Quality assessment: Overall rating: Fair</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 1 year</p> <p>Sample type(s) (with N randomized for each): - Patients: 720 - Clinicians: 91 (44 control, 47 intervention)</p> <p>User level of expertise/proficiency: Users already familiar with receiving notifications. Intervention is simply modification to notifications in patient charts.</p>	<p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p>		<p>Change from enrollment to 12 months (P = 0.03): Control (n = 280): 1.3 ± 2.0 Intervention (n = 269): -0.6 ± 2.0</p> <p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Provider adherence to heart failure care suggestions, # of suggestions (# [%] adhered to)— At 6 months (P = 0.4): Control: 479 (90 [20%]) Intervention: 528 (110 [23%]) At 12 months (P = 0.4): Control: 665 (185 [30%]) Intervention: 738 (221 [33%])</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and</p>	<p>Comments: Randomization by coin flip; insufficient methods reporting</p> <p>Applicability/generalizability: General setting: VA hospital</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 		implementation: NR	
<p>Sundaram, Lazzeroni, Douglass, et al., 2009</p> <p>#258</p>	<p>Geographical location: Palo Alto, CA</p> <p>Study dates: January 2001–September 2001</p> <p>General setting: VA</p>	<p>Authors' basic description of system: The study intervention was computer-based reminders to assess HIV risk behaviors or to offer HIV testing; feedback on adherence to reminders was provided.</p> <p>Source/origin of system:</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Change in HIV screening rates (P = 0.75)—Control: 0.52% 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 9 months</p> <p>Sample type(s) (with N randomized for each): Individual HCPs: 32 MDs</p> <p>User level of expertise/proficiency: All users familiar with EMR used for CDSS</p>	<p>Locally developed</p> <p>Content: a) <i>Objective(s):</i> Lab test ordering</p> <p>b) <i>Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Justification for not complying</p> <p>Information delivery: a) <i>Delivery format:</i> Integrated with CPOE/EHR</p> <p>b) <i>Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: a) <i>General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p>b) <i>Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations:</p>		<p>Intervention: 0.29%</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Reasons for not following recommendations on reminders— Lack of time: Preintervention: 21 (66) Postintervention: 18 (64) Disagree with recommendation in general: Preintervention: 6 (19) Postintervention: 3 (11) Disagree with recommendation for that patient visit: Preintervention: 22 (69) Postintervention: 20 (17) Recommendation not received concurrently with visit: Preintervention: 8 (25) Postintervention: 9 (32)</p> <p>- HCP satisfaction: Clinical practice reminders are useful (Preintervention: n = 32 clinicians; postintervention =</p>	<p>generalizability: Set at VA hospital associated with Stanford Hospital</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Can't tell</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 		<p>28)</p> <p>Agree:</p> <ul style="list-style-type: none"> Preintervention: 21 (66) Postintervention: 17 (61) <p>Disagree:</p> <ul style="list-style-type: none"> Preintervention: 5 (16) Postintervention: 5 (18) <p>- HCP use: NR</p> <p>- Implementation of CDSS/KMS: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Tamblyn, Huang, Perreault, et al., 2003</p> <p>#4434</p>	<p>Geographical location: Quebec, Canada</p> <p>Study dates: January 1997–February 1998</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 13 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 12,560 - Individual HCPs: > MDs: 107 primary care</p> <p>User level of expertise/proficiency: New system for all</p>	<p>Authors' basic description of system: Physicians in the CDS group had access to information on current and past prescriptions through a dedicated computer link to the provincial seniors' drug insurance program. When any of 159 relevant prescribing problems were identified by the CDS software, the physician received an alert that identified the nature of the problem, possible consequences, and alternative therapy.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated ("push")</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Percentage of patients with at least one potentially inappropriate prescription— At baseline: Control: 33.3% Intervention: 31.8%</p> <p>During the study the number of new potentially inappropriate prescriptions per 1000 visits was significantly lower (18%) in the CDS group than in the control group (relative rate 0.82, 95% confidence interval 0.69 to 0.98)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Set in Canada</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	users	<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p>			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			
<p>Tamblyn, Huang, Taylor, et al., 2008</p> <p>#1158</p> <p>Comparison 1 of 2</p>	<p>Geographical location: Montreal, Quebec, Canada</p> <p>Study dates: February 1, 2004–September 30, 2004</p> <p>General setting: NR</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of</p>	<p>Authors' basic description of system: A single-blind, cluster randomized controlled trial was conducted to assess the benefits of customizable computer-triggered versus on-demand drug decision support in reducing the prevalence of prescribing problems.</p> <p><u>Computer-triggered alerts</u></p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i> Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Synchronous</p>	<p>Comparator(s): Another CDSS/KMS:</p> <p>1) Intervention is computer-triggered alerts</p> <p>2) Comparator is on-demand drug decision support</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prevalence of any prescribing problem at end of the intervention period— Computer-triggered (N = 13 MDs, 1069 patients): N = 389 (38.8%) On-demand (N = 12 MDs, 416 patients): N = 116 (30.1%) Odds ratio = 1.31 95% CI = 0.89 to 1.92 P-value = 0.17 - Impact on user knowledge: NR 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: No true control; study compared two new interventions with no usual care control arm</p> <p>Applicability/generalizability: Set in Canada</p> <p>Academic setting</p> <p>Control arm did</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 3449 - Individual HCPs: > MDs: 28 general practitioners or family physicians</p> <p>User level of expertise/proficiency: NR</p>	<p>Decision support: <i>Response requirement:</i> Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a</p>		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Total number of prescribing problems— Computer-triggered (N = 14 MDs, 1899 patients): 6505 On-demand (N = 14 MDs, 1550 patients): 4445</p> <p>Prescribing problem alerts revised by study MD— Computer-triggered: 81 (12.1%) On-demand: 31 (75.6%)</p> <p>Prescribing problem alerts ignored by study MD— Computer-triggered: 585 (87.8%) On-demand: 10 (24.4%)</p> <p>Reasons for ignoring prescribing alerts, # (% ignored)— Total number of alerts seen and ignored: Computer-triggered: 585 On-demand: 10</p> <p>Benefit greater than risk: Computer-triggered: 159 (27.1%) On-demand: 1 (10.0%)</p> <p>Drug/disease information incorrect: Computer-triggered: 97 (16.5%)</p>	not represent usual practice

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>recommendation, not just an assessment: Can't tell</p> <ul style="list-style-type: none"> - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>On-demand: 0 (0%)</p> <p>Interaction already known:</p> <p>Computer-triggered: 113 (19.2%)</p> <p>On-demand: 9 (90.0%)</p> <p>Need to consult with prescribing physician:</p> <p>Computer-triggered: 36 (6.1%)</p> <p>On-demand: 0 (0%)</p> <p>No time at this visit:</p> <p>Computer-triggered: 5 (0.9%)</p> <p>On-demand: 0 (0%)</p> <p>Not clinically important:</p> <p>Computer-triggered: 173 (29.5%)</p> <p>On-demand: 0 (0%)</p> <p>Patient resistant to change:</p> <p>Computer-triggered: 4 (0.7%)</p> <p>On-demand: 0 (0%)</p> <p>- HCP satisfaction: NR</p> <p>- HCP use: Total number of prescribing problems—</p> <p>Computer-triggered (N = 14 MDs, 1899 patients): 6505</p> <p>On-demand (N = 14 MDs, 1550 patients): 4445</p> <p>Prescribing problem alerts seen by study MD—</p> <p>Computer-triggered: 668 (10.3%)</p> <p>On-demand: 41 (0.9%)</p> <p>Prescribing problem alerts revised by study MD—</p> <p>Computer-triggered: 81 (12.1%)</p> <p>On-demand: 31 (75.6%)</p> <p>Prescribing problem alerts ignored by study MD—</p> <p>Computer-triggered: 585 (87.8%)</p> <p>On-demand: 10 (24.4%)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				- Implementation of CDSS/KMS: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>Tamblyn, Huang, Taylor, et al., 2008</p> <p>#1158</p> <p>Comparison 2 of 2</p>	<p>Geographical location: Montreal, Quebec, Canada</p> <p>Study dates: February 1, 2004–September 30, 2004</p> <p>General setting: NR</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 3449 - Individual HCPs: > MDs: 28 general practitioners or family physicians</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: A single-blind, cluster randomized controlled trial was conducted to assess the benefits of customizable computer-triggered versus on-demand drug decision support in reducing the prevalence of prescribing problems.</p> <p>On-demand decision support</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Asynchronous</p> <p>Decision support: <i>Response requirement:</i> Justification for not complying</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/HER <i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p>	<p>Comparator(s): Another CDSS/KMS:</p> <p>1) Intervention is computer-triggered alerts</p> <p>2) Comparator is on-demand drug decision support</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prevalence of any prescribing problem at end of the intervention period— Computer-triggered (N = 13 MDs, 1069 patients): N = 389 (38.8%) On-demand (N = 12 MDs, 416 patients): N = 116 (30.1%) Odds ratio = 1.31 95% CI = 0.89 to 1.92 P-value = 0.17</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Total number of prescribing problems— Computer-triggered (N = 14 MDs,</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: No true control; study compared two new interventions with no usual care control arm</p> <p>Applicability/generalizability: Set in Canada</p> <p>Academic setting</p> <p>Control arm did not represent usual practice</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: Can't tell</p>		<p>1899 patients): 6505 On-demand (N = 14 MDs, 1550 patients): 4445 Prescribing problem alerts revised by study MD— Computer-triggered: 81 (12.1%) On-demand: 31 (75.6%) Prescribing problem alerts ignored by study MD— Computer-triggered: 585 (87.8%) On-demand: 10 (24.4%)</p> <p>Reasons for ignoring prescribing alerts, # (% ignored)— Total number of alerts seen and ignored: Computer-triggered: 585 On-demand: 10 Benefit greater than risk: Computer-triggered: 159 (27.1%) On-demand: 1 (10.0%) Drug/disease information incorrect: Computer-triggered: 97 (16.5%) On-demand: 0 (0%) Interaction already known: Computer-triggered: 113 (19.2%) On-demand: 9 (90.0%) Need to consult with prescribing physician: Computer-triggered: 36 (6.1%) On-demand: 0 (0%) No time at this visit: Computer-triggered: 5 (0.9%) On-demand: 0 (0%) Not clinically important: Computer-triggered: 173 (29.5%) On-demand: 0 (0%) Patient resistant to change: Computer-triggered: 4 (0.7%)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<ul style="list-style-type: none"> On-demand: 0 (0%) - HCP satisfaction: NR - HCP use: Total number of prescribing problems— <ul style="list-style-type: none"> Computer-triggered (N = 14 MDs, 1899 patients): 6505 On-demand (N = 14 MDs, 1550 patients): 4445 Prescribing problem alerts seen by study MD— <ul style="list-style-type: none"> Computer-triggered: 668 (10.3%) On-demand: 41 (0.9%) - Implementation of CDSS/KMS: NR 	
Tamblyn, Reidel, Huang, et al., 2009 #240	Geographical location: Montreal, Quebec, Canada Study dates: NR General setting: NR Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention:	Authors' basic description of system: A single-blind randomized controlled trial was conducted to assess the benefits of providing an adherence-tracking and alert system for patients receiving medications for cardiovascular diseases. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous Decision support:	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Drug profile reviewed— <ul style="list-style-type: none"> Control (N = 1127): 400 (35.5%) Odds ratio = 1 Intervention (N = 1166): 519 (44.5%) Odds ratio = 1.46 95% CI = 1.21 to 1.76, P < 0.0001 - Impact on user knowledge: NR 3) Impact on workload, efficiency,	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Set in Canada Academic setting New system, but built off previously used drug management and ordering system

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	6 months Sample type(s) (with N randomized for each): Patients: 2293 User level of expertise/proficiency: NR	<i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”) Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell <i>c) Communication content features:</i>		and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Adherence status to drug profile review— Control N (%): Adherent: 204 of 625 (32.6%) Nonadherent (< 80%): 196 of 502 (39.0%) Intervention N (%) Adherent: 269 of 649 (41.5%) Nonadherent (< 80%): 250 of 517 (48.4%) Odds ratio = 1.37 95% CI = 1.16 to 1.62, P < 0.0002 Change in therapy during the 6-month followup period for discontinuation of therapy for adverse effects— Control (N = 1127): N = 23 (2.0%) Odds ratio = 1 Intervention (N = 1166): N = 27 (2.3%) Odds ratio = 1.18 95% CI = 0.63 to 2.19, P = 0.61 Adherence status to change in therapy during the 6-month followup period for discontinuation of therapy for adverse effects—	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 		<p>Control N (%):</p> <p>Adherent: 10 of 625 1.6%</p> <p>Nonadherent (< 80%) 13 of 502 2.6%</p> <p>Intervention N (%):</p> <p>Adherent: 18 of 649 2.8%</p> <p>Nonadherent (< 80%) 9 of 517 1.7%</p> <p>Odds ratio = 1.01</p> <p>95% CI = 0.52 to 1.94, P = 0.98</p> <p>Change in therapy during the 6-months followup period for increase in therapy—</p> <p>Control (N = 1127):</p> <p>N = 328 (29.1%)</p> <p>Odds ratio = 1</p> <p>Intervention (N = 1166):</p> <p>N = 332 (28.5%)</p> <p>Odds ratio = 0.98</p> <p>95% CI = 0.80 to 1.21, P = 0.86</p> <p>Adherence status to change in therapy during the 6-months followup period adherence status for increase in therapy—</p> <p>Control N (%):</p> <p>Adherent: 169 of 625 (27.0%)</p> <p>Nonadherent (< 80%): 159 of 502 (31.7%)</p> <p>Intervention N (%):</p> <p>Adherent: 177 of 649 (27.3%)</p> <p>Nonadherent (< 80%): 155 of 517 (30.0%)</p> <p>Odds ratio = 1.14</p> <p>95% CI = 0.94 to 1.38, P = 1.93</p> <p>Adherence to cardiovascular medications in the 6 months before and after the intervention for lipid-lowering and antihypertensive</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/Quality/Applicability
				<p>therapy—</p> <p>Control (N = 1127):</p> <p>Before mean = 79.2</p> <p>After mean = 72.9</p> <p>Difference (SD) = -6.4 (24.1)</p> <p>Intervention (N = 1166):</p> <p>Before mean = 79.7</p> <p>After mean = 73.5</p> <p>Difference (SD) = -6.2 (24.1)</p> <p>Adjusted difference = 0.11</p> <p>95% CI = -1.8 to 2.1, P = 0.90</p> <p>Adherence status to cardiovascular medications in the 6 months before and after the intervention for lipid-lowering and antihypertensive therapy—</p> <p>Control:</p> <p>Adherent before mean: 95.5; after mean: 80.3; diff (SD): -15.1 (18.6)</p> <p>Nonadherent before mean: 59.1; after mean: 63.6; diff (SD): 4.5 (25.8)</p> <p>Intervention:</p> <p>Adherent before mean: 95.3; after mean: 80.2; diff (SD): -15.1 (17.9)</p> <p>Nonadherent before mean: 60.2; after mean: 65.1; diff(SD) 4.9 (26.3)</p> <p>- HCP satisfaction: NR</p> <p>- HCP use: NR</p> <p>- Implementation of CDSS/KMS: NR</p>	
Taylor, Thompson, Lessler, et al., 1999 #6112	<p>Geographical location:</p> <p>Seattle, WA</p> <p>Study dates:</p> <p>September 1995–</p>	<p>Authors' basic description of system:</p> <p>The intervention program included a computer-generated provider mammography prompt that routinely appeared</p>	<p>Comparator(s):</p> <p>Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: Mammography</p>	<p>General comments:</p> <p>CDSS was only one part of a multi-intervention strategy including</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>November 1996</p> <p>General setting:</p> <ul style="list-style-type: none"> - Academic - Community <p>Specific setting:</p> <p>Outpatient</p> <p>Study design:</p> <p>RCT, firm system</p> <p>Unit of randomization:</p> <ul style="list-style-type: none"> - Clinician - Patient <p>Duration of intervention:</p> <p>15 months</p> <p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Patients: 314 - Individual HCPs: <ul style="list-style-type: none"> > Training MDs: 17 > Attending physicians: 15 <p>User level of expertise/proficiency:</p> <p>Academic detailing session for intervention firms</p>	<p>on intervention firm patient profile reports (for those women never screened at the hospital or out of compliance with institutional guidelines for interval screening).</p> <p>Source/origin of system:</p> <p>Not clearly described</p> <p>Content:</p> <p><i>a) Objective(s):</i></p> <ul style="list-style-type: none"> - Lab test ordering - Initiating discussion with patient - Preventive care <p><i>b) Relationship to point of care:</i></p> <p>Synchronous</p> <p>Decision support:</p> <p><i>Response requirement:</i></p> <p>NR (unclear whether response requirement)</p> <p>Information delivery:</p> <p><i>a) Delivery format:</i></p> <p>Paper-based</p> <p><i>b) Delivery mode:</i></p> <p>System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i></p> <p>Integration with charting or order entry system to support</p>		<p>completion within 8 weeks of index clinic visit—</p> <p>Intervention (n = 232): 49%</p> <p>Control (n = 82): 22%</p> <p>P < 0.001</p> <ul style="list-style-type: none"> - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>physician education, provider prompts, patient education, patient transportation assistance</p> <p>Quality assessment:</p> <p>Overall rating: Good</p> <p>Applicability/generalizability:</p> <p>Approximately one-third age-eligible women were not entered in the study</p> <p>Urban setting</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y			
Terrell, Perkins, Dexter, et al., 2009 #260	Geographical location: Indianapolis, IN Study dates: January 12, 2005–July 7, 2007 General setting: Academic Specific setting: Emergency department (ED) Study design: RCT, parallel group Unit of randomization: Clinician Duration of intervention: 2.5 years Sample type(s) (with N randomized for each): - Individual HCPs: > MDs: 63 emergency	Authors' basic description of system: Decision support to decrease the prescription of potentially inappropriate medications to older adults discharged from the ED and to identify the various reasons why providers reject decision support. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Pharmacotherapy - Preventive care <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: NR - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: NR - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Prescriptions that were inappropriate, n (%)— Control: 103 (5.4) Intervention: 69 (3.4) P-value = 0.006 Odds ratio (95% CI): 0.59 (0.41 to 0.85) Visits with an inappropriate medication prescription, n (%)— Control: 99 (3.9) Intervention: 69 (2.6) P-value = 0.2 Odds ratio (95% CI): 0.55 (0.34 to 0.89)	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Academic setting Well-established health IT infrastructure Not patient-centered outcomes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>department MDs - Patients visits: 7458, of which 5,162 (69%) led to an ED discharge</p> <p>User level of expertise/proficiency: Intervention was integrated into an electronic prescribing system the users were already familiar with</p>	<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N</p>		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Intervention physicians accepted 49 of 114 (43%) decision support recommendations pertaining to potentially inappropriately prescribed medications - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Terrell, Perkins, Hui, et al., 2010 #14951	Geographical location: Indianapolis, IN Study dates: 7/22/2005–7/7/2007 General setting: Academic Specific setting: - Emergency department - Acute Study design: RCT, parallel group Unit of randomization: Clinician Duration of intervention: 2 years	Authors' basic description of system: Decision support for emergency physicians in an established computerized physician order entry system to reduce excessive medication dosing for patients with clinically important renal impairment. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response	Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Percentage of targeted medications that were excessively dosed— Control: 74% (34/46) Intervention: 43% (31/73) P = 0.001 Effect size: 31%; 95% CI 14% to 49% Percentage of excessive dosing by faculty physicians— Control: 69% Intervention: 41% Effect size: 28%; 95% CI 5% to 51% Percentage of excessive dosing by resident physicians—	General comments: None Quality assessment: Overall rating: Fair Comments: No important baseline differences Valid outcome measures Applicability/generalizability: Well-established health IT infrastructure and history of being an early adopter of health IT

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Patients: 2783 - Individual HCPs: 42 <ul style="list-style-type: none"> > Training MDs > MDs [emergency medicine] <p>User level of expertise/ proficiency: NR</p>	<p>Information delivery:</p> <p><i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y 		<p>Control: 86% Intervention: 47% Effect size: 39%; 95% CI 2% to 75%</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Long study duration</p> <p>Majority of study patients were women or African American</p> <p>Single site study prevents having a more generalizable result</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Thomas, Lewis, Watson, et al., 2004 #3745	Geographical location: 5 general practices in Bristol and Cardiff, UK Study dates: NR General setting: Community Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient	Authors' basic description of system: The experimental intervention required participants to complete a computerized psychosocial assessment that generated a report for the GP including patient-specific treatment recommendations. The control patients were treated as usual with access to locally agreed guidelines. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> More effective mental health	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: NR - Mortality: NR <ul style="list-style-type: none"> - Validated measure of HRQOL or functional status: Mean quality-of-life (QOL) scores at baseline and at followup adjusted for baseline scores with analysis of covariance— <p>Control:</p> <ul style="list-style-type: none"> Baseline QOL score (n = 387): Mean (95% CI): 4.7 (4.4 to 4.9) 6-week QOL score (n = 319): Mean (95% CI): 5.8 (5.4 to 6.1) 6-month QOL score (n = 299): Mean (95% CI): 6.2 (5.8 to 6.6) <p>Intervention:</p> <ul style="list-style-type: none"> Baseline QOL score (n = 358): 	General comments: None Quality assessment: Overall rating: Fair Comments: Significant loss to followup (26% at 6 months) Applicability/generalizability: No information about familiarity with system or

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): Patients: 762</p> <p>User level of expertise/proficiency: New guidelines provided for both control and intervention (with additional guidance for intervention). Both control and intervention were nonexperts for new guidelines and intervention system.</p>	<p>treatment, assessed by lower score on standardized scoring system</p> <p><i>b) Relationship to point of care:</i> Asynchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y (printout integration with paper chart)</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N</p>		<p>Mean (95% CI): 4.8 (4.5 to 5.1) 6-week QOL score (n = 283): Mean (95% CI): 5.9 (5.5 to 6.2) P = 0.73</p> <p>6-month QOL score (n = 243): Mean (95% CI): 6.4 (6.0 to 6.9) P = 0.52</p> <p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>guidelines</p> <p>Intervention was locally developed</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Tierney, Hui, and McDonald, 1986	Geographical location: Indianapolis, IN	Authors' basic description of system: Reminder system to compare the effect of monthly feedback reports of compliance with	Comparator(s): Another CDSS/KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care	General comments: None Quality
#7374	Study dates:		The effects of		

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Comparison 1 of 2	April 1983–January 1984	immediate specific reminders given to physicians at the time of patient visits on 13 preventive care protocols.	specific reminders given to them at the time of patient visits	ordered/completed: Percent compliance with preventive care protocols in eligible patients— Group A preventive care protocols: Control: 15% Intervention: 30% Group B preventive care protocols: Control: 10% Intervention: 22% - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	assessment: Overall rating: Good
	General setting: Academic Specific setting: Outpatient Study design: RCT, 2 x 2 Unit of randomization: Clinic or team Duration of intervention: 7 months Sample type(s) (with N randomized for each): - Patients: 6045 - Individual HCPs > Training MDs: 135 - Events: 16,258 User level of expertise/proficiency: NR	Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Preventive care - Immunization - Lab test ordering <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)			Applicability/generalizability: Included training MDs Well-established health IT infrastructure Not patient-centered outcomes
		Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell <i>b) Clinician-system interaction</i>		3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		conventional education: N			
Tierney, Hui, and McDonald, 1986 #7374 Comparison 2 of 2	Geographical location: Indianapolis, IN Study dates: April 1983–January 1984 General setting: Academic Specific setting: Outpatient Study design: RCT, 2 x 2 Unit of randomization: Clinic or team Duration of intervention: 7 months Sample type(s) (with N randomized for each): - Patients: 6045 - Individual HCPs > Training MDs: 135 - Events: 16,258 User level of expertise/proficiency: NR	Authors' basic description of system: Reminder system to compare the effect of monthly feedback reports of compliance with immediate specific reminders given to physicians at the time of patient visits on 13 preventive care protocols. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Preventive care - Immunization - Lab test ordering <i>b) Relationship to point of care:</i> Asynchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated ("push") Contextual factors/features influencing the implementation and use of	Comparator(s): Another CDSS/KMS The effects of supplying monthly feedback reports of compliance with preventive care protocols	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: Percent compliance with preventive care protocols in eligible patients— Group A preventive care protocols: Control: 15% Intervention: 22% Group B preventive care protocols: Control: 10% Intervention: 14% - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: - HCP acceptance: Users' response to the feedback reports— Mark the chart on the next visit: 80% Stop the reminder: 9.8%	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Included training MDs Well-established health IT infrastructure Not patient-centered outcomes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <i>d) Auxiliary features:</i> - Local user involvement in development process: Can't		Protocol not applicable in this patient: 8.5% Pull the chart for review now: 1.3% Reschedule the patient earlier: 0.5% Physicians more often disagreed with the suggested action for therapeutic interventions (such as calcium supplements, digitalis, or nitrates) than for clinical testing (e.g., fecal occult blood or mammography) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: N			
Tierney, McDonald, Hui, et al., 1988 #15375	Geographical location: Indianapolis, IN Study dates: March 24–September 30, 1986 General setting: Academic Specific setting: Outpatient Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: 6 months Sample type(s) (with N randomized for each):	Authors' basic description of system: A microcomputer that displays the predicted probabilities of test abnormalities to physicians when ordering outpatient tests. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> - Diagnosis - Lab test ordering <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: - Cost: Charges for study tests per patient visit— Intervention = \$11.18 ± 0.59 [SEM] Control = \$12.27 ± 0.63 P < 0.05 Charges for study tests per patient visit by residents— Intervention = \$11.44 Control = \$12.70 P < 0.05 Charges for non-study tests per patient— Intervention = \$27.05	General comments: None Quality assessment: Overall rating: Fair Comments: No information on randomization, blinding and concealment Baseline information not available Learning bias Applicability/generalizability: Single study site enrolled in an academic setting Physicians were

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<ul style="list-style-type: none"> - Patients 9496 - Individual HCPs:112 <ul style="list-style-type: none"> > Training MDs 98 > MDs [general internists] 14 <p>User level of expertise/ proficiency: NR</p>	<p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y </p> <p><i>c) Communication content features:</i> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision </p>		<p>Control = \$26.65</p> <ul style="list-style-type: none"> - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation:</p> <ul style="list-style-type: none"> - HCP acceptance: NR - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: Before the intervention, there were no differences in charges for study tests between intervention and control patients. During the intervention period, these charges dropped 10.8% for intervention patients ($P < 0.05$) while decreasing only 3.7% for control patients (not significant). After the intervention was discontinued, the ordering of study tests returned to prestudy levels, and again there was no difference between intervention and control patients. 	<p>required to use microcomputers to enter orders since November 1984</p> <p>Well-established health IT infrastructure and history of being an early adopter of health IT</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Tierney, McDonald, Martin et al., 1987 #15376	<p>Geographical location: Indianapolis, IN</p> <p>Study dates: NR</p> <p>General setting: Academic</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 16 weeks</p> <p>Sample type(s) (with N randomized for each): - Patients 5946 - Individual HCPs: 111 > Training MDs: 97 > MDs [general internists] 14 - Events: 8148 visits</p> <p>User level of expertise/proficiency: NR</p>	<p>Authors' basic description of system: A microcomputer-based order-entry system that displays past relevant diagnostic test results on the ordering of selected outpatient tests by physicians.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> Mandatory response</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Number of tests ordered per 1000 visits— All study tests: Control = 558 Intervention = 510</p> <p>Number of study tests ordered per patient— Control = 0.56 ± 0.03 [SE] Intervention = 0.51 ± 0.03 P = 0.05</p> <p>Number of non-study tests ordered per patient— Control = 1.00 ± 0.05 Intervention = 0.97 ± 0.04</p> <p>- Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: Intervention took 4.5 seconds (8%) longer than control to order study tests (P < 0.01)</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Physicians were not blinded to the intervention and no information on concealment</p> <p>Baseline information not available</p> <p>Learning bias</p> <p>Applicability/generalizability: Single study site enrolled in an academic setting with a well-established health IT infrastructure</p> <p>Short intervention duration</p> <p>Physicians were required to use microcomputers</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>b) Clinician-system interaction features:</i> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N 		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Total cost for study tests ordered per 1000 visits— Control = \$13994 Intervention = \$12171 - Patient charges for study tests ordered per scheduled visit— Control = \$13.99 ± 0.77 Intervention = \$12.17 ± 0.62 P = 0.01 - Patient charges for non-study tests ordered per scheduled visit— Control = \$28.59 ± 1.50 Intervention = \$27.54 ± 1.34 - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation: NR</p>	to enter orders since November 1984
		<i>c) Communication content features:</i> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N 			
		<i>d) Auxiliary features:</i> <ul style="list-style-type: none"> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- CDSS accompanied by conventional education: N			
Tierney, Overhage, Murray, et al., 2003 #4334 Comparison 1 of 2	Geographical location: Indianapolis, IN Study dates: January 1, 1994–May 1, 1996 General setting: Academic Specific setting: Outpatient Study design: RCT, 2 x 2 factorial Unit of randomization: - Clinic or team - Clinician Duration of intervention: 28 months Sample type(s) (with N randomized for each): - Patients: 706 - Clinics/practices/hospitals: 32 - Individual HCPs: > Training MDs: 61 > MDs: 33 general internists	Authors' basic description of system: Evidence-based cardiac care suggestions, approved by a panel of local cardiologists and general internists, were displayed to physicians and pharmacists as they cared for enrolled patients. Multifaceted intervention including a physician intervention, pharmacist intervention, both interventions, and control. Source/origin of system: Locally developed Content: a) <i>Objective(s):</i> Chronic disease management b) <i>Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Noncommittal acknowledgement Information delivery: a) <i>Delivery format:</i> - Integrated with CPOE/EHR - Paper-based b) <i>Delivery mode:</i> System-initiated ("push")	Comparator(s): Usual care/no CDSS or KMS 1) <u>Physician Intervention</u> 2) Pharmacist Intervention	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Number of hospitalizations, \pm SD [all]— Control (N = 181): 0.5 ± 1.1 Intervention (N = 197): 1.1 ± 1.9 Number of hospitalizations, \pm SD [heart disease-specific]— Control (N = 181): 0.2 ± 0.5 Intervention (N = 197): 0.2 ± 0.6 - Mortality: NR - Validated measure of HRQOL or functional status: HRQOL outcomes (n = 480)— No differences between groups in any of the SF-36 subscales or the 4 subscales of the CHQ Overall health status on chronic heart disease questionnaire subscales, \pm SD Control (no intervention) (n = 119): 4.6 ± 1.2 Physician Intervention (n = 142): 4.5 ± 1.2 - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Well-established health IT infrastructure Did use some patient-centered outcomes Recommendation s based on evidence-based guideline published by the Agency for Health Care Policy and Research and national professional organizations

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>> Nurse practitioner: 1 > Pharmacists: 20</p> <p>User level of expertise/proficiency: Intervention modified the electronic medical record users were already familiar with</p>	<p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Y</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell</p>		<p>- Recommended treatment ordered/prescribed: Compliance with treatment suggestions; all cardiac care suggestions— Control (N = 181) Patients with any suggestions, n (%): 163 (90) Suggestions, mean/patient \pm SD: 589 (3.6 \pm 1.7) Suggestions complied with, n (%) : 130 (22)</p> <p><u>Physician intervention</u> (N = 197) Patients with any suggestions, n (%): 174 (88) Suggestions, mean/patient \pm SD: 648 (3.7 \pm 1.9) Suggestions complied with, n (%): 152 (23)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: Direct health care charges \pm SD— Control: 7025 \pm 17,024 <u>Physician intervention</u>: 6302 \pm 10,928 - Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Tierney, Overhage, Murray, et al., 2003 #4334 Comparison 2 of 2	Geographical location: Indianapolis, IN Study dates: January 1, 1994–May 1, 1996 General setting: Academic Specific setting: Outpatient Study design: RCT, 2 x 2 factorial Unit of randomization: - Clinic or team - Clinician Duration of intervention: 28 months	Authors' basic description of system: Evidence-based cardiac care suggestions, approved by a panel of local cardiologists and general internists, were displayed to physicians and pharmacists as they cared for enrolled patients. Multifaceted intervention including a physician intervention, pharmacist intervention, both interventions, and control. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support:	Comparator(s): Usual care/no CDSS or KMS: 1) Physician Intervention <u>2) Pharmacist Intervention</u>	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Number of hospitalizations, \pm SD [all]— Control: 0.5 ± 1.1 Intervention: 0.5 ± 1.0 Number of hospitalizations, \pm SD [heart disease-specific]— Control: 0.2 ± 0.5 Intervention: 0.2 ± 0.6 - Mortality: NR - Validated measure of HRQOL or functional status: HRQOL outcomes (n = 480)— No differences between groups in any of the SF-36 subscales or the 4 subscales of the CHQ Overall health status on chronic heart disease questionnaire subscales, \pm SD Control (no intervention) (n = 119): 4.6 ± 1.2 Pharmacist Intervention (n = 106): 4.6	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Well-established health IT infrastructure Did use some patient-centered outcomes Recommendations based on evidence-based guideline published by the Agency for Health

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Sample type(s) (with N randomized for each):</p> <ul style="list-style-type: none"> - Patients: 706 - Clinics/practices/hospitals: 32 - Individual HCPs: <ul style="list-style-type: none"> > Training MDs: 61 > MDs: 33 general internists > Nurse practitioner: 1 > Pharmacists: 20 <p>User level of expertise/proficiency: Intervention modified the electronic medical record users were already familiar with</p>	<p><i>Response requirement:</i> Noncommittal acknowledgement</p> <p>Information delivery: <i>a) Delivery format:</i> - Integrated with CPOE/EHR - Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: Can’t tell</p> <p><i>c) Communication content features:</i></p>		<p>± 1.2</p> <p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Compliance with treatment suggestions; all cardiac care suggestions— Control (N = 181): Patients with any suggestions, n (%): 163 (90) Suggestions, mean/patient ± SD: 589 (3.6 ± 1.7) Suggestions complied with, n (%): 130 (22)</p> <p><u>Pharmacist intervention</u> (N = 158): Patients with any suggestions, n (%): 140 (89) Suggestions, mean/patient ± SD: 535 (3.8 ± 1.9) Suggestions complied with, n (%): 125 (23)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p>	Care Policy and Research and national professional organizations

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Y - CDSS accompanied by conventional education: Y 		<p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Direct health care charges \pm SD— Control (N = 181): 7025 \pm 17,024 <u>Pharmacist intervention</u> (N = 158): 7387 \pm 13,206 - Cost-effectiveness: <p>6) Impact on HCP use and implementation: NR</p>	
<p>Tierney, Overhage, Murray, et al., 2005</p> <p>#3487</p> <p>Comparison 1 of 2</p>	<p>Geographical location: Indiana</p> <p>Study dates: 1/1/1994–5/1/1996</p> <p>General setting: Academic</p> <p>Specific setting:</p> <ul style="list-style-type: none"> - Outpatient - Chronic 	<p>Authors' basic description of system: Patient-specific, guideline-based care suggestions.</p> <p>Source/origin of system: Locally developed</p> <p>Content:</p> <p><i>a) Objective(s):</i> Chronic disease management</p> <p><i>b) Relationship to point of care:</i> Synchronous</p>	<p>Comparator(s): Another CDSS/KMS</p> <p>2 x 2 factorial design with 4 resulting groups:</p> <p>1) No intervention (control)</p> <p>2) <u>Physician intervention</u></p>	<p>1) Impact on clinical outcomes:</p> <ul style="list-style-type: none"> - Length of stay: NR - Morbidity: All hospitalizations— Control: 0.4 \pm 0.8 Physician: 0.5 \pm 1.6 Pharmacist: 0.5 \pm 1.1 Both: 0.4 \pm 1.1 <p>For reactive airways disease hospitalizations—</p> <ul style="list-style-type: none"> Control: 0.1 \pm 0.3 Physician: 0.1 \pm 0.5 Pharmacist: 0.1 \pm 0.5 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Poor</p> <p>Comments: Study arm allocation not fully random (post-randomization)</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Study design: RCT: 2 x 2 factorial randomization</p> <p>Unit of randomization: Clinicians randomized by half-day practice sessions and patients randomized to intervention or control pharmacists</p> <p>Duration of intervention: 28 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 706 - Individual HCPs: > MDs: 274 internal medicine (25% faculty and 75% residents)</p> <p>User level of expertise/proficiency: NR</p>	<p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <u>Physician intervention</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N (physicians required to enter severity of symptoms) - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y</p>	<p>3) Pharmacist intervention</p> <p>4) Both interventions</p>	<p>Both: 0.1 ± 0.5</p> <p>- Mortality: NR</p> <p>- Validated measure of HRQOL or functional status: Short-form 36 subscales— General health: Control: 34 ± 22 Physician: 37 ± 24 Pharmacist: 29 ± 25 Both: 35 ± 20</p> <p>Chronic respiratory disease questionnaire subscales— Overall health status: Control: 4.2 ± 1.1 Physician: 4.4 ± 1.2 Pharmacist: 4.3 ± 1.3 Both: 4.1 ± 1.1</p> <p>Asthma quality-of-life questionnaire subscales— Overall health status: Control: 3.7 ± 1.3 Physician: 4.0 ± 1.5 Pharmacist: 4.2 ± 1.4 Both: 4.2 ± 1.1</p> <p>- Adverse events: NR</p> <p>2) Impact on health care process outcomes: All indicated tests and treatments suggestions adhered to: Control: 135 (32%) Physician intervention: 161 (32%) Pharmacist intervention: 123 (32%) Both interventions: 173 (37%)</p>	<p>adjustments made), multiple comparisons leading to probably underpowered study, participants not blinded, and inadequate statistical analysis and reporting of findings</p> <p>Applicability/generalizability: Academic setting</p> <p>Physicians in training (residents) were among the clinicians</p> <p>Relevant, valid, and reproducible patient-centered outcomes were used</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Recommendations executed by noting agreement: N		- Recommended preventive care ordered/completed: Influenza vaccination, N (%) of suggestions adhered to— Control: 36 (42%) Physician: 37 (40%) Pharmacist: 34 (43%) Both: 37 (37%)	
		c) <i>Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y		Pneumococcal vaccination, N (%) of suggestions adhered to— Control: 7 (9%) Physician: 7 (8%) Pharmacist: 6 (8%) Both: 15 (16%)	
		d) <i>Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		- Recommended clinical study ordered/completed: Obtain pulmonary function test, N (%) of suggestions adhered to— Control: 4 (6%) Physician: 6 (6%) Pharmacist: 4 (6%) Both: 9 (12%)	
				- Recommended treatment ordered/prescribed: Start ipratropium, N (%) of suggestions adhered to— Control: 17 (25%) Physician: 30 (42%) Pharmacist: 15 (25%) Both: 23 (35%)	
				Start inhaled β -agonist, N (%) of suggestions adhered to— Control: 23 (70%) Physician: 18 (60%) Pharmacist: 13 (52%)	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				Both: 16 (67%)	
				Switch to cheaper β -agonist, N (%) of suggestions adhered to— Control: 17 (71%) Physician: 23 (77%) Pharmacist: 13 (65%) Both: 30 (91%)	
				Increase/decrease theophylline dose, N (%) of suggestions adhered to— Control: 16 (67%) Physician: 26 (67%) Pharmacist: 18 (72%) Both: 20 (65%)	
				Stop ipratropium, N (%) of suggestions adhered to— Control: 12 (57%) Physician: 7 (32%) Pharmacist: 10 (56%) Both: 16 (57%)	
				Start inhaled corticosteroid, N (%) of suggestions adhered to— Control: 1 (11%) Physician: 2 (11%) Pharmacist: 3 (30%) Both: 3 (27%)	
				Start oral corticosteroid, N (%) of suggestions adhered to— Control: 2 (22%) Physician: 5 (50%) Pharmacist: 2 (50%) Both: 3 (33%)	
				Mean medication compliance score (Inui measure) (%)—	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Control: 80 Physician: 81 Pharmacist: 80 Both: 82</p> <p>Mean medication compliance score (Morisky measure)— Control: 0.88 ± 1.0 Physician: 0.95 ± 1.1 Pharmacist: 0.85 ± 1.0 Both: 0.89 ± 1.1</p> <p>N (%) of subjects with ≥ 2 prescription refills— Control: 96 (87%) Physician: 128 (95%) Pharmacist: 89 (81%) Both: 109 (92%)</p> <p>Medication possession ratio (mean \pm SD) $p < 0.05$ after adjusting for baseline values— Control: 0.92 ± 1.0 Physician: 0.98 ± 0.8 Pharmacist: 1.00 ± 2.7 Both: 1.1 ± 2.0</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: - Patient satisfaction with physician: Control: 2.1 ± 0.7 Physician: 1.9 ± 0.9 Pharmacist: 2.0 ± 0.9</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Both: 2.1 ± 0.6</p> <p>- Patient satisfaction with pharmacist: Control: 2.1 ± 0.7 Physician: 2.1 ± 0.7 Pharmacist: 2.1 ± 0.8 Both: 2.0 ± 0.6</p> <p>5) Impact on economic outcomes:</p> <p>- Cost: Outpatient charges— Control: $\\$3,129 \pm 2,921$ Physician: $\\$3,142 \pm 3,381$ Pharmacist: $\\$2,814 \pm 3,282$ Both: $\\$3,177 \pm 3,558$</p> <p>Inpatient charges:— Control: $\\$2,671 \pm 6,805$ Physician: $\\$4,864 \pm 17,257$ Pharmacist: $\\$2,519 \pm 7,267$ Both: $\\$2,475 \pm 8,699$</p> <p>Total health care charges— Control: $\\$5,800 \pm 8,536$ Physician: $\\$8,006 \pm 18,720$ Pharmacist: $\\$5,333 \pm 9,400$ Both: $\\$5,652 \pm 10,579$</p> <p>- Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	
Tierney, Overhage, Murray, et al., 2005 #3487	<p>Geographical location: Indiana</p> <p>Study dates: 1/1/1994–5/1/1996</p>	<p>Authors' basic description of system: Patient-specific, guideline-based care suggestions.</p> <p>Source/origin of system:</p>	<p>Comparator(s): Another CDSS/KMS</p> <p>2 x 2 factorial design with 4</p>	<p>1) Impact on clinical outcomes:</p> <p>- Length of stay: NR</p> <p>- Morbidity: All hospitalizations— Control: 0.4 ± 0.8 Physician: 0.5 ± 1.6</p>	<p>General comments: None</p> <p>Quality assessment:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Comparison 2 of 2	General setting: Academic Specific setting: - Outpatient - Chronic Study design: RCT: 2 x 2 factorial randomization Unit of randomization: Clinicians randomized by half-day practice sessions and patients randomized to intervention or control pharmacists Duration of intervention: 28 months Sample type(s) (with N randomized for each): - Patients: 706 - Individual HCPs: > MDs: 274 internal medicine (25% faculty and 75% residents) User level of expertise/proficiency: NR	Locally developed Content: <i>a) Objective(s):</i> Chronic disease management <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement) Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated ("push")	resulting groups: 1) No intervention (control) 2) Physician intervention 3) <u>Pharmacist intervention</u> 4) Both interventions	Pharmacist: 0.5 ± 1.1 Both: 0.4 ± 1.1 For reactive airways disease hospitalizations— Control: 0.1 ± 0.3 Physician: 0.1 ± 0.5 Pharmacist: 0.1 ± 0.5 Both: 0.1 ± 0.5 - Mortality: NR - Validated measure of HRQOL or functional status: Short-form 36 subscales— General health: Control: 34 ± 22 Physician: 37 ± 24 Pharmacist: 29 ± 25 Both: 35 ± 20 Chronic respiratory disease questionnaire subscales— Overall health status: Control: 4.2 ± 1.1 Physician: 4.4 ± 1.2 Pharmacist: 4.3 ± 1.3 Both: 4.1 ± 1.1 Asthma quality-of-life questionnaire subscales— Overall health status: Control: 3.7 ± 1.3 Physician: 4.0 ± 1.5 Pharmacist: 4.2 ± 1.4 Both: 4.2 ± 1.1 - Adverse events: NR	Overall rating: Poor Comments: Study arm allocation not fully random (post-randomization adjustments made), multiple comparisons leading to probably underpowered study, participants not blinded, and inadequate statistical analysis and reporting of findings Applicability/generalizability: Academic setting Physicians in training (residents) were among the clinicians Relevant, valid, and reproducible patient-centered outcomes were used
		Contextual factors/features influencing the implementation and use of CDSS/KMS: <u>Pharmacist intervention</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Can't tell 		<p>2) Impact on health care process outcomes:</p> <p>All indicated tests and treatments suggestions adhered to:</p> <p>Control: 135 (32%) Physician intervention: 161 (32%) Pharmacist intervention: 123 (32%) Both interventions: 173 (37%)</p> <p>- Recommended preventive care ordered/completed: Influenza vaccination, N (%) of suggestions adhered to—</p> <p>Control: 36 (42%) Physician: 37 (40%) Pharmacist: 34 (43%) Both: 37 (37%)</p> <p>Pneumococcal vaccination, N (%) of suggestions adhered to—</p> <p>Control: 7 (9%) Physician: 7 (8%) Pharmacist: 6 (8%) Both: 15 (16%)</p> <p>- Recommended clinical study ordered/completed: Obtain pulmonary function test, N (%) of suggestions adhered to—</p> <p>Control: 4 (6%) Physician: 6 (6%) Pharmacist: 4 (6%) Both: 9 (12%)</p> <p>- Recommended treatment ordered/prescribed: Start ipratropium, N (%) of suggestions adhered to—</p> <p>Control: 17 (25%) Physician: 30 (42%)</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>Pharmacist: 15 (25%) Both: 23 (35%)</p> <p>Start inhaled β-agonist, N (%) of suggestions adhered to— Control: 23 (70%) Physician: 18 (60%) Pharmacist: 13 (52%) Both: 16 (67%)</p> <p>Switch to cheaper β-agonist, N (%) of suggestions adhered to— Control: 17 (71%) Physician: 23 (77%) Pharmacist: 13 (65%) Both: 30 (91%)</p> <p>Increase/decrease theophylline dose, N (%) of suggestions adhered to— Control: 16 (67%) Physician: 26 (67%) Pharmacist: 18 (72%) Both: 20 (65%)</p> <p>Stop ipratropium, N (%) of suggestions adhered to— Control: 12 (57%) Physician: 7 (32%) Pharmacist: 10 (56%) Both: 16 (57%)</p> <p>Start inhaled corticosteroid, N (%) of suggestions adhered to— Control: 1 (11%) Physician: 2 (11%) Pharmacist: 3 (30%) Both: 3 (27%)</p> <p>Start oral corticosteroid, N (%) of</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>suggestions adhered to— Control: 2 (22%) Physician: 5 (50%) Pharmacist: 2 (50%) Both: 3 (33%)</p> <p>Mean medication compliance score (Inui measure) (%)— Control: 80 Physician: 81 Pharmacist: 80 Both: 82</p> <p>Mean medication compliance score (Morisky measure)— Control: 0.88 ± 1.0 Physician: 0.95 ± 1.1 Pharmacist: 0.85 ± 1.0 Both: 0.89 ± 1.1</p> <p>N (%) of subjects with ≥ 2 prescription refills— Control: 96 (87%) Physician: 128 (95%) Pharmacist: 89 (81%) Both: 109 (92%)</p> <p>Medication possession ratio (mean \pm SD) $p < 0.05$ after adjusting for baseline values— Control: 0.92 ± 1.0 Physician: 0.98 ± 0.8 Pharmacist: 1.00 ± 2.7 Both: 1.1 ± 2.0</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				<p>delivery: NR</p> <p>4) Impact on relationship-centered outcomes:</p> <ul style="list-style-type: none"> - Patient satisfaction with physician: Control: 2.1 ± 0.7 Physician: 1.9 ± 0.9 Pharmacist: 2.0 ± 0.9 Both: 2.1 ± 0.6 - Patient satisfaction with pharmacist: Control: 2.1 ± 0.7 Physician: 2.1 ± 0.7 Pharmacist: 2.1 ± 0.8 Both: 2.0 ± 0.6 <p>5) Impact on economic outcomes:</p> <ul style="list-style-type: none"> - Cost: Outpatient charges— Control: $\\$3,129 \pm 2,921$ Physician: $\\$3,142 \pm 3,381$ Pharmacist: $\\$2,814 \pm 3,282$ Both: $\\$3,177 \pm 3,558$ Inpatient charges— Control: $\\$2,671 \pm 6,805$ Physician: $\\$4,864 \pm 17,257$ Pharmacist: $\\$2,519 \pm 7,267$ Both: $\\$2,475 \pm 8,699$ Total health care charges— Control: $\\$5,800 \pm 8,536$ Physician: $\\$8,006 \pm 18,720$ Pharmacist: $\\$5,333 \pm 9,400$ Both: $\\$5,652 \pm 10,579$ - Cost-effectiveness: NR <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
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Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Unrod, Smith, Spring, et al., 2007 #2098	<p>Geographical location: New York, NY</p> <p>Study dates: Physician recruitment occurred in 2002–2004</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Clinician</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Patients: 580 - Individual HCPs: > MDs: 70 family or internal medicine</p> <p>User level of expertise/ proficiency: NR</p>	<p>Authors' basic description of system: A computer-tailored intervention designed to increase smoking cessation counseling by primary care physicians: "We tested an intervention that integrates a brief, tailored expert-system report with face-to-face physician-delivered counseling ..."</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Initiating discussion with patient <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based. <i>b) Delivery mode:</i> System-initiated ("push")</p> <p>Contextual factors/features influencing the</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR</p> <p>GEE generalized linear modeling indicated that intervention physicians exceeded controls on "Assess," "Advise," "Assist," and "Arrange" ($p < 0.0001$)</p> <p>More intervention than control physicians advised their patients to quit smoking (OR 2.79; 95% CI 1.70, 4.59)</p> <p>7-day point prevalence abstinence— Intervention: 12% Control: 8% OR: 1.77; 95% CI 0.94, 3.34, p-value: 0.078</p> <p>- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes:</p>	<p>General comments: None</p> <p>Quality assessment: Overall rating: Fair</p> <p>Comments: Participants not blinded, outcomes not assessed using validated methodology, insufficient data regarding whether physicians or patients selected to participate are representative of larger populations</p> <p>Applicability/generalizability: Community setting</p> <p>Locally developed system</p> <p>All physicians were paid \$150, and physicians in the intervention</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can't tell</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in 		<p>NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>group received an additional \$50. Patients were paid \$20 for completing initial assessments and \$10 for the followup interview.</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		development process: Can't tell - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Y ("academic detailing")			
Vadher, Patterson, and Leaning, 1997A #6536	Geographical location: 1 site in London, England Study dates: NR General setting: Community Specific setting: - Inpatient–ICU - Inpatient–non-ICU Study design: RCT, parallel group Unit of randomization: Patient Duration of intervention: NR Sample type(s) (with N randomized for	Authors' basic description of system: Management by trainee doctors (to achieve therapeutic range of international normalized ration [INR] of 2 to 3) with indirect assistance from computerized decision support system (intervention group) or without such assistance (control group). Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Median time to achieve a stable dose was significantly lower in intervention group than in controls (7 days versus 9 days, $P = 0.01$) without excessive overtreatment or undertreatment with anticoagulant. Patients in intervention group spent greater proportion of time in therapeutic range, both as inpatients (59% versus 52%) and as outpatients (64% versus 51%). - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR	General comments: None Quality assessment: Overall rating: Fair Comments: Issues in blinding control MDs from the computerized decision support system's suggestions Applicability/generalizability: Setting was England Study's control arm included physicians also treating

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>each): Patients: 148</p> <p>User level of expertise/ proficiency: NR</p>	<p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can’t tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y</p>		<p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>intervention patients, so control arm may have been biased</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
Vadher, Patterson, and Leaning, 1997B #6464	Geographical location: 1 site in London, England Study dates: NR General setting: Community Specific setting: Outpatient Study design: RCT, parallel group	Authors' basic description of system: The quality of anticoagulant control achieved by a nurse practitioner using a computer decision support system (CDSS) was compared with that achieved by trainee doctors without CDSS. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: In this study, 57.6% of INRs were within the therapeutic range in the nurse practitioner group compared with 43.3% in the clinician group - Impact on user knowledge: NR 	General comments: None Quality assessment: Overall rating: Fair Comments: It was difficult to shield the clinicians from the CDSS suggestions due to logistical

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Unit of randomization: Patient</p> <p>Duration of intervention: 1 month</p> <p>Sample type(s) (with N randomized for each): - Patients: 177 - Individual HCPs: > Training MDs: 3 > PAs/NPs: 1</p> <p>User level of expertise/proficiency: NP given training in the use of the CDSS over a period of 1 month</p>	<p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Standalone system</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can’t tell - No need for additional clinician data entry: Can’t tell - Request documentation of the reason for not following CDSS recommendations: Can’t tell - Provision of decision support at time and location of decision making: Y/</p>		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: Dose suggestion acceptance in the nurse practitioner group for patients with therapeutic range of 2-3 was 88% compared with agreement between the CDSS and the clinicians (60%)</p> <p>Acceptance of dose suggestion in the nurse practitioner group for patients with therapeutic range of 3-4.5 was 67% compared with agreement between the CDSS and the clinicians (73%)</p> <p>- HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR</p>	<p>problems, and hence there may have been some learning and carryover effect in the decisions made in the clinician group</p> <p>Applicability/generalizability: Set in England</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>- Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i></p> <p>- Provision of a recommendation, not just an assessment: Y</p> <p>- Promotion of action rather than inaction: Can't tell</p> <p>- Justification of decision support via provision of reasoning: N</p> <p>- Justification of decision support via provision of research evidence: N</p> <p><i>d) Auxiliary features:</i></p> <p>- Local user involvement in development process: Can't tell</p> <p>- Provision of decision support results to patients as well as providers: N</p> <p>- CDSS accompanied by periodic performance feedback: N</p> <p>- CDSS accompanied by conventional education: Y</p>			
<p>van Wijk, van der Lei, Mosseveld, et al., 2001</p> <p>#5433</p>	<p>Geographical location: 44 sites in the Delft region, Netherlands</p> <p>Study dates: 03/1996–02/1997</p>	<p>Authors' basic description of system: CDSS for blood test ordering that included two different versions of the same set of tests:</p> <p>(1) BloodLink-Guideline</p>	<p>Comparator(s): Another CDSS/KMS:</p> <p>1) BloodLink-Guideline (an indication-oriented order</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <p>- Recommended preventive care ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: Relative risk of the</p>	<p>General comments: Users had the choice of using BloodLink or a paper form to order tests</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: Cluster RCT</p> <p>Unit of randomization: Practice</p> <p>Duration of intervention: 12 months</p> <p>Sample type(s) (with N randomized for each): - Clinics/practices/hospitals: 46 - Individual HCPs: > MDs: 62 general practitioners</p> <p>User level of expertise/proficiency: After BloodLink was installed, one of the authors gave a brief orientation presentation to the participating practitioners</p>	<p>presented physicians with an indication-oriented order form based on guidelines where the user selected the appropriate guideline and indication and then the system proposed the relevant tests</p> <p>(2) BloodLink-Restricted presented the physician with an order form with a restricted number of tests available</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Lab test ordering <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i> User initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i></p>	<p>form)</p> <p>2) BloodLink-Restricted (an order form with a restricted number of tests)</p>	<p># of tests ordered per form per practice was 1.19 (95% CI: 1.10 to 1.19) for the BloodLink-Restricted group, with the BloodLink-Guideline group as the referent</p> <p>Number of tests ordered per form mean [\pmSD], median: GPs who had access to BloodLink-Guideline ordered 20% fewer tests per form than did GPs who had access to BloodLink-Restricted (mean [\pmSD], 5.5 \pm 0.9 tests versus 6.9 \pm 1.6 tests [median, 6.6 versus 4.6], respectively; $p = 0.003$).</p> <p>- Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: NR - HCP use: Of the 12,742 order forms that the laboratory received from practices using BloodLink-Restricted, 11,151 orders (88%) were made by using the software; the remaining 1591 orders were placed by using traditional</p>	<p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Study conducted in the Netherlands Community setting, with apparently good generalizability to other GPs in the Netherlands Locally developed system</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as 		<p>paper order forms.</p> <p>Of the 12,668 orders placed by the practices using Blood-Link-Guideline, 9091 (71%) were generated by using the decision support system.</p> <p>- Implementation of CDSS/KMS: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
<p>van Wyk, van Wijk, Sturkenboom, et al., 2008</p> <p>#1487</p> <p>Comparison 1 of 2</p>	<p>Geographical location: 38 sites in the Delft region, Netherlands</p> <p>Study dates: Practices recruited May and June 2004</p> <p>General setting: Community</p> <p>Specific setting: Outpatient, chronic care</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Clinics/practices/hospitals: 38 - Individual HCPs: > Training MDs > MDs, GPs: 80</p> <p>User level of expertise/</p>	<p>Authors' basic description of system: The CDSS is integrated within the EHR to provide decision support as part of the clinician's workflow. Two CDSS versions were developed: (1) CDSS on-demand and (2) CDSS alerting. In the on-demand version, the user had to actively initiate the overview screen. In the alerting version, the recommendations were automatically shown to the user.</p> <p>Source/origin of system: Commercially available (ELIAS EHR)</p> <p>Content: <i>a) Objective(s):</i> - Screening and treatment of dyslipidemia - Preventive care - Diagnosis <i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i></p>	<p>Comparator(s): Another CDSS/KMS</p> <p>3 Groups:</p> <p>1) <u>Alerting: recommendations automatically shown to the user</u></p> <p>2) On-demand: user has to actively initiate the overview screen</p> <p>3) Control: no overview screen available</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes: - Recommended preventive ordered/completed: Adjusted RR for total patients requiring screening, with control group (n = 882) as referent (95% CI)— Alerting group (n = 1079): 1.76 (1.41,2.20) On-demand group (n = 1249): 1.28 (0.98,1.68)</p> <p>Adjusted RR for total patients requiring screening, with on-demand group as referent (95% CI)— Alerting group: 1.40 (1.08,1.81)</p> <p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Adjusted RR for total patients requiring treatment, with control group (n=766) as referent (95% CI)— Alerting group (n = 1218): 1.40 (1.15,1.70) On-demand group (n = 969): 1.19 (0.94,1.50)</p> <p>Adjusted RR for total patients requiring treatment, with on-demand group as referent (95% CI)— Alerting group: 1.18 (0.96,1.45)</p> <p>- Impact on user knowledge: NR</p>	<p>General comments: Well-designed and executed 3-arm study with a head-to-head comparison of 2 CDSS systems with a usual care control</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability: Netherlands study</p> <p>Community setting</p> <p>Appears to be locally developed modification of a commercially available system</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	proficiency: High; only practices with full EHRs for more than 1 year included	Integrated with CPOE/EHR <i>b) Delivery mode:</i> System-initiated (“push”)		3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: NR	
		Contextual factors/features influencing the implementation and use of CDSS/KMS: <u>Alerting DSS group</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can’t tell			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			
van Wyk, van Wijk, Sturkenboom, et al., 2008 #1487 Comparison 2 of 2	Geographical location: 38 sites in the Delft region, Netherlands Study dates: Practices recruited May and June 2004 General setting: Community Specific setting: Outpatient, chronic care Study design: RCT, cluster	Authors' basic description of system: The CDSS is integrated within the EHR to provide decision support as part of the clinician's workflow. Two CDSS versions were developed: (1) CDSS on-demand and (2) CDSS alerting. In the on-demand version, the user had to actively initiate the overview screen. In the alerting version, the recommendations were automatically shown to the user. Source/origin of system:	Comparator(s): Another CDSS/KMS 3 Groups: 1) Alerting: recommendations automatically shown to the user 2) <u>On-demand: user has to actively initiate the overview screen</u>	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive ordered/completed: Adjusted RR for total patients requiring screening, with control group (n = 882) as referent (95% CI)— Alerting group (n = 1079): 1.76 (1.41,2.20) On-demand group (n = 1249): 1.28 (0.98,1.68) Adjusted RR for total patients requiring screening, with on-demand group as referent (95% CI)— Alerting group: 1.40 (1.08,1.81)	General comments: Well-designed and executed 3-arm study with a head-to-head comparison of 2 CDSS systems with a usual care control Quality assessment: Overall rating: Good Applicability/generalizability:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>randomization</p> <p>Unit of randomization: Clinic or team</p> <p>Duration of intervention: NR</p> <p>Sample type(s) (with N randomized for each): - Clinics/practices/hospitals: 38 - Individual HCPs: > Training MDs > MDs, GPs: 80</p> <p>User level of expertise/proficiency: High; only practices with full EHRs for more than 1 year included</p>	<p>Commercially available (ELIAS EHR)</p> <p>Content: <i>a) Objective(s):</i> - Screening and treatment of dyslipidemia - Preventive care - Diagnosis</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> User-initiated ("pull")</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><u>On-demand DSS group</u> <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of</p>	<p>3) Control: no overview screen available</p>	<p>- Recommended clinical study ordered/completed: NR</p> <p>- Recommended treatment ordered/prescribed: Adjusted RR for total patients requiring treatment, with control group (n = 766) as referent (95% CI)— Alerting group (n = 1218): 1.40 (1.15,1.70) On-demand group (n=969): 1.19 (0.94,1.50)</p> <p>Adjusted RR for total patients requiring treatment, with on-demand group as referent (95% CI)— Alerting group: 1.18 (0.96,1.45)</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Netherlands study</p> <p>Community setting</p> <p>Appears to be locally developed modification of a commercially available system</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>decision support as part of clinician workflow: Y</p> <ul style="list-style-type: none"> - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Visser, Birt, van der Linden, et al., 1996 #6717 AND Visser, Hasman, and van der Linden, 1995 #6793	Geographical location: Nijmegen, Netherlands Study dates: October 13, 1992–June 9, 1993 General setting: Academic Specific setting: Emergency department Study design: RCT, crossover Unit of randomization: Clinician Duration of intervention: 7 months Sample type(s) (with N randomized for each): - Patients: 224 - Individual HCPs: > Training MDs: 8 User level of expertise/proficiency: NR	Authors' basic description of system: ProtoVIEW provides protocol information for diagnostic and therapeutic purposes. ProtoVIEW is supplied with a protocol that contains mainly therapeutic information about the management of common isolated fractures. Source/origin of system: Not clearly described Content: <i>a) Objective(s):</i> - Diagnosis - Other [general reference] <i>b) Relationship to point of care:</i> - Synchronous - Asynchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Standalone system <i>b) Delivery mode:</i> User-initiated ("pull") Contextual factors/features influencing the implementation and use of CDSS/KMS:	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Adjusted treatments from proposed initial treatment to final initial treatment— Baseline Period: Total Changes: 2 of 39 (5%) Trial Period: Total Changes: Control Group: 14 of 99 (14%) Intervention Group: 26 of 125 (21%) - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR 6) Impact on HCP use and implementation: Acceptance and attitude toward ProtoVIEW as a useful information source (1-5 scale where 1 = strongly disagree, 5 = strongly agree)— - HCP acceptance: NR	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Setting was the Netherlands Locally developed

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: N</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Can't tell</p> <p><i>d) Auxiliary features:</i> - Local user involvement in development process: N</p>		<p>- HCP satisfaction: (mean scores) Appropriate information for most patients: 3.8 ProtoVIEW is easy to use: 3.9 Clear and convenient presentation: 4.2 Slower than other information sources: 3.4 Diagnostic and/or therapeutic delay shorter: 2.1 ProtoVIEW serves as a useful training source: 4.7 Performance increases: 2.2 Computer support might be useful in clinical decision making: 4.1 Less conversation with colleagues: 2.4 Would use system in daily practice: 3.3</p> <p>- HCP use: NR</p> <p>- Implementation of CDSS/KMS: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<ul style="list-style-type: none"> - Provision of decision support results to patients as well as providers: Can't tell - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: Can't tell 			
Walker, Fairley, Walker, et al., 2010 #15004	Geographical location: 68 sites in Melbourne, Victoria, Australia Study dates: Feb 20, 2006–Oct 9, 2007 General setting: Community Specific setting: Outpatient Study design: RCT, cluster randomization Unit of randomization: Clinic or team Duration of intervention: 12 months Sample type(s) (with	Authors' basic description of system: An on-screen computer alert prompting general practitioners to discuss Chlamydia testing with women aged between 16 and 24 years. Source/origin of system: Commercially available Content: <i>a) Objective(s):</i> - Lab test ordering - Initiating discussion with patient <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i>	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Chlamydia testing (95% CI)— Intervention: 12.2% (9.1 to 15.3) Control: 10.6% (8.5 to 12.7) - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR 3) Impact on workload, efficiency, and organization of health care delivery: NR 4) Impact on relationship-centered outcomes: NR 5) Impact on economic outcomes: NR	General comments: None Quality assessment: Overall rating: Good Comments: Alerts did not operate for 14.8% of the time Applicability/generalizability: Large study conducted within the metropolitan area More female GPs in the study High ineligibility rate where many clinics were not included because

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>N randomized for each):</p> <ul style="list-style-type: none"> - Clinics/practices/hospitals 68 - Individual HCPs: 225 > MDs [general practice] <p>User level of expertise/proficiency: NR</p>	<p>Integrated with CPOE/EHR</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of 		<p>6) Impact on HCP use and implementation: NR</p>	<p>of low female patients</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		reasoning: N - Justification of decision support via provision of research evidence: N d) <i>Auxiliary features:</i> - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Can't tell - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y			
Weir, Lees, MacWalter, et al., 2003 #4696	Geographical location: NR Study dates: NR General setting: - Academic - Community Specific setting: - Inpatient–ICU - Inpatient–non-ICU - Outpatient - Acute Study design: RCT, cluster randomization Unit of randomization:	Authors' basic description of system: To evaluate the influence on prescribing practice of a computer-based decision support system (CDSS) that provided patient-specific estimates of the expected ischaemic and haemorrhagic vascular event rates under each potential antithrombotic therapy. Source/origin of system: Not clearly described Content: a) <i>Objective(s):</i> Pharmacotherapy b) <i>Relationship to point of care:</i>	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Optimal therapy prescribed— Control: 140 (34%) Intervention: 56 (30%) Estimated relative risk reduction in ischaemic and haemorrhagic vascular events— Control: 16.3% (13.1 to 23.8) Intervention: 16.7% (13.5 to 22.9) - Impact on user knowledge: NR	General comments: None Quality assessment: Overall rating: Good Comments: Details of particular CDSS not fully explained Applicability/generalizability: Did not use patient-centered outcomes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>Clinic or team</p> <p>Duration of intervention: 6 months</p> <p>Sample type(s) (with N randomized for each): - Patients: 1952 - Clinics/practices/hospitals: 16</p> <p>User level of expertise/proficiency: NR</p>	<p>Asynchronous</p> <p>Decision support: <i>Response requirement:</i> NR (assume no response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based <i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y <i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Can’t tell - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Can’t tell - Recommendations executed by noting agreement: Can’t tell</p>		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: From Physician Survey (N = 9)—</p> <p>- HCP acceptance: NR</p> <p>- HCP satisfaction: The format in which the evidence was presented was acceptable to eight clinicians. Three respondents disagreed with the CDSS. All respondents confirmed that the CDSS information was available sufficiently soon to be of use in the prescribing decision. Finally, 55% (5.9) of respondents felt that the CDSS had influenced their prescribing practice.</p> <p>- HCP use: NR</p> <p>- Implementation of CDSS/KMS: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N 			
<p>White, Lindsay, Pryor, et al., 1984</p> <p>#7405</p>	<p>Geographical location: Salt Lake City, UT</p> <p>Study dates: NR</p> <p>General setting: Community</p> <p>Specific setting: - Inpatient-ICU</p>	<p>Authors' basic description of system: A computerized monitoring system was developed and implemented at LDS Hospital, whereby patients were automatically monitored for existing signs and predisposing factors of digoxin intoxication.</p>	<p>Comparator(s): Usual care/no CDSS or KMS</p>	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Physician actions, any action taken— 	<p>General comments: None</p> <p>Quality assessment: Overall rating: Good</p> <p>Applicability/generalizability:</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>- Inpatient–non-ICU</p> <p>Study design: RCT, parallel group</p> <p>Unit of randomization: Patient</p> <p>Duration of intervention: 3 month(s)</p> <p>Sample type(s) (with N randomized for each): Patients: 396</p> <p>User level of expertise/ proficiency: NR</p>	<p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> Pharmacotherapy</p> <p><i>b) Relationship to point of care:</i> Asynchronous</p> <p>Decision support: <i>Response requirement:</i> No response requirement</p> <p>Information delivery: <i>a) Delivery format:</i> Paper-based</p> <p><i>b) Delivery mode:</i> System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following</p>		<p>Frequency for alert group: 175 Frequency for nonalert group: 136 Weighted ratio (AI/NAI): 1.22 Statistical p-value: < 0.003 S - Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	<p>Locally developed</p> <p>Not patient-centered outcomes</p> <p>Well-established health IT infrastructure</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p>CDSS recommendations: N</p> <ul style="list-style-type: none"> - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: Can't tell - CDSS accompanied by conventional education: N 			
Wilson, Torrance, Mollison, et al., 2006	Geographical location: Grampian region of Scotland	Authors' basic description of system: The risk assessment module gave clear instructions on the information required from a	Comparator(s): Usual care/no CDSS or KMS	<p>1) Impact on clinical outcomes: NR</p> <p>2) Impact on health care process outcomes:</p> <ul style="list-style-type: none"> - Recommended preventive care 	<p>General comments:</p> <p>None</p> <p>Quality</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
#2468	<p>Study dates: January 1, 2000–June 30, 2002</p> <p>General setting: Community</p> <p>Specific setting: Outpatient</p> <p>Study design: RCT, cluster randomization</p> <p>Unit of randomization: - Clinician - Practice</p> <p>Duration of intervention: 8 months</p> <p>Sample type(s) (with N randomized for each): - Clinics/practices/hospitals: 86 - Individual HCPs: > MDs: 346 general practitioners</p> <p>User level of expertise/proficiency: NR</p>	<p>patient and assisted users in making a rapid decision about whether or not a patient met Scottish referral guidelines.</p> <p>Source/origin of system: Locally developed</p> <p>Content: <i>a) Objective(s):</i> - Initiating discussion with patient - Providing information to GP to enable informed discussions with patients</p> <p><i>b) Relationship to point of care:</i> Synchronous</p> <p>Decision support: <i>Response requirement:</i> NR (unclear whether response requirement)</p> <p>Information delivery: <i>a) Delivery format:</i> Not clearly described</p> <p><i>b) Delivery mode:</i> User-initiated (“pull”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS: <i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Can’t tell</p>		<p>ordered/completed: NR</p> <p>- Recommended clinical study ordered/completed: Proportion (%) of referred patients with elevated genetic risk— Intervention: 49 of 85 (58%) Control: 14 of 29 (48) Risk ratio (95%CI): 1.18 (0.88, 1.37)</p> <p>- Recommended treatment ordered/prescribed: NR</p> <p>- Impact on user knowledge: NR</p> <p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: - Cost: Total average cost for the software development (2001 prices) was £71.69 per CD, with a marginal cost for each additional CD of £3.12. The cost for each GP attending the postgraduate education session was £106.07 per GP (marginal cost = £77.60). - Cost-effectiveness: NR</p> <p>6) Impact on HCP use and implementation: - HCP acceptance: NR - HCP satisfaction: When the primary outcome (self-reported GP confidence in activities related to managing patients concerned about genetic risk of breast cancer) was examined for the latter group of respondents (those</p>	<p>assessment: Overall rating: Poor</p> <p>Comments: From the discussion section: Less than half of the intervention GPs to whom it (the CDSS) had been supplied reported awareness if its existence, and only a third of this group actually used it</p> <p>Implications for limitations related to incomplete outcome data and inappropriate control arms</p> <p>Applicability/generalizability: Conducted in Scotland</p> <p>Locally developed</p> <p>Intervention providers not required to use intervention</p>

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		<p><i>b) Clinician-system interaction features:</i></p> <ul style="list-style-type: none"> - Automatic provision of decision support as part of clinician workflow: Can't tell - No need for additional clinician data entry: Can't tell - Request documentation of the reason for not following CDSS recommendations: Can't tell - Provision of decision support at time and location of decision making: - Recommendations executed by noting agreement: Can't tell <p><i>c) Communication content features:</i></p> <ul style="list-style-type: none"> - Provision of a recommendation, not just an assessment: Can't tell - Promotion of action rather than inaction: Can't tell - Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell <p><i>d) Auxiliary features:</i></p> <ul style="list-style-type: none"> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by 		<p>who reported use of the software), statistically significantly higher self-reported confidence was noted for the activity of "reassuring low-risk patients" compared with the 127 intervention group respondents who did not use the software (moderately or very confident, 20 of 22 versus 63 of 127, $P < 0.001$).</p> <ul style="list-style-type: none"> - HCP use: NR - Implementation of CDSS/KMS: NR 	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		periodic performance feedback: N - CDSS accompanied by conventional education: Y			
Zanetti, Flanagan, Cohn, et al., 2003 #4771	Geographical location: Boston, MA Study dates: March 23, 2000–June 23, 2000 General setting: Academic Specific setting: Inpatient [cardiac surgery] Study design: RCT, parallel group Unit of randomization: Patient/ cardiac procedures Duration of intervention: 3 months Sample type(s) (with N randomized for each): Patients: 449 randomized, 273 eligible	Authors' basic description of system: An audible and visual reminder on the operating room computer console at 225 minutes after the administration of preoperative antibiotics or control. After another 30 minutes, the circulating nurse was required to indicate whether a followup dose of antibiotics had been administered. Source/origin of system: Locally developed Content: <i>a) Objective(s):</i> Pharmacotherapy <i>b) Relationship to point of care:</i> Synchronous Decision support: <i>Response requirement:</i> Mandatory response Information delivery: <i>a) Delivery format:</i> Integrated with CPOE/EHR <i>b) Delivery mode:</i>	Comparator(s): Usual care/no CDSS or KMS	1) Impact on clinical outcomes: - Length of stay: NR - Morbidity: Attack rate of surgical site infection after procedures eligible for intraoperative redosing— Baseline: 48 of 480 (10%) Control: 8 of 136 (6%) Intervention: 5 of 137 (4%) (P = 0.4 compared with the control group and P = 0.02 compared with baseline) - Mortality: NR - Validated measure of HRQOL or functional status: NR - Adverse events: NR 2) Impact on health care process outcomes: - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Eligible patients who received intraoperative antibiotic redosing, # (%)— Control (N = 136): 55 (40%) Intervention (N = 137): 93 (68%) P < 0.001 Eligible intervention patients for which redosing refused (N = 137): 19 (14%) - Impact on user knowledge: NR	General comments: None Quality assessment: Overall rating: Good Applicability/generalizability: Well-established health IT and historically early adoption of health IT among users Intervention was locally developed Study used patient-centered outcomes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	<p>User level of expertise/proficiency: New CDSS for all users in intervention group</p>	<p>System-initiated (“push”)</p> <p>Contextual factors/features influencing the implementation and use of CDSS/KMS:</p> <p><i>a) General system features:</i> Integration with charting or order entry system to support workflow integration: Y</p> <p><i>b) Clinician-system interaction features:</i> - Automatic provision of decision support as part of clinician workflow: Y - No need for additional clinician data entry: Y - Request documentation of the reason for not following CDSS recommendations:/N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N</p> <p><i>c) Communication content features:</i> - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of</p>		<p>3) Impact on workload, efficiency, and organization of health care delivery: NR</p> <p>4) Impact on relationship-centered outcomes: NR</p> <p>5) Impact on economic outcomes: NR</p> <p>6) Impact on HCP use and implementation: NR</p>	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		research evidence: Can't tell			
		<i>d) Auxiliary features:</i> - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			

Abbreviations: ADHD = attention deficit hyperactivity disorder, AE = adverse event, ARI = acute respiratory illness, ATP = Adult Treatment Panel, AVM = automated voice message, BG = blood glucose, BMI = body mass index, BP = blood pressure, C = control group, CAD = coronary artery disease, CAIP = computer-assisted insulin protocol, CDSS = clinical decision support system, CHF = congestive heart failure, CI = confidence interval, CPOE = computerized physician/provider order entry, DCP = diabetes care protocol, DVT = deep vein thrombosis, ED = emergency department, EHR = electronic health record, EMR = electronic medical record, EPO = erythropoietin, ER = emergency room, FOBT = fecal occult blood test, FPTK = fall prevention toolkit, FRS = Framingham Risk Score, GP = general practitioner, HCP = health care provider, HIT = health information technology, HMO = health maintenance organization, HRQOL = health-related quality of life, ICU = intensive care unit, INR = international normalized ratio, IPCAAD = Improving Primary Care of African Americans with Diabetes, IQR = interquartile range, JNC = Joint National Committee, KMS = knowledge management system, LDL = low density lipoprotein, LLT = lower lipid levels, MI = myocardial infarction, mo = month/months, MPC = model predictive control, N = number, NAEPP = National Asthma Education and Prevention Program, NPT = near-patient testing, NR = not reported, NS = not significant, NSAID = nonsteroidal anti-inflammatory drug, OR = odds ratio, p = probability, PA = physician assistant, PCP = primary care physician, PDA = personal digital assistant, PE = pulmonary embolism, QALY = quality-adjusted life year, RCT = randomized controlled trial, RR = relative risk, Sbp = systolic blood pressure, SD = standard deviation, SE = standard error, SOC = standard of care, UC = usual care, vs = versus, wk = week/weeks, yr = year/years

References Cited in Appendix E (in Alphabetical Order)

- Alper BS, White DS, Ge B. Physicians answer more clinical questions and change clinical decisions more often with synthesized evidence: a randomized trial in primary care. *Ann Fam Med* 2005;3(6):507-13.
- Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107(22):2799-804.
- Apkon M, Mattera JA, Lin Z, et al. A randomized outpatient trial of a decision-support information technology tool. *Arch Intern Med* 2005;165(20):2388-94.
- Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106(2):144-50.
- Bell LM, Grundmeier R, Localio R, et al. Electronic Health Record-Based Decision Support to Improve Asthma Care: A Cluster-Randomized Trial. *Pediatrics* 2010;125(4):E770-E777.
- Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med* 2009;169(7):678-86.
- Bird JA, McPhee SJ, Jenkins C, et al. Three strategies to promote cancer screening. How feasible is wide-scale implementation? *Med Care* 1990;28(11):1005-12.
- Bosworth HB, Olsen MK, Dudley T, et al. Patient education and provider decision support to control blood pressure in primary care: a cluster randomized trial. *Am Heart J* 2009;157(3):450-6.
- Bosworth HB, Olsen MK, Goldstein MK, et al. The veterans' study to improve the control of hypertension (V-STITCH): design and methodology. *Contemp Clin Trials* 2005;26(2):155-68.
- Bourgeois FC, Linder J, Johnson SA, et al. Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clin Pediatr (Phila)* 2010;49(10):976-83.
- Brier ME, Gaweda AE, Dailey A, et al. Randomized trial of model predictive control for improved anemia management. *Clin J Am Soc Nephrol* 2010;5(5):814-20.
- Burack RC, Gimotty PA. Promoting screening mammography in inner-city settings. The sustained effectiveness of computerized reminders in a randomized controlled trial. *Med Care* 1997;35(9):921-31.
- Burack RC, Gimotty PA, George J, et al. How reminders given to patients and physicians affected pap smear use in a health maintenance organization: results of a randomized controlled trial. *Cancer* 1998;82(12):2391-400.
- Burack RC, Gimotty PA, George J, et al. Promoting screening mammography in inner-city settings: a randomized controlled trial of computerized reminders as a component of a program to facilitate mammography. *Med Care* 1994;32(6):609-24.
- Burack RC, Gimotty PA, Simon M, et al. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. *Prev Med* 2003;36(5):547-54.
- Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. *J Am Med Inform Assoc* 2000;7(2):196-203.
- Cavalcanti AB, Silva E, Pereira AJ, et al. A randomized controlled trial comparing a computer-assisted insulin infusion protocol with a strict and a conventional protocol for glucose control in critically ill patients. *J Crit Care* 2009;24(3):371-8.
- Chambers CV, Balaban DJ, Carlson BL, et al. Microcomputer-generated reminders. Improving the compliance of primary care physicians with mammography screening guidelines. *J Fam Pract* 1989;29(3):273-80.
- Christakis DA, Zimmerman FJ, Wright JA, et al. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics* 2001;107(2):E15.

Cleveringa FG, Gorter KJ, van den Donk M, et al. Combined task delegation, computerized decision support, and feedback improve cardiovascular risk for type 2 diabetic patients: a cluster randomized trial in primary care. *Diabetes Care* 2008;31(12):2273-5.

Cleveringa FG, Welsing PM, van den Donk M, et al. Cost-effectiveness of the diabetes care protocol, a multifaceted computerized decision support diabetes management intervention that reduces cardiovascular risk. *Diabetes Care* 2010;33(2):258-63.

Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126(2):239-46.

Cobos A, Vilaseca J, Asenjo C, et al. Cost effectiveness of a clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Disease Management & Health Outcomes* 2005;13(6):421-432.

Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2(5):e25.

Del Fiol G, Haug PJ, Cimino JJ, et al. Effectiveness of topic-specific infobuttons: a randomized controlled trial. *J Am Med Inform Assoc* 2008;15(6):752-9.

Demakis JG, Beauchamp C, Cull WL, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. *JAMA* 2000;284(11):1411-6.

Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345(13):965-70.

Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA* 2004;292(19):2366-71.

Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332(7543):692-6.

Dykes PC, Carroll DL, Hurley A, et al. Fall Prevention in Acute Care Hospitals A Randomized Trial. *Jama-Journal of the American Medical Association* 2010;304(17):1912-1918.

Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002;325(7370):941.

Emery J, Morris H, Goodchild R, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. *Br J Cancer* 2007;97(4):486-93.

Etchells E, Adhikari NK, Cheung C, et al. Real-time clinical alerting: effect of an automated paging system on response time to critical laboratory values--a randomised controlled trial. *Qual Saf Health Care* 2010;19(2):99-102.

Feldstein A, Elmer PJ, Smith DH, et al. Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. *J Am Geriatr Soc* 2006;54(3):450-7.

Feldstein AC, Smith DH, Perrin N, et al. Improved therapeutic monitoring with several interventions: a randomized trial. *Arch Intern Med* 2006;166(17):1848-54.

Field TS, Rochon P, Lee M, et al. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16(4):480-5.

Fihn SD, McDonnell MB, Vermes D, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. *J Gen Intern Med* 1994;9(3):131-9.

Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124(1):159-69.

Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26(5):1497-500.

Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *Arch Intern Med* 2000;160(15):2343-8.

Flanagan JR, Doebbeling BN, Dawson J, et al. Randomized study of online vaccine reminders in adult primary care. *Proc Amia Symp* 1999:755-9.

Flottorp S, Oxman AD, Havelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325(7360):367.

Fordham D, McPhee SJ, Bird JA, et al. The Cancer Prevention Reminder System. *MD Comput* 1990;7(5):289-95.

Fortuna RJ, Zhang F, Ross-Degnan D, et al. Reducing the prescribing of heavily marketed medications: a randomized controlled trial. *J Gen Intern Med* 2009;24(8):897-903.

Frame PS, Zimmer JG, Werth PL, et al. Computer-based vs manual health maintenance tracking. A controlled trial. *Arch Fam Med* 1994;3(7):581-8.

Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33(1-2):87-90.

Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. *PLoS Med* 2006;3(6):e216.

Fretheim A, Oxman AD, Havelsrud K, et al. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. *PLoS Med* 2006;3(6):e134.

Gill JM, Chen YX, Glutting JJ, et al. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12(5):221-6.

Gilutz H, Novack L, Shvartzman P, et al. Computerized community cholesterol control (4C): meeting the challenge of secondary prevention. *Isr Med Assoc J* 2009;11(1):23-9.

Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.

Graumlich JF, Novotny NL, Nace GS, et al. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2009;4(6):356-63.

Graumlich JF, Novotny NL, Nace GS, et al. Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial. *J Hosp Med* 2009;4(7):E11-9.

Greiver M, Drummond N, White D, et al. Angina on the Palm: randomized controlled pilot trial of Palm PDA software for referrals for cardiac testing. *Can Fam Physician* 2005;51:382-3.

Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56(12):2225-33.

Hamilton E, Platt R, Gauthier R, et al. The effect of computer-assisted evaluation of labor on cesarean rates. *J Healthc Qual* 2004;26(1):37-44.

Harpole LH, Khorasani R, Fiskio J, et al. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4(6):511-21.

Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115(22):2829-34.

Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. *Scand J Prim Health Care* 1999;17(1):35-40.

Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of hypertension in general practice. *Blood Press* 1998;7(5-6):270-6.

Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. *Int J Technol Assess Health Care* 2000;16(1):210-27.

Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23(4):429-41.

Hobbs FD, Delaney BC, Carson A, et al. A prospective controlled trial of computerized decision support for lipid management in primary care. *Fam Pract* 1996;13(2):133-7.

Holbrook A, Thabane L, Keshavjee K, et al. Individualized electronic decision support and reminders to improve diabetes care in the community: COMPETE II randomized trial. *CMAJ* 2009;181(1-2):37-44.

Holt TA, Thorogood M, Griffiths F, et al. Protocol for the 'e-Nudge trial': a randomised controlled trial of electronic feedback to reduce the cardiovascular risk of individuals in general practice [ISRCTN64828380]. *Trials* 2006;7:11.

Holt TA, Thorogood M, Griffiths F, et al. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60(573):e137-43.

Judge J, Field TS, DeFlorio M, et al. Prescribers' responses to alerts during medication ordering in the long term care setting. *J Am Med Inform Assoc* 2006;13(4):385-90.

Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20(10):916-21.

Khan S, Maclean CD, Littenberg B. The effect of the Vermont Diabetes Information System on inpatient and emergency room use: results from a randomized trial. *Health Outcomes Res Med* 2010;1(1):e61-e66.

Kline JA, Zeitouni RA, Hernandez-Nino J, et al. Randomized trial of computerized quantitative pretest probability in low-risk chest pain patients: effect on safety and resource use. *Ann Emerg Med* 2009;53(6):727-35 e1.

Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107(Pt 1):135-9.

Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352(10):969-77.

Kuperman GJ, Teich JM, Tanasijevic MJ, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6(6):512-22.

Lee NJ, Chen ES, Currie LM, et al. The effect of a mobile clinical decision support system on the diagnosis of obesity and overweight in acute and primary care encounters. *ANS Adv Nurs Sci* 2009;32(3):211-21.

Linder JA, Rigotti NA, Schneider LI, et al. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169(8):781-7.

Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med* 1993;8(6):311-7.

Lo HG, Matheny ME, Seger DL, et al. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16(1):66-71.

Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. *Proc Annu Symp Comput Appl Med Care* 1994:787-91.

Locatelli F, Covic A, Macdougall IC, et al. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22(5):662-74.

Maclean CD, Gagnon M, Callas P, et al. The Vermont diabetes information system: a cluster randomized trial of a population based decision support system. *J Gen Intern Med* 2009;24(12):1303-10.

Manotti C, Moia M, Palareti G, et al. Effect of computer-aided management on the quality of treatment in anticoagulated patients: a prospective, randomized, multicenter trial of APROAT (Automated PProgram for Oral Anticoagulant Treatment). *Haematologica* 2001;86(10):1060-70.

Marco F, Sedano C, Bermudez A, et al. A prospective controlled study of a computer-assisted acenocoumarol dosage program. *Pathophysiol Haemost Thromb* 2003;33(2):59-63.

Martens JD, van der Aa A, Panis B, et al. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. *Stud Health Technol Inform* 2006;124:617-23.

Martens JD, van der Weijden T, Severens JL, et al. The effect of computer reminders on GPs' prescribing behaviour: a cluster-randomised trial. *Int J Med Inform* 2007;76 Suppl 3:S403-16.

Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15(4):424-9.

Maviglia SM, Yoon CS, Bates DW, et al. KnowledgeLink: impact of context-sensitive information retrieval on clinicians' information needs. *J Am Med Inform Assoc* 2006;13(1):67-73.

McDonald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med* 1976;84(2):162-7.

McCowan C, Neville RG, Ricketts IW, et al. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26(3):191-201.

McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Ann Intern Med* 1984;100(1):130-8.

McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Comput* 1992;9(5):304-12.

McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. *CMAJ* 1986;135(9):991-7.

McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *J Fam Pract* 1989;28(4):420-4.

McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. *Med Care* 1989;27(3):297-305.

McGregor JC, Weekes E, Forrest GN, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(4):378-84.

McLaughlin D, Hayes JR, Kelleher K. Office-Based Interventions for Recognizing Abnormal Pediatric Blood Pressures. *Clin Pediatr (Phila)* 2010;49(4):355-362.

McPhee SJ, Bird JA, Jenkins CN, et al. Promoting cancer screening. A randomized, controlled trial of three interventions. *Arch Intern Med* 1989;149(8):1866-72.

Montgomery AA, Fahey T, Peters TJ, et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000;320(7236):686-90.

Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24(3):324-37.

Ornstein SM, Garr DR, Jenkins RG, et al. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. *J Fam Pract* 1991;32(1):82-90.

Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156(14):1551-6.

Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4(5):364-75.

Palen TE, Price DW, Snyder AJ, et al. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16(11):e267-75.

Palen TE, Raebel M, Lyons E, et al. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. *Am J Manag Care* 2006;12(7):389-95.

Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58(6):1238-45.

Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129(Pt 2):1037-40.

Peterson KA, Radosevich DM, O'Connor PJ, et al. Improving Diabetes Care in Practice: findings from the TRANSLATE trial. *Diabetes Care* 2008;31(12):2238-43.

Phillips LS, Ziemer DC, Doyle JP, et al. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. *Diabetes Care* 2005;28(10):2352-60.

Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18(4):223-9.

Price M. Can hand-held computers improve adherence to guidelines? A (Palm) Pilot study of family doctors in British Columbia. *Can Fam Physician* 2005;51:1506-7.

Raebel MA, Charles J, Dugan J, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. *J Am Geriatr Soc* 2007;55(7):977-85.

Raebel MA, Chester EA, Newsom EE, et al. Randomized trial to improve laboratory safety monitoring of ongoing drug therapy in ambulatory patients. *Pharmacotherapy* 2006;26(5):619-26.

Raebel MA, Lyons EE, Chester EA, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. *Arch Intern Med* 2005;165(20):2395-401.

Reeve JF, Tenni PC, Peterson GM. An electronic prompt in dispensing software to promote clinical interventions by community pharmacists: a randomized controlled trial. *Br J Clin Pharmacol* 2008;65(3):377-85.

Rollman BL, Hanusa BH, Gilbert T, et al. The electronic medical record. A randomized trial of its impact on primary care physicians' initial management of major depression [corrected]. *Arch Intern Med* 2001;161(2):189-97.

Rood E, Bosman RJ, van der Spoel JJ, et al. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. *J Am Med Inform Assoc* 2005;12(2):172-80.

Rosser WW, Hutchison BG, McDowell I, et al. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992;146(6):911-7.

Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. *CMAJ* 1991;145(7):807-14.

Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. *J Gen Intern Med* 1997;12(11):672-8.

Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion (Paris)* 2007;47(2):228-39.

Roukema J, Steyerberg EW, van der Lei J, et al. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. *J Am Med Inform Assoc* 2008;15(1):107-13.

Roumie CL, Elasy TA, Greevy R, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. *Ann Intern Med* 2006;145(3):165-75.

Roy PM, Durieux P, Gillaizeau F, et al. A computerized handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151(10):677-86.

Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA* 2005;294(18):2305-14.

Schriefer SP, Landis SE, Turbow DJ, et al. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41(7):502-7.

Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12(4):431-7.

Sequist TD, Zaslavsky AM, Marshall R, et al. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169(4):364-71.

Shojania KG, Yokoe D, Platt R, et al. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5(6):554-62.

Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-968.

Smith DH, Feldstein AC, Perrin NA, et al. Improving laboratory monitoring of medications: an economic analysis alongside a clinical trial. *Am J Manag Care* 2009;15(5):281-9.

Smith SA, Shah ND, Bryant SC, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83(7):747-57.

Stiell IG, Clement CM, Grimshaw J, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.

Strom BL, Schinnar R, Abera F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med* 2010;170(17):1578-83.

Strom BL, Schinnar R, Bilker W, et al. Randomized clinical trial of a customized electronic alert requiring an affirmative response compared to a control group receiving a commercial passive CPOE alert: NSAID-warfarin co-prescribing as a test case. *J Am Med Inform Assoc* 2010;17(4):411-5.

Subramanian U, Fihn SD, Weinberger M, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. *Am J Med* 2004;116(6):375-84.

Sundaram V, Lazzeroni LC, Douglass LR, et al. A randomized trial of computer-based reminders and audit and feedback to improve HIV screening in a primary care setting. *Int J STD AIDS* 2009;20(8):527-33.

Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169(6):549-56.

Tamblyn R, Huang A, Taylor L, et al. A randomized trial of the effectiveness of on-demand versus computer-triggered drug decision support in primary care. *J Am Med Inform Assoc* 2008;15(4):430-8.

Tamblyn R, Reidel K, Huang A, et al. Increasing the Detection and Response to Adherence Problems with Cardiovascular Medication in Primary Care through Computerized Drug Management Systems: A Randomized Controlled Trial. *Med Decis Making* 2009.

Taylor V, Thompson B, Lessler D, et al. A clinic-based mammography intervention targeting inner-city women. *J Gen Intern Med* 1999;14(2):104-11.

- Terrell KM, Perkins AJ, Dexter PR, et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57(8):1388-94.
- Terrell KM, Perkins AJ, Hui SL, et al. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56(6):623-9.
- Thomas HV, Lewis G, Watson M, et al. Computerised patient-specific guidelines for management of common mental disorders in primary care: a randomised controlled trial. *Br J Gen Pract* 2004;54(508):832-7.
- Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care* 1986;24(8):659-66.
- Tierney WM, McDonald CJ, Hui SL, et al. Computer predictions of abnormal test results. Effects on outpatient testing. *JAMA* 1988;259(8):1194-8.
- Tierney WM, McDonald CJ, Martin DK, et al. Computerized display of past test results. Effect on outpatient testing. *Ann Intern Med* 1987;107(4):569-74.
- Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18(12):967-76.
- Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40(2):477-97.
- Unrod M, Smith M, Spring B, et al. Randomized controlled trial of a computer-based, tailored intervention to increase smoking cessation counseling by primary care physicians. *J Gen Intern Med* 2007;22(4):478-84.
- Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997;314(7089):1252-6.
- Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. *Clin Lab Haematol* 1997;19(3):203-7.
- van Wijk MA, van der Lei J, Mosseveld M, et al. Assessment of decision support for blood test ordering in primary care. a randomized trial. *Ann Intern Med* 2001;134(4):274-81.
- van Wyk JT, van Wijk MA, Sturkenboom MC, et al. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117(3):371-8.
- Vissers MC, Biert J, van der Linden CJ, et al. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. *Comput Methods Programs Biomed* 1996;49(2):177-84.
- Vissers MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. *Comput Methods Programs Biomed* 1995;48(1-2):53-8.
- Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37(7):445-50.
- Weir CJ, Lees KR, MacWalter RS, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM* 2003;96(2):143-53.
- White KS, Lindsay A, Pryor TA, et al. Application of a computerized medical decision-making process to the problem of digoxin intoxication. *J Am Coll Cardiol* 1984;4(3):571-6.
- Wilson BJ, Torrance N, Mollison J, et al. Cluster randomized trial of a multifaceted primary care decision-support intervention for inherited breast cancer risk. *Fam Pract* 2006;23(5):537-44.
- Zanetti G, Flanagan HL, Jr., Cohn LH, et al. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24(1):13-6.

Ziemer DC, Doyle JP, Barnes CS, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting:

Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. Arch Intern Med 2006;166(5):507-13.

Appendix F: List of Excluded Studies

All studies listed below were reviewed in their full-text version and excluded. Following each reference, in italics, is the reason for exclusion. Reasons for exclusion signify only the usefulness of the articles for this study and are not intended as criticisms of the articles.

Aarts J, Koppel R. Implementation of computerized physician order entry in seven countries. *Health Aff (Millwood)* 2009;28(2):404-14.

Full-text Exclude - Not original peer-reviewed data

Aase O. Clinical experience with a decision support computer program using Bayes' theorem to diagnose chest pain patients. *Cardiology* 1999;92(2):128-34.

Full-text Exclude - No acceptable comparator

Abadie R, Weymiller AJ, Tilburt J, et al. Clinician's use of the Statin Choice decision aid in patients with diabetes: a videographic study nested in a randomized trial. *J Eval Clin Pract* 2009;15(3):492-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Abboud PA, Cabana MD. Understanding barriers to the adoption of clinical decision rules. *Ann Emerg Med* 2001;38(6):703-4.

Full-text Exclude - Not original peer-reviewed data

Abernethy AP, Arnold RM. PC-FACS: a real-time evidence resource for busy palliative care clinicians. *J Palliat Med* 2006;9(1):24-8.

Full-text Exclude - Not original peer-reviewed data

Abookire SA, Teich JM, Sandige H, et al. Improving allergy alerting in a computerized physician order entry system. *Proc Amia Symp* 2000:2-6.

Full-text Exclude - No acceptable comparator

Abramson ZH, Avni O, Levi O, et al. Randomized trial of a program to increase staff influenza vaccination in primary care clinics. *Ann Fam Med* 2010;8(4):293-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Ad N, Henry L, Hunt S, et al. The implementation of a comprehensive clinical protocol improves long-term success after surgical treatment of atrial fibrillation. *J Thorac Cardiovasc Surg* 2010;139(5):1146-52.

Full-text Exclude - No electronic CDSS or KMS intervention

Adams R, Ruffin R, Smith B, et al. Problems and some solutions in adapting clinical practice guidelines for asthma patient management into a computerised management system. The Western region asthma pilot project (Wrapp). *Informatics in Healthcare Australia* 1998;7(1):16-21.

Full-text Exclude - No acceptable comparator

Adhikari N, Shrestha S, Ansari I. Evidence based medicine. *Kathmandu Univ Med J (KUMJ)* 2006;4(3):383-9.

Full-text Exclude - Not original peer-reviewed data

Agno W, Johnson J, Nowacki B, et al. A computer generated induction system for hospitalized patients starting on oral anticoagulant therapy. *Thromb Haemost* 2000;83(6):849-52.

Full-text Exclude - Mandatory compliance CDSS

Aggarwal R, Mytton OT, Greaves F, et al. Technology as applied to patient safety: an overview Introduction. *Quality & Safety in Health Care* 2010;19.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Agrawal A, Mayo-Smith MF. Adherence to computerized clinical reminders in a large healthcare delivery network. *Stud Health Technol Inform* 2004;107(Pt 1):111-4.

Full-text Exclude - No acceptable comparator

Ahmad F, Skinner HA, Stewart DE, et al. Perspectives of family physicians on computer-assisted health-risk assessments. *J Med Internet Res* 2010;12(2):e12.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Ahmed BA, Matheny ME, Rice PL, et al. A comparison of methods for assessing penetrating trauma on retrospective multi-center data. *J Biomed Inform* 2009;42(2):308-16.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ahmed M. Computer-facilitated dialogue with patients who have schizophrenia. *Psychiatr Serv* 2002;53(1):99-100.

Full-text Exclude - No electronic CDSS or KMS intervention

Albert KM. Integrating knowledge-based resources into the electronic health record: history, current status, and role of librarians. *Med Ref Serv Q* 2007;26(3):1-19.

Full-text Exclude - Not original peer-reviewed data

Alexander G, Hauser S, Steely K, et al. A usability study of the PubMed on Tap user interface for PDAs. *Stud Health Technol Inform* 2004;107(Pt 2):1411-5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Alexander GL. Human factors, automation, and alerting mechanisms in nursing home electronic health records [Ph.D.]. University of Missouri - Columbia; 2005.

Full-text Exclude - Not original peer-reviewed data

Alexander GL. Analysis of an integrated clinical decision support system in nursing home clinical information systems. *J Gerontol Nurs* 2008;34(2):15-20.

Full-text Exclude - No acceptable comparator

Ali J, Barrow L, Vuylsteke A. The impact of computerised physician order entry on prescribing practices in a cardiothoracic intensive care unit. *Anaesthesia* 2010;65(2):119-23.

Full-text Exclude - No electronic CDSS or KMS intervention

Allen K, Hazelett S, Jarjoura D, et al. Improving stroke outcomes: implementation of a postdischarge care management model. *Journal of Clinical Outcomes Management* 2004;11(11):707-714.

Full-text Exclude - No electronic CDSS or KMS intervention

Allerod C, Rees SE, Rasmussen BS, et al. A decision support system for suggesting ventilator settings: retrospective evaluation in cardiac surgery patients ventilated in the ICU. *Comput Methods Programs Biomed* 2008;92(2):205-12.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Allison JJ, Kiefe CI, Wall T, et al. Multicomponent Internet continuing medical education to promote chlamydia screening. *Am J Prev Med* 2005;28(3):285-90.

Full-text Exclude - No electronic CDSS or KMS intervention

Almond M, Gordon K, Kent JR, et al. The effect of the controlled entry of electronic prescribing and medicines administration on the quality of prescribing, safety and success of administration on an acute medical ward. *British Journal of Healthcare Computing & Information Management* 2002;19(2):41.

Full-text Exclude - No electronic CDSS or KMS intervention

Altmann A, Daumer M, Beerenwinkel N, et al. Predicting the response to combination antiretroviral therapy: retrospective validation of geno2pheno-THEO on a large clinical database. *J Infect Dis* 2009;199(7):999-1006.

Full-text Exclude - No electronic CDSS or KMS intervention

Alvarez Diaz AM, Delgado Silveira E, Perez Menendez-Conde C, et al. [New technologies applied to the medication-dispensing process, error analysis and contributing factors]. *Farm Hosp* 2010;34(2):59-67.

Full-text Exclude - No electronic CDSS or KMS intervention

Amarasingham R, Plantinga L, Diener-West M, et al. Clinical information technologies and inpatient outcomes: a multiple hospital study. *Arch Intern Med* 2009;169(2):108-14.

Full-text Exclude - No electronic CDSS or KMS intervention

Anderson JA, Willson P, Peterson NJ, et al. Prototype to Practice Developing and Testing a Clinical Decision Support System for Secondary Stroke Prevention in a Veterans Healthcare Facility. *Cin-Computers Informatics Nursing* 2010;28(6):353-363.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Anderson RM, Musch DC, Nwankwo RB, et al. For the patient. Eye screening can prevent eye disease. Personalized follow-up increases return rate at urban

eye disease screening clinics for African Americans with diabetes: results of a randomized trial. *Ethn Dis* 2003;13(1):149.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Anonymous. AARC (American Association for Respiratory Care) clinical practice guideline. Assessing response to bronchodilator therapy at point of care. *Respir Care* 1995;40(12):1300-7.

Full-text Exclude - Not original peer-reviewed data

Anonymous. California hospital alters doctors' habits with timely comparative data. *Hosp Peer Rev* 1996;21(3):37-41.

Full-text Exclude - Not original peer-reviewed data

Anonymous. [Commentary on] Computer decision aids for anticoagulation. *Bandolier* 2001;8(5):6-6.

Full-text Exclude - Not original peer-reviewed data

Anonymous. Decision support for ordering blood tests in primary care. *Bandolier* 2001;8(5):3-3.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Anonymous. Drug use issues and actions: a forum for drug management strategies and solutions. Simple physician-prompting intervention drastically improves outcomes in CHD. *Formulary* 2002;37(4):209-210.

Full-text Exclude - No electronic CDSS or KMS intervention

Anonymous. Researchers test system to custom-tailor guidelines. *Clin Resour Manag* 2002;3(1):8-10, 1.

Full-text Exclude - Not original peer-reviewed data

Anonymous. The formulary files. Electronic prescribing has no effect on formulary compliance. *Manag Care* 2003;12(12):63.

Full-text Exclude - Not original peer-reviewed data

Anonymous. "More Radical Steps" (2003) initiatives. *Inform Prim Care* 2003;11(3):167-73.

Full-text Exclude - Not original peer-reviewed data

Anonymous. Summaries for patients. Increasing the detection and treatment of osteoporosis in patients who present to an emergency department with a wrist fracture. *Ann Intern Med* 2004;141(5):154.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Anonymous. Summaries for patients. Reducing the prescription of hormone replacement therapy after the release of study results. *Ann Intern Med* 2004;141(2):147.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Anonymous. Strategies to reduce medication errors with reference to older adults. *Nurs Stand* 2006;20(41):53-7.

Full-text Exclude - Not original peer-reviewed data

Anonymous. Government rolls out computerised CBT. *Mental Health Today* 2007:6-6.

Full-text Exclude - Not original peer-reviewed data

Anonymous. Infobytes: from the Internet to informatics. Evidence-based resources for PDAs. *Nursing (Lond)* 2007;37(8):58.

Full-text Exclude - Not original peer-reviewed data

Anonymous. From the literature. *Med Ref Serv Q* 2008;27(2):229-237.

Full-text Exclude - Not original peer-reviewed data

Anonymous. AARC Clinical Practice Guidelines. Endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. *Respir Care* 2010;55(6):758-64.

Full-text Exclude - Not original peer-reviewed data

Arguin PM, Navin AW, Steele SF, et al. Health communication during SARS. *Emerg Infect Dis* 2004;10(2):377-80.

Full-text Exclude - Not original peer-reviewed data

Armstrong WF. [Commentary on] Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *ACC Cardiosource Review Journal* 2007;16(8):28-29.

Full-text Exclude - Not original peer-reviewed data

Arnold SR, Straus SE. Interventions to improve antibiotic prescribing practices in ambulatory care. *Cochrane Database Syst Rev* 2005(4):CD003539.

Full-text Exclude - Not original peer-reviewed data

Aronsky D, Fiszman M, Chapman WW, et al. Combining decision support methodologies to diagnose pneumonia. *Proc Amia Symp* 2001:12-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Arora P, Mustafa RA, Karam J, et al. Care of elderly patients with chronic kidney disease. *Int Urol Nephrol* 2006;38(2):363-70.

Full-text Exclude - No electronic CDSS or KMS intervention

Arya SC, Agarwal N. Apropos "evaluation of a rapid, point-of-care device for the diagnosis of hepatitis C infection". *J Clin Virol* 2010;49(1):77.

Full-text Exclude - Not original peer-reviewed data

Asaro PV, Sheldahl AL, Char DM. Physician perspective on computerized order-sets with embedded guideline information in a commercial emergency department information system. *AMIA Annu Symp Proc* 2005:6-10.

Full-text Exclude - Not original peer-reviewed data

Asberg A, Falck P, Undset LH, et al. Computer-assisted cyclosporine dosing performs better than traditional dosing in renal transplant recipients: results of a pilot study. *Ther Drug Monit* 2010;32(2):152-8.

Full-text Exclude - Sample size <50

Ash JS, Anderson NR, Tarczy-Hornoch P, et al. People and organizational issues in research systems implementation. *J Am Med Inform Assoc* 2008;15(3):283-9.

Full-text Exclude - Not original peer-reviewed data

Ashford P, Gozzard D, Jones J, et al. Guidelines for blood bank computing. *Transfus Med* 2000;10(4):307-14.

Full-text Exclude - Not original peer-reviewed data

Ather MH, Talati J, Biyabani R. Physician responsibility for removal of implants: the case for a computerized program for tracking overdue double-J stents. *Tech Urol* 2000;6(3):189-92.

Full-text Exclude - No electronic CDSS or KMS intervention

Atlas SJ, Grant RW, Lester WT, et al. A Cluster-Randomized Trial of a Primary Care Informatics-Based System for Breast Cancer Screening. *J Gen Intern Med* 2010.

Full-text Exclude - No electronic CDSS or KMS intervention

Augstein P, Vogt L, Kohnert KD, et al. Outpatient assessment of Karlsburg Diabetes Management System-based decision support. *Diabetes Care* 2007;30(7):1704-8.

Full-text Exclude - Sample size <50

Austin SM, Balas EA, Mitchell JA, et al. Effect of physician reminders on preventive care: meta-analysis of randomized clinical trials. *Proc Annu Symp Comput Appl Med Care* 1994:121-4.

Full-text Exclude - Not original peer-reviewed data

Aviles W, Ortega O, Kuan G, et al. Quantitative assessment of the benefits of specific information technologies applied to clinical studies in developing countries. *Am J Trop Med Hyg* 2008;78(2):311-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Ayello EA, Sibbald RG. Developing and evaluating pressure ulcer guidelines. *World Council of Enterostomal Therapists Journal* 2007;27(1):8.

Full-text Exclude - Not original peer-reviewed data

Ayres-de-Campos D, Ugwumadu A, Banfield P, et al. A randomised clinical trial of intrapartum fetal monitoring with computer analysis and alerts versus previously available monitoring. *BMC Pregnancy Childbirth* 2010;10:71.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Bailey TC, Noirot LA, Blickensderfer A, et al. An intervention to improve secondary prevention of coronary heart disease. *Arch Intern Med* 2007;167(6):586-90.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Bailey TC, Noirot LA, Gage BF, et al. Improving adherence to coronary heart disease secondary prevention medication guidelines at a community hospital. *AMIA Annu Symp Proc* 2006:850.

Full-text Exclude - No electronic CDSS or KMS intervention

Baird TK, Broekemeier RL, Anderson MW. Effectiveness of a computer-supported refill reminder system. *Am J Hosp Pharm* 1984;41(11):2395-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Bairstow PJ, Persaud J, Mendelson R, et al. Reducing inappropriate diagnostic practice through education and decision support. *Int J Qual Health Care* 2010;22(3):194-200.

Full-text Exclude - No electronic CDSS or KMS intervention

Baker AM, Lafata JE, Ward RE, et al. A Web-based diabetes care management support system. *Jt Comm J Qual Improv* 2001;27(4):179-90.

Full-text Exclude - No acceptable comparator

Baker RD, Weinand C, Jeng JC, et al. Using ordinal logistic regression to evaluate the performance of laser-Doppler predictions of burn-healing time. *BMC Med Res Methodol* 2009;9:11.

Full-text Exclude - No electronic CDSS or KMS intervention

Bakken S. Informatics for patient safety: a nursing research perspective. *Annu Rev Nurs Res* 2006;24:219-54.

Full-text Exclude - Not original peer-reviewed data

Bakken S, Currie LM, Lee NJ, et al. Integrating evidence into clinical information systems for nursing decision support. *Int J Med Inform* 2008;77(6):413-20.

Full-text Exclude - Not original peer-reviewed data

Bakken S, Ruland CM. Translating clinical informatics interventions into routine clinical care: how can the RE-AIM framework help? *J Am Med Inform Assoc* 2009;16(6):889-97.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Balas EA, Mitchell JA, Bopp K, et al. The Columbia Registry of Controlled Clinical Computer Trials. *Proc Annu Symp Comput Appl Med Care* 1992:220-4.

Full-text Exclude - Not original peer-reviewed data

Bankhead C, Richards SH, Peters TJ, et al. Improving attendance for breast screening among recent non-attenders: a randomised controlled trial of two interventions in primary care. *J Med Screen* 2001;8(2):99-105.

Full-text Exclude - No electronic CDSS or KMS intervention

Banner MJ, Euliano NR, Macintyre NR, et al. Ventilator advisory system employing load and tolerance strategy recommends appropriate pressure support ventilation settings: multisite validation study. *Chest* 2008;133(3):697-703.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Barajas-Nava L, Solà I, Delgado-Noguera M, et al. Quality assessment of clinical practice guidelines in perioperative care: a systematic appraisal. *Quality and Safety in Health Care* 2010;19(6):1.

Full-text Exclude - Not original peer-reviewed data

Barbato A, Panizzolo C, Biserna L, et al. Asthma prevalence and drug prescription in asthmatic children. *Eur Ann Allergy Clin Immunol* 2003;35(2):47-51.

Full-text Exclude - No electronic CDSS or KMS intervention

Barenfanger J, Short MA, Groesch AA. Improved antimicrobial interventions have benefits. *J Clin Microbiol* 2001;39(8):2823-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Barnett GO, Winickoff RN, Morgan MM, et al. A computer-based monitoring system for follow-up of elevated blood pressure. *Med Care* 1983;21(4):400-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Barnett PG, Rodgers JH. Use of the Decision Support System for VA cost-effectiveness research. *Med Care* 1999;37(4 Suppl Va):AS63-70.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Baron RC, Melillo S, Rimer BK, et al. Intervention to increase recommendation and delivery of screening for breast, cervical, and colorectal cancers by healthcare providers a systematic review of provider reminders. *Am J Prev Med* 2010;38(1):110-7.

Full-text Exclude - Not original peer-reviewed data

Barrett JR, Strayer SM, Schubart JR. Assessing medical residents' usage and perceived needs for personal digital assistants. *Int J Med Inform* 2004;73(1):25-34.

Full-text Exclude - No electronic CDSS or KMS intervention

Bartlett G, Tamblyn R, Huang A, et al. Evaluation of standardized tasks for primary care physicians using the MOXXI electronic prescribing and integrated drug management system. *AMIA Annu Symp Proc* 2003:786.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Basch E, Artz D, Iasonos A, et al. Evaluation of an online platform for cancer patient self-reporting of chemotherapy toxicities. *J Am Med Inform Assoc* 2007;14(3):264-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Bates DW. The quality case for information technology in healthcare. BMC Med Inform Decis Mak 2002;2:7.

Full-text Exclude - Not original peer-reviewed data

Bates DW. Getting in Step: Electronic Health Records and their Role in Care Coordination. J Gen Intern Med 2010;25(3):174-176.

Full-text Exclude - Not original peer-reviewed data

Bates DW, Evans RS, Murff H, et al. Detecting adverse events using information technology. J Am Med Inform Assoc 2003;10(2):115-28.

Full-text Exclude - Not original peer-reviewed data

Bates DW, Gawande AA, Bates DW, et al. Improving safety with information technology. N Engl J Med 2003;348(25):2526-34.

Full-text Exclude - Not original peer-reviewed data

Bauer BA, Lee M, Bergstrom L, et al. Internal medicine resident satisfaction with a diagnostic decision support system (DXplain) introduced on a teaching hospital service. Proc Amia Symp 2002:31-5.

Full-text Exclude - No acceptable comparator

Baumlin KM, Shapiro JS, Weiner C, et al. Clinical information system and process redesign improves emergency department efficiency. Joint Commission Journal on Quality & Patient Safety 2010;36(4):179-185.

Full-text Exclude - No electronic CDSS or KMS intervention

Bavdekar SB, Pawar M. Evaluation of an Internet delivered pediatric diagnosis support system (ISABEL) in a tertiary care center in India. Indian Pediatr 2005;42(11):1086-91.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Bayreuther J, Macgregor A, Sajjanhar T. Management of limb fractures in children under 1 year of age in a dedicated paediatric emergency department. Emerg Med J 2009;26(3):173-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Becker H, Stuifbergen AK, Dormire SL. The effects of hormone therapy decision support for women with mobility impairments. Health Care Women Int 2009;30(9):845-54.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Beech BA. Electronic fetal monitoring. Inherited clinical guidelines. Pract Midwife 2001;4(7):31-3.

Full-text Exclude - Not original peer-reviewed data

Beecroft C, Martin H, Puntis JW. How often do parenteral nutrition prescriptions for the newborn need to be individualized? Clin Nutr 1999;18(2):83-5.

Full-text Exclude - No acceptable comparator

Beerenhout CH, Kooman JP, Luik AJ, et al. Optimizing renal replacement therapy--a case for online filtration therapies? Nephrol Dial Transplant 2002;17(12):2065-70.

Full-text Exclude - Not original peer-reviewed data

Bekkering GE, Hendriks HJ, van Tulder MW, et al. Effect on the process of care of an active strategy to implement clinical guidelines on physiotherapy for low back pain: a cluster randomised controlled trial. Qual Saf Health Care 2005;14(2):107-12.

Full-text Exclude - No electronic CDSS or KMS intervention

Bekkering GE, van Tulder MW, Hendriks EJ, et al. Implementation of clinical guidelines on physical therapy for patients with low back pain: randomized trial comparing patient outcomes after a standard and active implementation strategy. Phys Ther 2005;85(6):544-55.

Full-text Exclude - No electronic CDSS or KMS intervention

Belda TE, Gajic O, Rabatin JT, et al. Practice variability in management of acute respiratory distress syndrome: bringing evidence and clinician education to the bedside using a web-based teaching tool. Respir Care 2004;49(9):1015-21.

Full-text Exclude - No electronic CDSS or KMS intervention

Belperio PS, Mole LX, Boothroyd DB, et al. Provider prescribing of 4 antiretroviral agents after implementation of drug use guidelines in the Department of Veterans Affairs. J Manag Care Pharm 2009;15(4):323-34.

Full-text Exclude - No acceptable comparator

Benkhaial A, Kaltschmidt J, Weisshaar E, et al. Prescribing errors in patients with documented drug allergies: comparison of ICD-10 coding and written patient notes. *Pharm World Sci* 2009;31(4):464-72.
Full-text Exclude - No electronic CDSS or KMS intervention

Bennett JW, Glasziou P, Del Mar C, et al. A computerised prescribing decision support system to improve patient adherence with prescribing. A randomised controlled trial. *Aust Fam Physician* 2003;32(8):667-71.
Full-text Exclude - No electronic CDSS or KMS intervention

Bennett JW, Glasziou PP. Computerised reminders and feedback in medication management: a systematic review of randomised controlled trials. *Med J Aust* 2003;178(5):217-22.
Full-text Exclude - Not original peer-reviewed data

Bennett KM, Briggs D, Zucker M, et al. A four-year experience with patient individualized heparin and protamine dosing using the Hemochron RxDx system. *J Extra Corpor Technol* 2001;33(1):19-22.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Bennett SJ, Litzelman DK, Wright A, et al. The PUMP UP tailored computerized program for heart failure care. *Nurs Outlook* 2006;54(1):39-45.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Bennis C, McGrath D, Caulfield B, et al. A common awareness and knowledge platform for studying and enabling independent living-CAPSIL. *IEEE*; 2010: 1-7.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Benton S. A successful anaemia management algorithm that achieves and maintains optimum haemoglobin status. *J Ren Care* 2008;34(2):54-8.
Full-text Exclude - No acceptable comparator

Berlin A, Sorani M, Sim I. A taxonomic description of computer-based clinical decision support systems. *J Biomed Inform* 2006;39(6):656-67.
Full-text Exclude - Not original peer-reviewed data

Berlin L. Tracking for breast cancer. *AJR Am J Roentgenol* 1998;170(1):93-5.
Full-text Exclude - Not original peer-reviewed data

Bernardes J, Costa-Pereira A. A multicentre comparative study of 17 experts and an intelligent computer system for managing labour using the cardiotocogram. *Br J Obstet Gynaecol* 1996;103(5):489-90.
Full-text Exclude - Not original peer-reviewed data

Berner ES, Houston TK, Ray MN, et al. Improving ambulatory prescribing safety with a handheld decision support system: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(2):171-9.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Berner ES, Maisiak RS, Heuderbert GR, et al. Clinician performance and prominence of diagnoses displayed by a clinical diagnostic decision support system. *AMIA Annu Symp Proc* 2003:76-80.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Bernstein K, Andersen U. Managing care pathways combining SNOMED CT, archetypes and an electronic guideline system. *Stud Health Technol Inform* 2008;136:353-8.
Full-text Exclude - Not original peer-reviewed data

Bertoli R, Bissig M, Caronzolo D, et al. Assessment of potential drug-drug interactions at hospital discharge. *Swiss Med Wkly* 2010;140:w13043.
Full-text Exclude - No acceptable comparator

Beuscart-Zephir MC, Pelayo S, Degoulet P, et al. A usability study of CPOE's medication administration functions: impact on physician-nurse cooperation. *Stud Health Technol Inform* 2004;107(Pt 2):1018-22.
Full-text Exclude - No electronic CDSS or KMS intervention

Beyerman K. Case management: finding the problem early. *Lippincotts Case Manag* 2001;6(4):169-76.
Full-text Exclude - No electronic CDSS or KMS intervention

Biber F. Implementierungsstrategien klinischer Pfade–Barrierenorientierte Interventionen am Beispiel „proximale Femurfraktur“. *Universitätsbibliothek Marburg*; 2010.

Full-text Exclude - Not original peer-reviewed data
Bindels R, Hasman A, van Wersch JW, et al.
Evaluation of an automated test ordering and
feedback system for general practitioners in daily
practice. *Int J Med Inform* 2004;73(9-10):705-12.
Full-text Exclude - No acceptable comparator

Black LA, McMeel C, McTear M, et al.
Implementing autonomy in a diabetes management
system. *J Telemed Telecare* 2005;11 Suppl 1:6-8.
*Full-text Exclude - Poster (or other publication type
providing insufficient detail)*

Blum JM, Kruger GH, Sanders KL, et al. Specificity
improvement for network distributed physiologic
alarms based on a simple deterministic reactive
intelligent agent in the critical care environment. *J
Clin Monit Comput* 2009;23(1):21-30.
*Full-text Exclude - CDSS/KMS not implemented in
clinical setting*

Bohicchio GV, Smit PA, Moore R, et al. Pilot study
of a web-based antibiotic decision management
guide. *J Am Coll Surg* 2006;202(3):459-67.
*Full-text Exclude - CDSS/KMS not implemented in
clinical setting*

Boegl K, Anastassova N, Adlassnig KP, et al.
Knowledge-based computer-aided decision support
in prenatal toxoplasmosis screening (TempToxopert).
AMIA Annu Symp Proc 2005:897.
*Full-text Exclude - Poster (or other publication type
providing insufficient detail)*

Bolton LB. Improving the acute care practice
environment through technology. *Nurs Outlook*
2006;54(3):120-1.
Full-text Exclude - Not original peer-reviewed data

Bonevski B, Sanson-Fisher RW, Campbell E, et al.
Randomized controlled trial of a computer strategy to
increase general practitioner preventive care. *Prev
Med* 1999;29(6 Pt 1):478-86.
*Full-text Exclude - No electronic CDSS or KMS
intervention*

Bonner L, Simons C, Parker L, et al. 'To take care of
the patients': Qualitative analysis of Veterans Health
Administration personnel experiences with a clinical
informatics system. *Implementation science: IS*
2010;5:63.
Full-text Exclude - No acceptable comparator

Bonnevie L, Thomsen T, Jorgensen T. The use of
computerized decision support systems in preventive
cardiology--principal results from the national
PRECARD survey in Denmark. *Eur J Cardiovasc
Prev Rehabil* 2005;12(1):52-5.
Full-text Exclude - No acceptable comparator

Bonney W. Is it appropriate, or ethical, to use health
data collected for the purpose of direct patient care to
develop computerized predictive decision support
tools? *Stud Health Technol Inform* 2009;143:115-21.
Full-text Exclude - Not original peer-reviewed data

Boord JB, Sharifi M, Greevy RA, et al. Computer-
based insulin infusion protocol improves glycemia
control over manual protocol. *J Am Med Inform
Assoc* 2007;14(3):278-87.
Full-text Exclude - No outcome of interest

Borbolla D, Otero C, Lobach DF, et al.
Implementation of a clinical decision support system
using a service model: results of a feasibility study.
Stud Health Technol Inform 2010;160(Pt 2):816-20.
Full-text Exclude - No acceptable comparator

Bosworth HB, Olsen MK, McCant F, et al.
Hypertension Intervention Nurse Telemedicine Study
(HINTS): testing a multifactorial tailored
behavioral/educational and a medication management
intervention for blood pressure control. *Am Heart J*
2007;153(6):918-24.
*Full-text Exclude - CDSS/KMS not implemented in
clinical setting*

Bouaud J, Seroussi B, Brizon A, et al. How updating
textual clinical practice guidelines impacts clinical
decision support systems: a case study with bladder
cancer management. *Stud Health Technol Inform*
2007;129(Pt 2):829-33.
*Full-text Exclude - CDSS/KMS not implemented in
clinical setting*

Bouaud J, Seroussi B, Falcoff H, et al. Design factors
for success or failure of guideline-based decision
support systems: an hypothesis involving case
complexity. *AMIA Annu Symp Proc* 2006:71-5.
*Full-text Exclude - CDSS/KMS not implemented in
clinical setting*

Boyle CA, Newton T, Milgrom P. Development of a
UK version of CARL: a computer program for
conducting exposure therapy for the treatment of
dental injection fear. *SAAD Dig* 2010;26:8-11.
*Full-text Exclude - No electronic CDSS or KMS
intervention*

Braithwaite J, Coiera E. Beyond patient safety Flatland. J R Soc Med 2010;103(6):219-225.
Full-text Exclude - Not original peer-reviewed data

Braswell A, Duggar S. The new look of bedside technology. The point-of-care evolution drives providers to rethink nursing workflow and medication management. Nurs Manage 2006;Suppl:14, 16-8, 32.
Full-text Exclude - Not original peer-reviewed data

Bravata DM, McDonald K, Owens DK, et al. Bioterrorism preparedness and response: use of information technologies and decision support systems. Evid Rep Technol Assess (Summ) 2002(59):1-8.
Full-text Exclude - Not original peer-reviewed data

Brehaut JC, Graham ID, Wood TJ, et al. Measuring acceptability of clinical decision rules: validation of the Ottawa acceptability of decision rules instrument (OADRI) in four countries. Med Decis Making 2010;30(3):398-408.
Full-text Exclude - No electronic CDSS or KMS intervention

Breslow MJ, Rosenfeld BA, Doerfler M, et al. Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcomes: an alternative paradigm for intensivist staffing. Crit Care Med 2004;32(1):31-8.
Full-text Exclude - No electronic CDSS or KMS intervention

Brietzke SA. Evidence-based medicine: a primer for the busy clinician. Mo Med 2008;105(6):481-8.
Full-text Exclude - Not original peer-reviewed data

Brigl B. Decision support, knowledge representation and management: A broad methodological spectrum. Findings from the Decision Support, Knowledge Representation and Management. Yearb Med Inform 2006;81-3.
Full-text Exclude - Not original peer-reviewed data

Brokel JM, Schwichtenberg TJ, Wakefield DS, et al. Evaluating Clinical Decision Support Rules as an Intervention in Clinician Workflows With Technology. Cin-Computers Informatics Nursing 2011;29(1):36-42.
Full-text Exclude - No acceptable comparator

Brosseau L, Lineker S, Bell M, et al. People getting a grip on arthritis: A knowledge transfer strategy to empower patients with rheumatoid arthritis and osteoarthritis. Health Educ J 2010.
Full-text Exclude - No electronic CDSS or KMS intervention

Brown JJ, Wacogne I, Fleckney S, et al. Achieving early surgery for undescended testes: Quality improvement through a multifaceted approach to guideline implementation. Child Care Health Dev 2004;30(2):97-102.
Full-text Exclude - No electronic CDSS or KMS intervention

Brown S, Black K, Mrochek S, et al. RADARx: Recognizing, Assessing, and Documenting Adverse Rx events. Proc Amia Symp 2000:101-5.
Full-text Exclude - No acceptable comparator

Brownogohl K, Kennedy K, Krotki K, et al. Increasing immunization: a Medicaid managed care model. Pediatrics 1997;99(1):E4.
Full-text Exclude - No electronic CDSS or KMS intervention

Bryan C, Boren SA. The use and effectiveness of electronic clinical decision support tools in the ambulatory/primary care setting: a systematic review of the literature. Inform Prim Care 2008;16(2):79-91.
Full-text Exclude - Not original peer-reviewed data

Bucher HC, Rickenbach M, Young J, et al. Randomized trial of a computerized coronary heart disease risk assessment tool in HIV-infected patients receiving combination antiretroviral therapy. Antivir Ther 2010;15(1):31-40.
Full-text Exclude - No outcome of interest

Bullard MJ, Emond SD, Graham TA, et al. Informatics and knowledge translation. Acad Emerg Med 2007;14(11):996-1002.
Full-text Exclude - Not original peer-reviewed data

Bullard MJ, Meurer DP, Colman I, et al. Supporting clinical practice at the bedside using wireless technology. Acad Emerg Med 2004;11(11):1186-92.
Full-text Exclude - No electronic CDSS or KMS intervention

Burack RC, Gimotty PA, Stengle W, et al. Detroit's avoidable mortality project: breast cancer control for inner-city women. Public Health Rep 1989;104(6):527-35.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Burke JP, Pestotnik SL. Antibiotic use and microbial resistance in intensive care units: impact of computer-assisted decision support. *J Chemother* 1999;11(6):530-5.

Full-text Exclude - No acceptable comparator

Burke R, Rossi A, Wilner B, et al. Transforming patient and family access to medical information: utilisation patterns of a patient-accessible electronic health record. *Cardiol Young* 2010;20(05):477-484.

Full-text Exclude - No electronic CDSS or KMS intervention

Burkiewicz JS, Vesta KS, Hume AL. Update in handheld electronic resources for evidence-based practice in the community setting. *Ann Pharmacother* 2005;39(12):2100-4.

Full-text Exclude - Not original peer-reviewed data

Burns KE, Lellouche F, Lessard MR. Automating the weaning process with advanced closed-loop systems. *Intensive Care Med* 2008;34(10):1757-65.

Full-text Exclude - Not original peer-reviewed data

Bury J, Hurt C, Roy A, et al. LISA: a web-based decision-support system for trial management of childhood acute lymphoblastic leukaemia. *Br J Haematol* 2005;129(6):746-54.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Butzlaff M, Vollmar HC, Floer B, et al. Learning with computerized guidelines in general practice?: A randomized controlled trial. *Fam Pract* 2004;21(2):183-8.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Byrne CM. Impact of prospective computerized clinical decision support information and targeted assistance on nursing home resident outcomes [Ph.D.]. State University of New York at Albany; 2005.

Full-text Exclude - Not original peer-reviewed data

Cabassa SC, Guttman MS, Parietti E, et al. Nurse-generated reminder system to reduce catheter associated urinary tract infection. *UPNAAI Nursing Journal* 2010;6(1):35-38.

Full-text Exclude - Not original peer-reviewed data

Cabrero-Canosa M, Hernandez-Pereira E, Moret-Bonillo V. Intelligent diagnosis of sleep apnea syndrome. *IEEE Eng Med Biol Mag* 2004;23(2):72-81.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Cameron KA, Persell SD, Brown T, et al. Patient Outreach to Promote Colorectal Cancer Screening Among Patients With an Expired Order for Colonoscopy: A Randomized Controlled Trial. *Arch Intern Med* 2010.

Full-text Exclude - No electronic CDSS or KMS intervention

Camp MC, Camp JS, Ray AO, et al. Demographic and geographic analysis of providers of cosmetic services in the greater Los Angeles area: 2008 to 2009. *Plast Reconstr Surg* 2010;126(2):115e-6e.

Full-text Exclude - Not original peer-reviewed data

Campbell J, Campbell S, Woodward G. Getting evidence into practice using an asthma desktop tool. *Aust Fam Physician* 2006;35(1-2):32-3.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Campbell R, Ash J. Comparing bedside information tools: a user-centered, task-oriented approach. *AMIA Annu Symp Proc* 2005:101-5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Campbell R, Ash J. An evaluation of five bedside information products using a user-centered, task-oriented approach. *J Med Libr Assoc* 2006;94(4):435-41, e206-7.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Campion TR, Jr., May AK, Waitman LR, et al. Effects of blood glucose transcription mismatches on a computer-based intensive insulin therapy protocol. *Intensive Care Med* 2010;36(9):1566-70.

Full-text Exclude - No acceptable comparator

Caprini JA, Hyers TM. Compliance with antithrombotic guidelines. *Manag Care* 2006;15(9):49-50, 53-60, 66.

Full-text Exclude - No electronic CDSS or KMS intervention

Carlton KH, Dillard N, Campbell BR, et al. Personal digital assistants for classroom and clinical use. *Comput Inform Nurs* 2007;25(5):253-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Carmichael M. Healthy at any age. *Newsweek* 2010;155-156(26-1):48-52.

Full-text Exclude - Not original peer-reviewed data

Carroll C, Marsden P, Soden P, et al. Involving users in the design and usability evaluation of a clinical decision support system. *Comput Methods Programs Biomed* 2002;69(2):123-35.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Carroll JK, Lewis BA, Marcus BH, et al. Computerized tailored physical activity reports: A randomized controlled trial. *Am J Prev Med* 2010;39(2):148-156.

Full-text Exclude - No electronic CDSS or KMS intervention

Carroll K, Rounsaville B. Computer-assisted Therapy in Psychiatry: Be Brave—It's a New World. *Current psychiatry reports* 2010:1-7.

Full-text Exclude - Not original peer-reviewed data

Carter CN, Ronald NC, Steele JH, et al. Knowledge-based patient screening for rare and emerging infectious/parasitic diseases: a case study of brucellosis and murine typhus. *Emerg Infect Dis* 1997;3(1):73-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Cartwright J, de Sylva S, Glasgow M, et al. Inaccessible information is useless information: addressing the knowledge gap. *J Med Pract Manage* 2002;18(1):36-41.

Full-text Exclude - Not original peer-reviewed data

Caruba T, Colombet I, Gillaizeau F, et al. Chronology of prescribing error during the hospital stay and prediction of pharmacist's alerts overriding: a prospective analysis. *BMC Health Serv Res* 2010;10:13.

Full-text Exclude - No electronic CDSS or KMS intervention

Castledine G. New initiative to provide evidence-based IV care. *Br J Nurs* 2002;11(20):1351.

Full-text Exclude - Not original peer-reviewed data

Cawood TJ, Hunt PJ, O'Shea D, et al. Recommended evaluation of adrenal incidentalomas is costly, has high false-positive rates and confers a risk of fatal cancer that is similar to the risk of the adrenal lesion becoming malignant; time for a rethink? *Eur J Endocrinol* 2009;161(4):513-27.

Full-text Exclude - Not original peer-reviewed data

Chaillet N, Dube E, Dugas M, et al. Evidence-based strategies for implementing guidelines in obstetrics: a systematic review. *Obstet Gynecol* 2006;108(5):1234-45.

Full-text Exclude - Not original peer-reviewed data

Chambers CV, Balaban DJ, Carlson BL, et al. The effect of microcomputer-generated reminders on influenza vaccination rates in a university-based family practice center. *J Am Board Fam Pract* 1991;4(1):19-26.

Full-text Exclude - Mandatory compliance CDSS

Chan PS, Oetgen WJ, Buchanan D, et al. Cardiac Performance Measure Compliance in Outpatients. *J Am Coll Cardiol* 2010;56(1):8-14.

Full-text Exclude - No electronic CDSS or KMS intervention

Chandrashekar NK. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2010;5(2):E1; author reply E1-2.

Full-text Exclude - Not original peer-reviewed data

Chang PL, Li YC, Wang TM, et al. Evaluation of a decision-support system for preoperative staging of prostate cancer. *Med Decis Making* 1999;19(4):419-27.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med* 2006;144(10):742-52.

Full-text Exclude - Not original peer-reviewed data

Chen C, Chen K, Hsu CY, et al. A guideline-based decision support for pharmacological treatment can improve the quality of hyperlipidemia management. *Comput Methods Programs Biomed* 2010;97(3):280-285.

Full-text Exclude - No acceptable comparator

Chin MH, Cook S, Drum ML, et al. Improving diabetes care in midwest community health centers with the health disparities collaborative. *Diabetes Care* 2004;27(1):2-8.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Christakis DA, Wright JA. Can continuity of care be improved? Results from a randomized pilot study. *Ambul Pediatr* 2004;4(4):336-9.

Full-text Exclude - No outcome of interest

Christensen A, Christrup LL, Fabricius PE, et al. Survey of patient and physician assessment of a compliance reminder device in the treatment of hypertension. *Blood Press* 2009;18(5):280-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Christensen MB, Christensen B, Mortensen JT, et al. Intervention among frequent attenders of the out-of-hours service: a stratified cluster randomized controlled trial. *Scand J Prim Health Care* 2004;22(3):180-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Chuang JH, Hripcsak G, Jenders RA. Considering clustering: a methodological review of clinical decision support system studies. *Proc Amia Symp* 2000:146-50.

Full-text Exclude - Not original peer-reviewed data

Cimino JJ. An integrated approach to computer-based decision support at the point of care. *Trans Am Clin Climatol Assoc* 2007;118:273-88.

Full-text Exclude - No acceptable comparator

Civitaresse LA, DeGregorio N. Congestive heart failure clinical outcomes study in a private community medical group. *J Am Board Fam Pract* 1999;12(6):467-72.

Full-text Exclude - No electronic CDSS or KMS intervention

Claiborne N, Videka L, Postiglione P, et al. Alcohol screening, evaluation, and referral for veterans. *Journal of Social Work Practice in the Addictions* 2010;10(3):308-326.

Full-text Exclude - No acceptable comparator

Clancy TR. Predicting the impact of an electronic health record on practice patterns using computational modeling and simulation [Ph.D.]. University of Iowa; 2006.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Clarke HF, Bradley C, Whytock S, et al. Pressure ulcers: implementation of evidence-based nursing practice. *J Adv Nurs* 2005;49(6):578-90.

Full-text Exclude - No acceptable comparator

Clarke JR, Hayward CZ, Santora TA, et al. Computer-generated trauma management plans: comparison with actual care. *World J Surg* 2002;26(5):536-8.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Clifford A, Jackson Pulver L, Richmond R, et al. Disseminating best-evidence health-care to Indigenous health-care settings and programs in Australia: identifying the gaps. *Health Promot Int* 2009;24(4):404-15.

Full-text Exclude - Not original peer-reviewed data

Cohen J. Computers for colonoscopy training: where do they fit in? *Gastrointest Endosc* 2010;71(2):308-11.

Full-text Exclude - Not original peer-reviewed data

Cohn SL, Adekile A, Mahabir V. Improved use of thromboprophylaxis for deep vein thrombosis following an educational intervention. *J Hosp Med* 2006;1(6):331-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Coiera E, Walther M, Nguyen K, et al. Architecture for knowledge-based and federated search of online clinical evidence. *J Med Internet Res* 2005;7(5):e52.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Coiera E, Westbrook J, Wyatt J. The safety and quality of decision support systems. *Yearb Med Inform* 2006:20-5.

Full-text Exclude - Not original peer-reviewed data

Coiera E, Westbrook JI, Rogers K. Clinical decision velocity is increased when meta-search filters enhance an evidence retrieval system. *J Am Med Inform Assoc* 2008;15(5):638-46.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Coleman M, Mabuza AM, Kok G, et al. Evaluation of an operational malaria outbreak identification and

response system in Mpumalanga Province, South Africa. *Malar J* 2008;7:69.

Full-text Exclude - No electronic CDSS or KMS intervention

Colombet I, Bura-Riviere A, Chatila R, et al. Personalized versus non-personalized computerized decision support system to increase therapeutic quality control of oral anticoagulant therapy: an alternating time series analysis. *BMC Health Serv Res* 2004;4(1):27.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Colpaert K, Hoste E, Van Hoecke S, et al. Implementation of a real-time electronic alert based on the RIFLE criteria for acute kidney injury in ICU patients. *Acta Clin Belg Suppl* 2007(2):322-5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Colvine K, Kerr AJ, McLachlan A, et al. Cardiovascular disease risk factor assessment and management in gout: an analysis using guideline-based electronic clinical decision support. *N Z Med J* 2008;121(1285):73-81.

Full-text Exclude - No acceptable comparator

Conroy S, Sweis D, Planner C, et al. Interventions to reduce dosing errors in children: a systematic review of the literature. *Drug Saf* 2007;30(12):1111-25.

Full-text Exclude - Not original peer-reviewed data

Cook CB, McMichael JP, Dunbar VG, et al. Description and preliminary evaluation of a Multiagent Intelligent Dosing System (MAIDS) to manage combination insulin-oral agent therapy in type 2 diabetes. *Diabetes Technol Ther* 2005;7(6):937-47.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Cook DA. Medical Decision Making: What Do We Trust? *J Gen Intern Med* 2010;25(4):282-283.

Full-text Exclude - Not original peer-reviewed data

Cordingley JJ, Vlasselaers D, Dormand NC, et al. Intensive insulin therapy: enhanced Model Predictive Control algorithm versus standard care. *Intensive Care Med* 2009;35(1):123-8.

Full-text Exclude - Sample size <50

Cornelius FH. Handheld technology and nursing education: utilization of handheld technology in development of clinical decision-making in undergraduate nursing students [Ph.D.]. Drexel University; 2005.

Full-text Exclude - Not original peer-reviewed data

Cosgrove SE, Patel A, Song X, et al. Impact of different methods of feedback to clinicians after postprescription antimicrobial review based on the Centers For Disease Control and Prevention's 12 Steps to Prevent Antimicrobial Resistance Among Hospitalized Adults. *Infect Control Hosp Epidemiol* 2007;28(6):641-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Costa A, Ayres-de-Campos D, Costa F, et al. Prediction of neonatal acidemia by computer analysis of fetal heart rate and ST event signals. *Am J Obstet Gynecol* 2009;201(5):464 e1-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Costanza ME, Stoddard AM, Luckmann R, et al. Promoting mammography: Results of a randomized trial of telephone counseling and a medical practice intervention. *Am J Prev Med* 2000;19(1):39-46.

Full-text Exclude - No electronic CDSS or KMS intervention

Cottrell E, Roddy E, Foster NE. The attitudes, beliefs and behaviours of GPs regarding exercise for chronic knee pain: a systematic review. *BMC Fam Pract* 2010;11(1):4.

Full-text Exclude - Not original peer-reviewed data

Coumou HC, Meijman FJ. How do primary care physicians seek answers to clinical questions? A literature review. *J Med Libr Assoc* 2006;94(1):55-60.

Full-text Exclude - Not original peer-reviewed data

Cowan JA, Heckerling PS, Parker JB. Effect of a fact sheet reminder on performance of the periodic health examination: a randomized controlled trial. *Am J Prev Med* 1992;8(2):104-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Cramer JA, Rosenheck R. Enhancing medication compliance for people with serious mental illness. *J Nerv Ment Dis* 1999;187(1):53-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Cricelli I. Use of personal digital assistant devices in order to access, consult and apply a corpus of clinical guidelines and decision-based support documentation like the Italian SPREAD Guidelines on stroke disease. *Neurol Sci* 2006;27 Suppl 3:S238-9.
Full-text Exclude - Not original peer-reviewed data

Cross SS, Harrison RF, Sanders DS. Supporting decisions in clinical medicine: neural networks in lower gastrointestinal haemorrhage. *Lancet* 2003;362(9392):1250-1.
Full-text Exclude - Not original peer-reviewed data

Czosnowski QA, Swanson JM, Lobo BL, et al. Evaluation of glycemic control following discontinuation of an intensive insulin protocol. *J Hosp Med* 2009;4(1):28-34.
Full-text Exclude - No electronic CDSS or KMS intervention

Daley MF, Steiner JF, Kempe A, et al. Quality improvement in immunization delivery following an unsuccessful immunization recall. *Ambul Pediatr* 2004;4(3):217-23.
Full-text Exclude - No electronic CDSS or KMS intervention

Damiani G, Pinnarelli L, Colosimo SC, et al. The effectiveness of computerized clinical guidelines in the process of care: a systematic review. *BMC Health Serv Res* 2010;10(1):2.
Full-text Exclude - Not original peer-reviewed data

Daniels JP, King AD, Cochrane DD, et al. A human factors and survey methodology-based design of a web-based adverse event reporting system for families. *Int J Med Inf* 2010;79(5):339-348.
Full-text Exclude - No electronic CDSS or KMS intervention

Datta SK, Oddone EZ, Olsen MK, et al. Economic analysis of a tailored behavioral intervention to improve blood pressure control for primary care patients. *Am Heart J* 2010;160(2):257-63.
Full-text Exclude - No electronic CDSS or KMS intervention

Daugaard S. Comment on "The implementation of guidelines and computerised forms improves the completeness of cancer pathology reporting. The CROPS project: a randomised controlled trial in pathology" by Branston and colleagues. *Eur J Cancer* 2002;38(6):743-4.
Full-text Exclude - Not original peer-reviewed data

Davey P. The potential role of computerized decision support systems to improve empirical antibiotic prescribing. *J Antimicrob Chemother* 2006;58(6):1105-6.
Full-text Exclude - Not original peer-reviewed data

Davidson PC, Hebblewhite HR, Steed RD, et al. Analysis of guidelines for basal-bolus insulin dosing: basal insulin, correction factor, and carbohydrate-to-insulin ratio. *Endocr Pract* 2008;14(9):1095-101.
Full-text Exclude - No electronic CDSS or KMS intervention

Davis RL. Computerized physician order entry systems: the coming of age for outpatient medicine. *PLoS Med* 2005;2(9):e290.
Full-text Exclude - Not original peer-reviewed data

Dawes M, Sampson U. Knowledge management in clinical practice: a systematic review of information seeking behavior in physicians. *Int J Med Inform* 2003;71(1):9-15.
Full-text Exclude - Not original peer-reviewed data

de Borst GJ, Froio A, Biasi G, et al. The need for questionnaires in vascular surgery: the paradigm of carotid revascularisation. *Eur J Vasc Endovasc Surg* 2010;40(3):309-11.
Full-text Exclude - Not original peer-reviewed data

de Nooijer J, Lechner L, Candel M, et al. Short- and long-term effects of tailored information versus general information on determinants and intentions related to early detection of cancer. *Prev Med* 2004;38(6):694-703.
Full-text Exclude - No electronic CDSS or KMS intervention

de Richemond J. Work in Progress: What is "Enough"? 2010.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

de Vries-Bouwstra J, Le Cessie S, Allaart C, et al. Using predicted disease outcome to provide differentiated treatment of early rheumatoid arthritis. *J Rheumatol* 2006;33(9):1747-53.
Full-text Exclude - No electronic CDSS or KMS intervention

de Wet C, Bowie P. The preliminary development and testing of a global trigger tool to detect error and patient harm in primary-care records. *Postgrad Med J* 2009;85(1002):176-80.

Full-text Exclude - No electronic CDSS or KMS intervention

Dean NC, Suchyta MR, Bateman KA, et al. Implementation of admission decision support for community-acquired pneumonia. *Chest* 2000;117(5):1368-77.

Full-text Exclude - No electronic CDSS or KMS intervention

Debrix I, Combeau D, Stephan F, et al. Clinical practice guidelines for the use of albumin: results of a drug use evaluation in a Paris hospital. *Tenon Hospital Paris. Pharm World Sci* 1999;21(1):11-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Degoulet P, Chatellier G, Devries C, et al. Computer-assisted techniques for evaluation and treatment of hypertensive patients. *Am J Hypertens* 1990;3(2):156-63.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Delaney B. General practice at the cutting edge of information technology, or failing to keep pace? *Br J Gen Pract* 2010;60(573):239-240.

Full-text Exclude - Not original peer-reviewed data

Delaney B. Primary care research in the era of translational medicine, challenges and successes. *Fam Pract* 2010;27(2):127-128.

Full-text Exclude - Not original peer-reviewed data

Dell'Aquila R, Rodighiero MP, Bonello M, et al. Automated peritoneal dialysis technology. *Contrib Nephrol* 2003(140):278-93.

Full-text Exclude - Not original peer-reviewed data

Delpierre C, Cuzin L, Fillaux J, et al. A systematic review of computer-based patient record systems and quality of care: more randomized clinical trials or a broader approach? *Int J Qual Health Care* 2004;16(5):407-16.

Full-text Exclude - Not original peer-reviewed data

DeMolles DA, Sparrow D, Gottlieb DJ, et al. A pilot trial of a telecommunications system in sleep apnea management. *Med Care* 2004;42(8):764-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Derose SF, Dudl JR, Benson VM, et al. Point-of-Service reminders for prescribing cardiovascular medications. *Am J Manag Care* 2005;11(5):298-304.

Full-text Exclude - No electronic CDSS or KMS intervention

Devine EB, Hollingworth W, Hansen RN, et al. Electronic prescribing at the point of care: a time-motion study in the primary care setting. *Health Serv Res* 2010;45(1):152-71.

Full-text Exclude - No electronic CDSS or KMS intervention

Dexheimer JW, Jones I, Waitman R, et al. Prospective evaluation of a closed-loop, computerized reminder system for pneumococcal vaccination in the emergency department. *AMIA Annu Symp Proc* 2006:910.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Dexheimer JW, Sanders DL, Rosenbloom ST, et al. Prompting clinicians: a systematic review of preventive care reminders. *AMIA Annu Symp Proc* 2005:938.

Full-text Exclude - Not original peer-reviewed data

Dexheimer JW, Talbot TR, Sanders DL, et al. Prompting clinicians about preventive care measures: a systematic review of randomized controlled trials. *J Am Med Inform Assoc* 2008;15(3):311-20.

Full-text Exclude - Not original peer-reviewed data

Dexter PR, Wolinsky FD, Gramelspacher GP, et al. Effectiveness of computer-generated reminders for increasing discussions about advance directives and completion of advance directive forms. A randomized, controlled trial. *Ann Intern Med* 1998;128(2):102-10.

Full-text Exclude - No outcome of interest

Di Pentima MC, Chan S, Eppes SC, et al. Antimicrobial prescription errors in hospitalized children: role of antimicrobial stewardship program in detection and intervention. *Clin Pediatr (Phila)* 2009;48(5):505-12.

Full-text Exclude - No electronic CDSS or KMS intervention

Di Pietro T, Coburn G, Dharamshi N, et al. What nurses want: diffusion of an innovation. *J Nurs Care Qual* 2008;23(2):140-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Dickinson KC, Sharma R, Duckart JP, et al. VA healthcare costs of a collaborative intervention for chronic pain in primary care. *Med Care* 2010;48(1):38-44.

Full-text Exclude - No electronic CDSS or KMS intervention

Dijkstra RF, Niessen LW, Braspenning JC, et al. Patient-centred and professional-directed implementation strategies for diabetes guidelines: a cluster-randomized trial-based cost-effectiveness analysis. *Diabet Med* 2006;23(2):164-70.

Full-text Exclude - No electronic CDSS or KMS intervention

Dollarhide AW, Rutledge T, Weinger MB, et al. Use of a handheld computer application for voluntary medication event reporting by inpatient nurses and physicians. *J Gen Intern Med* 2008;23(4):418-422.

Full-text Exclude - No electronic CDSS or KMS intervention

Donders GG, Riphagen I. Short-term results of a new programme for breast carcinoma risk analysis. *Eur J Cancer Prev* 1993;2 Suppl 3:59-63.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Dong SL, Bullard MJ, Meurer DP, et al. Predictive validity of a computerized emergency triage tool. *Acad Emerg Med* 2007;14(1):16-21.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Dong SL, Bullard MJ, Meurer DP, et al. Emergency triage: comparing a novel computer triage program with standard triage. *Acad Emerg Med* 2005;12(6):502-7.

Full-text Exclude - No outcome of interest

Donnan PT, McLernon D, Dillon JF, et al. Development of a decision support tool for primary care management of patients with abnormal liver function tests without clinically apparent liver disease: a record-linkage population cohort study and decision analysis (ALFIE). *Health Technol Assess* 2009;13(25):iii-iv, ix-xi, 1-134.

Full-text Exclude - No electronic CDSS or KMS intervention

Doolan DF, Bates DW, James BC. The use of computers for clinical care: a case series of advanced U.S. sites. *J Am Med Inform Assoc* 2003;10(1):94-107.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Doran D, Paterson J, Clark C, et al. A pilot study of an electronic interprofessional evidence-based care planning tool for clients with mental health problems and addictions. *Worldviews Evid Based Nurs* 2010;7(3):174-84.

Full-text Exclude - Sample size <50

Doran DM, Haynes RB, Kushniruk A, et al. Supporting evidence-based practice for nurses through information technologies. *Worldviews Evid Based Nurs* 2010;7(1):4-15.

Full-text Exclude - No acceptable comparator

Doran DM, Mylopoulos J, Kushniruk A, et al. Evidence in the palm of your hand: development of an outcomes-focused knowledge translation intervention. *Worldviews Evid Based Nurs* 2007;4(2):69-77.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Dormann H, Criegee-Rieck M, Neubert A, et al. Implementation of a computer-assisted monitoring system for the detection of adverse drug reactions in gastroenterology. *Aliment Pharmacol Ther* 2004;19(3):303-9.

Full-text Exclude - No acceptable comparator

Dorr D, Bonner LM, Cohen AN, et al. Informatics systems to promote improved care for chronic illness: a literature review. *J Am Med Inform Assoc* 2007;14(2):156-63.

Full-text Exclude - Not original peer-reviewed data

Douglas VC, Johnston CM, Elkins J, et al. Head computed tomography findings predict short-term stroke risk after transient ischemic attack. *Stroke* 2003;34(12):2894-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Dowding D, Mitchell N, Randell R, et al. Nurses' use of computerised clinical decision support systems: a case site analysis. *J Clin Nurs* 2009;18(8):1159-1167.

Full-text Exclude - No acceptable comparator

Downs SM, Biondich PG, Anand V, et al. Using Arden Syntax and adaptive turnaround documents to evaluate clinical guidelines. *AMIA Annu Symp Proc* 2006:214-8.

Full-text Exclude - Not an evaluation study

Drake RE, Deegan PE, Woltmann E, et al. Comprehensive Electronic Decision Support Systems. *Psychiatr Serv* 2010;61(7):714-717.
Full-text Exclude - Not original peer-reviewed data

Draper AL, Pouliot CK. Surgical Time-Out: Driving Change Through Electronic Documentation. *Jognn- Journal of Obstetric Gynecologic and Neonatal Nursing* 2010;39:S55-S56.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Dreiseitl S, Binder M. Do physicians value decision support? A look at the effect of decision support systems on physician opinion. *Artif Intell Med* 2005;33(1):25-30.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Dreiseitl S, Binder M, Hable K, et al. Computer versus human diagnosis of melanoma: evaluation of the feasibility of an automated diagnostic system in a prospective clinical trial. *Melanoma Res* 2009;19(3):180-4.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Dreiseitl S, Binder M, Vinterbo S, et al. Applying a decision support system in clinical practice: results from melanoma diagnosis. *AMIA Annu Symp Proc* 2007:191-5.
Full-text Exclude - No acceptable comparator

Droney J, Riley J, Bertsche, et al., Multidisciplinary pain management based on a computerized clinical decision support system in cancer pain patients. *Pain* 2009;147(1-3):1-2.
Full-text Exclude - Not original peer-reviewed data

Dufour JC, Bouvenot J, Ambrosi P, et al. Textual guidelines versus computable guidelines: a comparative study in the framework of the PRESQUID project in order to appreciate the impact of guideline format on physician compliance. *AMIA Annu Symp Proc* 2006:219-23.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Dupuis EA, White HF, Newman D, et al. Tracking abnormal cervical cancer screening: evaluation of an EMR-based intervention. *J Gen Intern Med* 2010;25(6):575-80.
Full-text Exclude - No electronic CDSS or KMS intervention

Durand MA, Stiel M, Boivin J, et al. Where is the theory? Evaluating the theoretical frameworks described in decision support technologies. *Patient Educ Couns* 2008;71(1):125-35.
Full-text Exclude - Not original peer-reviewed data

Durieux P, Trinquart L, Colombet I, et al. Computerized advice on drug dosage to improve prescribing practice. *Cochrane Database of Systematic Reviews* 2008(3).
Full-text Exclude - Not original peer-reviewed data

Duru OK, Mangione CM, Steers NW, et al. The association between clinical care strategies and the attenuation of racial/ethnic disparities in diabetes care: the Translating Research Into Action for Diabetes (TRIAD) Study. *Med Care* 2006;44(12):1121-8.
Full-text Exclude - No electronic CDSS or KMS intervention

Dykes PC, Acevedo K, Boldrighini J, et al. Clinical practice guideline adherence before and after implementation of the HEARTFELT (HEART Failure Effectiveness & Leadership Team) intervention. *J Cardiovasc Nurs* 2005;20(5):306-14.
Full-text Exclude - No electronic CDSS or KMS intervention

East TD, Heermann LK, Bradshaw RL, et al. Efficacy of computerized decision support for mechanical ventilation: results of a prospective multi-center randomized trial. *Proc Amia Symp* 1999:251-5.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

East TD, Morris AH. Decision support systems for management of mechanical ventilation. *Respir Care* 1996;41(4):327-340.
Full-text Exclude - Not original peer-reviewed data

Ebrahiminia V, Riou C, Seroussi B, et al. Design of a Decision Support System for Chronic Diseases Coupling Generic Therapeutic Algorithms with Guideline-Based Specific Rules. In: Hasman A, Haux R, VanderLei J, DeClercq E, France FHR, eds. *Ubiquity: Technologies for Better Health in Aging Societies*. Vol. 124; 2006:483-488.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Eccles M, Grimshaw J, Steen N, et al. The design and analysis of a randomized controlled trial to evaluate computerized decision support in primary care: the COGENT study. *Fam Pract* 2000;17(2):180-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Eden A, Pizov R, Toderis L, et al. The impact of an electronic reminder on the use of alarms after separation from cardiopulmonary bypass. *Anesth Analg* 2009;108(4):1203-8.

Full-text Exclude - Mandatory compliance CDSS

Edgeworth A, Coles EC. An evaluation of near-patient testing of anticoagulant control in general practice. *Int J Health Care Qual Assur* 2010;23(4):410-21.

Full-text Exclude - Sample size <50

Effken J, Hoshi M, Lin Z, et al. Clinical information systems to improve trauma outcomes: usability study 1... 37th Annual Communicating Nursing Research Conference/18th Annual WIN Assembly, "Hallmarks of Quality: Generating and Using Knowledge," held April 22-24, 2004, Portland Marriott Downtown, Portland, Oregon. *Commun Nurs Res* 2004;37:392-392.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Egan JE, Casadonte P, Gartenmann T, et al. The Physician Clinical Support System-Buprenorphine (PCSS-B): a novel project to expand/improve buprenorphine treatment. *J Gen Intern Med* 2010;25(9):936-41.

Full-text Exclude - No acceptable comparator

Ehrenberg A, Fraser KD, Gunningberg L. Can decision support improve nurses' use of knowledge? *J Wound Ostomy Continence Nurs* 2004;31(5):256-8.

Full-text Exclude - Not original peer-reviewed data

Eisenstein EL, Lobach DF, Kawamoto K, et al. A randomized clinical trial of clinical decision support in a rural community health network serving lower income individuals: study design and baseline characteristics. *Stud Health Technol Inform* 2009;143:220-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ekelund U, Forberg JL. New methods for improved evaluation of patients with suspected acute coronary syndrome in the emergency department. *Postgrad Med J* 2008;84(988):83-6.

Full-text Exclude - Not original peer-reviewed data

Eliasson M, Bastholm P, Forsberg P, et al. Janus computerised prescribing system provides pharmacological knowledge at point of care - design, development and proof of concept. *Eur J Clin Pharmacol* 2006;62(4):251-8.

Full-text Exclude - No acceptable comparator

Elstein AS, Friedman CP, Wolf FM, et al. Effects of a decision support system on the diagnostic accuracy of users: a preliminary report. *J Am Med Inform Assoc* 1996;3(6):422-8.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Elvidge K. Improving pain & symptom management for advanced cancer patients with a clinical decision support system. *Stud Health Technol Inform* 2008;136:169-74.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Embi PJ, Jain A, Harris CM. Physicians' perceptions of an electronic health record-based clinical trial alert approach to subject recruitment: a survey. *BMC Med Inform Decis Mak* 2008;8:13.

Full-text Exclude - No electronic CDSS or KMS intervention

Emery J. The GRAIDS Trial: the development and evaluation of computer decision support for cancer genetic risk assessment in primary care. *Ann Hum Biol* 2005;32(2):218-27.

Full-text Exclude - No electronic CDSS or KMS intervention

Ensor CR, Kockler DR, Dugger RW, et al. Erythropoiesis-stimulating agents: creation and validation of a computerized prescriber order entry alert. *Ann Pharmacother* 2009;43(6):1143-4.

Full-text Exclude - Not original peer-reviewed data

Epstein RH, Dexter F, Ehrenfeld JM, et al. Implications of event entry latency on anesthesia information management decision support systems. *Anesth Analg* 2009;108(3):941-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Erdman HP. A computer consultation program for primary care physicians. Impact of decisionmaking model and explanation capability. *Med Care* 1987;25(12 Suppl):S138-47.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ernesater A, Engstrom M, Holmstrom I, et al. Incident reporting in nurse-led national telephone triage in Sweden: the reported errors reveal a pattern that needs to be broken. *J Telemed Telecare* 2010;16(5):243-7.

Full-text Exclude - No acceptable comparator

Ernesater A, Holmstrom I, Engstrom M. Telenurses' experiences of working with computerized decision support: supporting, inhibiting and quality improving. *J Adv Nurs* 2009;65(5):1074-83.

Full-text Exclude - No acceptable comparator

Eslami S, Abu-Hanna A, de Keizer NF. Evaluation of outpatient computerized physician medication order entry systems: a systematic review. *J Am Med Inform Assoc* 2007;14(4):400-6.

Full-text Exclude - Not original peer-reviewed data

Eslami S, de Keizer NF, Abu-Hanna A. The impact of computerized physician medication order entry in hospitalized patients--a systematic review. *Int J Med Inform* 2008;77(6):365-76.

Full-text Exclude - Not original peer-reviewed data

Eslami S, de Keizer NF, Abu-Hanna A, et al. Effect of a clinical decision support system on adherence to a lower tidal volume mechanical ventilation strategy. *J Crit Care* 2009;24(4):523-529.

Full-text Exclude - No outcome of interest

Esposito S, Pelucchi C, Tel F, et al. Factors conditioning effectiveness of a reminder/recall system to improve influenza vaccination in asthmatic children. *Vaccine* 2009;27(5):633-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Etter JF, Perneger TV. Post-intervention effect of a computer tailored smoking cessation programme. *J Epidemiol Community Health* 2004;58(10):849-51.

Full-text Exclude - No electronic CDSS or KMS intervention

Evans RS, Johnson KV, Flint VB, et al. Unit-wide notification of ventilator disconnections. *AMIA Annu Symp Proc* 2005:951.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Evans RS, Johnson KV, Flint VB, et al. Enhanced notification of critical ventilator events. *J Am Med Inform Assoc* 2005;12(6):589-95.

Full-text Exclude - No acceptable comparator

Evans RS, Wallace CJ, Lloyd JF, et al. Rapid identification of hospitalized patients at high risk for MRSA carriage. *J Am Med Inform Assoc* 2008;15(4):506-12.

Full-text Exclude - No acceptable comparator

Falcão F, Russomano T. Clinical validation of the earlobe arterialized blood collector. *Aviat Space Environ Med* 2010;81(11):1053-4.

Full-text Exclude - No electronic CDSS or KMS intervention

Farion KJ, Michalowski W, Rubin S, et al. Prospective evaluation of the MET-AP system providing triage plans for acute pediatric abdominal pain. *Int J Med Inform* 2008;77(3):208-18.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Farrington M, Cullen L, Dawson C. Assessment of oral mucositis in adult and pediatric oncology patients: an evidence-based approach. *ORL Head Neck Nurs* 2010;28(3):8-15.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Feldman PH, McDonald MV, Mongoven JM, et al. Home-based blood pressure interventions for blacks. *Circ Cardiovasc Qual Outcomes* 2009;2(3):241-8.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Feldman PH, Murtaugh CM, Pezzin LE, et al. Just-in-time evidence-based e-mail "reminders" in home health care: impact on patient outcomes. *Health Serv Res* 2005;40(3):865-85.

Full-text Exclude - No electronic CDSS or KMS intervention

Feldstein A, Simon SR, Schneider J, et al. How to design computerized alerts to safe prescribing practices. *Jt Comm J Qual Saf* 2004;30(11):602-13.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Fielding S, Fayers PM, Ramsay CR. Investigating the missing data mechanism in quality of life outcomes: a comparison of approaches. *Health Qual Life Outcomes* 2009;7:57.

Full-text Exclude - No electronic CDSS or KMS intervention

Fieschi M, Dufour JC, Staccini P, et al. Medical decision support systems: old dilemmas and new paradigms? *Methods Inf Med* 2003;42(3):190-8.
Full-text Exclude - Not original peer-reviewed data

Figar S, Waisman G, De Quiros FG, et al. Narrowing the gap in hypertension: effectiveness of a complex antihypertensive program in the elderly. *Dis Manag* 2004;7(3):235-43.
Full-text Exclude - No electronic CDSS or KMS intervention

Fiscella K, Yosha A, Hendren SK, et al. Get screened: a pragmatic randomized controlled trial to increase mammography and colorectal cancer screening in a large, safety net practice. *BMC Health Serv Res* 2010;10:280.
Full-text Exclude - No electronic CDSS or KMS intervention

Fishbein DB, Willis BC, Cassidy WM, et al. A comprehensive patient assessment and physician reminder tool for adult immunization: effect on vaccine administration. *Vaccine* 2006;24(18):3971-83.
Full-text Exclude - No electronic CDSS or KMS intervention

Fitzmaurice DA, Hobbs FD, Delaney BC, et al. Review of computerized decision support systems for oral anticoagulation management. *Br J Haematol* 1998;102(4):907-9.
Full-text Exclude - Not original peer-reviewed data

Fitzmaurice DA, Hobbs FD, McManus RJ. Thromboembolism. *Am Fam Physician* 2004;69(1):132-4.
Full-text Exclude - Not original peer-reviewed data

Fitzmaurice DA, Hobbs FD, Murray ET, et al. Evaluation of computerized decision support for oral anticoagulation management based in primary care. *Br J Gen Pract* 1996;46(410):533-5.
Full-text Exclude - Sample size <50

Fitzpatrick RB. Decision support with Ovid. *Med Ref Serv Q* 2001;20(4):47-53.
Full-text Exclude - Not original peer-reviewed data

Flanagan JR, Peterson M, Dayton C, et al. Email recruitment to use web decision support tools for pneumonia. *Proc Amia Symp* 2002:255-9.

Full-text Exclude - No acceptable comparator

Fleeman N, McLeod C, Bagust A, et al. The clinical effectiveness and cost-effectiveness of testing for cytochrome P450 polymorphisms in patients with schizophrenia treated with antipsychotics: a systematic review and economic evaluation. *Health Technol Assess* 2010;14(3):1-157, iii.
Full-text Exclude - Not original peer-reviewed data

Fleming B, Silver A, Ocepek-Welikson K, et al. The relationship between organizational systems and clinical quality in diabetes care. *Am J Manag Care* 2004;10(12):934-44.
Full-text Exclude - No electronic CDSS or KMS intervention

Flottorp S, Håvvelsrud K, Oxman AD. Process evaluation of a cluster randomized trial of tailored interventions to implement guidelines in primary care--why is it so hard to change practice? *Fam Pract* 2003;20(3):333-339.
Full-text Exclude - No electronic CDSS or KMS intervention

Fonarow GC, Albert NM, Curtis AB, et al. Improving evidence-based care for heart failure in outpatient cardiology practices: primary results of the Registry to Improve the Use of Evidence-Based Heart Failure Therapies in the Outpatient Setting (IMPROVE HF). *Circulation* 2010;122(6):585-96.
Full-text Exclude - No electronic CDSS or KMS intervention

Ford II J, Wise M, Wisdom J. A Peek Inside the Box: How Information Flows Through Substance Abuse Treatment Agencies. *Journal of Technology in Human Services* 2010;28(3):121-143.
Full-text Exclude - No electronic CDSS or KMS intervention

Fox J, Glasspool D, Patkar V, et al. Delivering clinical decision support services: There is nothing as practical as a good theory. *Journal of Biomedical Informatics* 2010;43(5):831-843.
Full-text Exclude - Not original peer-reviewed data

Fox J, Patkar V, Chronakis I, et al. From practice guidelines to clinical decision support: closing the loop. *J R Soc Med* 2009;102(11):464-473.
Full-text Exclude - Not original peer-reviewed data

Foy J, Kelleher K, Laraque D. Enhancing Pediatric Mental Health Care: Strategies for Preparing a Primary Care Practice. *Pediatrics* 2010;125(Supplement):S87.

Full-text Exclude - Not original peer-reviewed data

Foy R, Hawthorne G, Gibb I, et al. A cluster randomised controlled trial of educational prompts in diabetes care: study protocol. *Implement Sci* 2007;2:22.

Full-text Exclude - Not an evaluation study

Foy R, Hempel S, Rubenstein L, et al. Meta-analysis: Effect of Interactive Communication Between Collaborating Primary Care Physicians and Specialists. *Ann Intern Med* 2010;152(4):247.

Full-text Exclude - Not original peer-reviewed data

Frances CD, Alperin P, Adler JS, et al. Does a fixed physician reminder system improve the care of patients with coronary artery disease? A randomized controlled trial. *West J Med* 2001;175(3):165-6.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Fransen J, Twisk JW, Creemers MC, et al. Design and analysis of a randomized controlled trial testing the effects of clinical decision support on the management of rheumatoid arthritis. *Arthritis Rheum* 2004;51(1):124-7.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Freiherr G. Smartphones hustle to maintain pace with rapid rate of change in oncology. *Oncology News International* 2010;19(8):22-23.

Full-text Exclude - Not original peer-reviewed data

French SD, Green S, Buchbinder R, et al. Interventions for improving the appropriate use of imaging in people with musculoskeletal conditions. *Cochrane Database Syst Rev* 2010(1):CD006094.

Full-text Exclude - Not original peer-reviewed data

Fretheim A, Oxman AD, Treweek S, et al. Rational Prescribing in Primary Care (RaPP-trial). A randomised trial of a tailored intervention to improve prescribing of antihypertensive and cholesterol-lowering drugs in general practice [ISRCTN48751230]. *BMC Health Serv Res* 2003;3(1):5.

Full-text Exclude - Not original peer-reviewed data

Froio A, Jan de Borst G, Moll FL, et al. The need for questionnaires in vascular surgery: the paradigm of carotid revascularization. A joint survey by the International Society for Vascular Surgery (ISVS) and the European Society for Vascular Surgery (ESVS). *Vascular* 2010;18(6):309-12.

Full-text Exclude - Not original peer-reviewed data

Fry JP, Neff RA. Periodic prompts and reminders in health promotion and health behavior interventions: systematic review. *J Med Internet Res* 2009;11(2):e16.

Full-text Exclude - Not original peer-reviewed data

Fuchs J, Heller I, Topilsky M, et al. CaDet, a computer-based clinical decision support system for early cancer detection. *Cancer Detect Prev* 1999;23(1):78-87.

Full-text Exclude - No acceptable comparator

Fung CH, Tsai JS, Lulejian A, et al. An evaluation of the Veterans Health Administration's clinical reminders system: a national survey of generalists. *J Gen Intern Med* 2008;23(4):392-8.

Full-text Exclude - No acceptable comparator

Fung CH, Woods JN, Asch SM, et al. Variation in implementation and use of computerized clinical reminders in an integrated healthcare system. *Am J Manag Care* 2004;10(11 Pt 2):878-85.

Full-text Exclude - No acceptable comparator

Furuno JP, Schweizer ML, McGregor JC, et al. Economics of infection control surveillance technology: cost-effective or just cost? *Am J Infect Control* 2008;36(3 Suppl):S12-7.

Full-text Exclude - Not original peer-reviewed data

Gagnon M, Ouimet M, Godin G, et al. Study protocol Multi-level analysis of electronic health record adoption by health care professionals: A study protocol. 2010.

Full-text Exclude - No electronic CDSS or KMS intervention

Galanter W, Liu XF, Lambert BL. Analysis of computer alerts suggesting oral medication use during computerized order entry of i.v. medications. *Am J Health Syst Pharm* 2010;67(13):1101-5.

Full-text Exclude - No acceptable comparator

Gance-Cleveland B, Gilbert LH, Kopanos T, et al. Evaluation of technology to identify and assess overweight children and adolescents. *J Spec Pediatr Nurs* 2010;15(1):72-83.

Full-text Exclude - No outcome of interest

Gao H, McDonnell A, Harrison DA, et al. Systematic review and evaluation of physiological track and trigger warning systems for identifying at-risk patients on the ward. *Intensive Care Med* 2007;33(4):667-79.

Full-text Exclude - Not original peer-reviewed data

Garcia J, Trigo JD, Alesanco A, et al. Design and evaluation of a wireless decision-support system for heart rate variability study in haemodialysis follow-up procedures. *Comput Methods Programs Biomed* 2007;88(3):273-82.

Full-text Exclude - No acceptable comparator

Garcia-Smith D. Building clinical information systems dependence in the nursing work environment. *Commun Nurs Res* 2010;43:401-401.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Garg AX, Adhikari NK, McDonald H, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. *JAMA* 2005;293(10):1223-38.

Full-text Exclude - Not original peer-reviewed data

Garr DR, Ornstein SM, Jenkins RG, et al. The effect of routine use of computer-generated preventive reminders in a clinical practice. *Am J Prev Med* 1993;9(1):55-61.

Full-text Exclude - No acceptable comparator

Garthwaite EA, Will EJ, Bartlett C, et al. Patient-specific prompts in the cholesterol management of renal transplant outpatients: results and analysis of underperformance. *Transplantation* 2004;78(7):1042-7.

Full-text Exclude - No acceptable comparator

Geersing GJ, Janssen K, Oudega R, et al. Diagnostic classification in patients with suspected deep venous thrombosis: physicians' judgement or a decision rule? *Br J Gen Pract* 2010;60(579):742-748.

Full-text Exclude - No electronic CDSS or KMS intervention

Georgiou A, Westbrook J, Braithwaite J. Computerized provider order entry systems—Research imperatives and organizational challenges facing pathology services. *Journal of Pathology Informatics* 2010;1.

Full-text Exclude - Not original peer-reviewed data

Georgiou A, Williamson M, Westbrook JI, et al. The impact of computerised physician order entry systems on pathology services: a systematic review. *Int J Med Inform* 2007;76(7):514-29.

Full-text Exclude - Not original peer-reviewed data

Gerds TA, Cai T, Schumacher M. The performance of risk prediction models. *Biom J* 2008;50(4):457-79.

Full-text Exclude - No electronic CDSS or KMS intervention

Ghosh AK. Clinical applications and update on evidence-based medicine. *J Assoc Physicians India* 2007;55:787-94.

Full-text Exclude - Not original peer-reviewed data

Gibbons M, Bali R, Marshall I, et al. The Potential of Serious Games for Improving Health and Reducing Urban Health Inequalities. *Perspectives of Knowledge Management in Urban Health* 2010:129-136.

Full-text Exclude - Not original peer-reviewed data

Gilhuly TJ, Macleod BA, Dumont GA, et al. Improved neuromuscular blockade using a novel neuromuscular blockade advisory system: a randomized, controlled, clinical trial. *Anesth Analg* 2008;107(5):1609-17.

Full-text Exclude - Sample size <50

Gill JM, Saldarriaga AM. The impact of a computerized physician reminder and a mailed patient reminder on influenza immunizations for older patients. *Del Med J* 2000;72(10):425-30.

Full-text Exclude - No electronic CDSS or KMS intervention

Gimotty PA, Burack RC, George JA. Delivery of preventive health services for breast cancer control: a longitudinal view of a randomized controlled trial. *Health Serv Res* 2002;37(1):65-85.

Full-text Exclude - Mandatory compliance CDSS

Glasgow RE, Nutting PA, King DK, et al. A practical randomized trial to improve diabetes care. *J Gen Intern Med* 2004;19(12):1167-74.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Goicoechea M, Vidal A, Capparelli E, et al. A computer-based system to aid in the interpretation of plasma concentrations of antiretrovirals for therapeutic drug monitoring. *Antivir Ther* 2007;12(1):55-62.

Full-text Exclude - No electronic CDSS or KMS intervention

Goldberg HI, Lessler DS, Mertens K, et al. Self-management support in a web-based medical record: a pilot randomized controlled trial. *Jt Comm J Qual Saf* 2004;30(11):629-35, 589.

Full-text Exclude - No electronic CDSS or KMS intervention

Goldie M. Personalized medicine and informatics. *International Journal of Dental Hygiene* 2010;8(1):76-77.

Full-text Exclude - Not original peer-reviewed data

Goldman L, Cook EF, Brand DA, et al. A computer protocol to predict myocardial infarction in emergency department patients with chest pain. *N Engl J Med* 1988;318(13):797-803.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Goldstein DH, VanDenKerkhof EG, Rimmer MJ. A model for real time information at the patient's side using portable computers on an acute pain service. *Can J Anaesth* 2002;49(7):749-54.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Gonzalez ER, Vanderheyden BA, Ornato JP, et al. Computer-assisted optimization of aminophylline therapy in the emergency department. *Am J Emerg Med* 1989;7(4):395-401.

Full-text Exclude - Mandatory compliance CDSS

Gooder VJ. Predictive value of physiologic variables in bedside caregiver initiated extubation of postoperative cardiac surgery patients [Ph.D.]. University of Utah; 2001.

Full-text Exclude - Not original peer-reviewed data

Gordon NF, English CD, Contractor AS, et al. Effectiveness of three models for comprehensive cardiovascular disease risk reduction. *Am J Cardiol* 2002;89(11):1263-8.

Full-text Exclude - No outcome of interest

Gorin SS, Ashford AR, Lantigua R, et al. Implementing academic detailing for breast cancer screening in underserved communities. *Implement Sci* 2007;2:43.

Full-text Exclude - No electronic CDSS or KMS intervention

Goud R, Jaspers MW, Hasman A, et al. Subjective usability of the CARDSS guideline-based decision support system. *Stud Health Technol Inform* 2008;136:193-8.

Full-text Exclude - No acceptable comparator

Goud R, Peek N, Strijbis AM, et al. A computer-based guideline implementation system for cardiac rehabilitation screening. *Computers in Cardiology* 2005, Vol 32. Vol. 32; 2005:323-326.

Full-text Exclude - No acceptable comparator

Goud R, van Engen-Verheul M, de Keizer NF, et al. The effect of computerized decision support on barriers to guideline implementation: A qualitative study in outpatient cardiac rehabilitation. *Int J Med Inf* 2010;79(6):430-437.

Full-text Exclude - No acceptable comparator

Gouin-Thibault I, Levy C, Pautas E, et al. Improving anticoagulation control in hospitalized elderly patients on warfarin. *J Am Geriatr Soc* 2010;58(2):242-247.

Full-text Exclude - Mandatory compliance CDSS

Grad RM, Pluye P, Meng Y, et al. Assessing the impact of clinical information-retrieval technology in a family practice residency. *J Eval Clin Pract* 2005;11(6):576-86.

Full-text Exclude - No acceptable comparator

Grant RW, Campbell EG, Gruen RL, et al. Prevalence of basic information technology use by U.S. physicians. *J Gen Intern Med* 2006;21(11):1150-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Gravely-Witte S, Leung YW, Nariani R, et al. Effects of cardiac rehabilitation referral strategies on referral and enrollment rates. *Nat Rev Cardiol* 2010;7(2):87-96.

Full-text Exclude - Not original peer-reviewed data

Grayson ML, Melvani S, Kirsa SW, et al. Impact of an electronic antibiotic advice and approval system on antibiotic prescribing in an Australian teaching hospital. *Med J Aust* 2004;180(9):455-8.

Full-text Exclude - No acceptable comparator

Green CJ, Maclure M. Factors critical to successful implementation of clinical decision support for chronic disease management in primary care. *AMIA Annu Symp Proc* 2006:933.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Grey C, Wells S, Riddell T, et al. A comparative analysis of the cardiovascular disease risk factor profiles of Pacific peoples and Europeans living in New Zealand assessed in routine primary care: PREDICT CVD-11. *N Z Med J* 2010;123(1309):62-75.

Full-text Exclude - No acceptable comparator

Grime PR. Computerized cognitive behavioural therapy at work: a randomized controlled trial in employees with recent stress-related absenteeism. *Occup Med (Lond)* 2004;54(5):353-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Grimshaw J, Freemantle N, Wallace S, et al. Developing and implementing clinical practice guidelines. *Qual Health Care* 1995;4(1):55-64.

Full-text Exclude - Not original peer-reviewed data

Grizzle AJ, Mahmood MH, Ko Y, et al. Reasons provided by prescribers when overriding drug-drug interaction alerts. *Am J Manag Care* 2007;13(10):573-8.

Full-text Exclude - No acceptable comparator

Grohman K, Fals-Stewart W. Computer-assisted cognitive rehabilitation with substance-abusing patients: effects on treatment response. *Journal of Cognitive Rehabilitation* 2003;21(4):10-17.

Full-text Exclude - No electronic CDSS or KMS intervention

Gurses AP, Xiao Y. A systematic review of the literature on multidisciplinary rounds to design information technology. *J Am Med Inform Assoc* 2006;13(3):267-76.

Full-text Exclude - Not original peer-reviewed data

Haase A, Follmann M, Skipka G, et al. Developing search strategies for clinical practice guidelines in SUMSearch and Google Scholar and assessing their retrieval performance. *BMC Med Res Methodol* 2007;7:28.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Haberman S, Feldman J, Merhi ZO, et al. Effect of clinical-decision support on documentation compliance in an electronic medical record. *Obstet Gynecol* 2009;114(2 Pt 1):311-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Haberman S, Rotas M, Perlman K, et al. Variations in compliance with documentation using computerized obstetric records. *Obstet Gynecol* 2007;110(1):141-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Hacker E. *Technology and Quality of Life Outcomes*. Elsevier; 2010: 47-58.

Full-text Exclude - Not original peer-reviewed data

Hak E, Hermens RP, Hoes AW, et al. Effectiveness of a co-ordinated nation-wide programme to improve influenza immunisation rates in The Netherlands. *Scand J Prim Health Care* 2000;18(4):237-41.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Haller G, Myles PS, Stoelwinder J, et al. Integrating incident reporting into an electronic patient record system. *J Am Med Inform Assoc* 2007;14(2):175-81.

Full-text Exclude - No electronic CDSS or KMS intervention

Halpin L, Henry L, Dunning E, et al. Comparison of blood glucose management strategies to achieve control following cardiac surgery (computerized versus paper). *AACN Adv Crit Care* 2010;21(2):146-51.

Full-text Exclude - No outcome of interest

Handler JA, Feied CF, Coonan K, et al. Computerized physician order entry and online decision support. *Acad Emerg Med* 2004;11(11):1135-41.

Full-text Exclude - Not original peer-reviewed data

Hands D, Stephens M, Brown D. A systematic review of the clinical and economic impact of drug information services on patient outcome. *Pharm World Sci* 2002;24(4):132-8.

Full-text Exclude - Not original peer-reviewed data

Hannes K, Vander Stichele RH, Simons E, et al. Implementing and optimising an Electronic Library of Health Care in Belgium: results of a pilot study. *Acta Clin Belg* 2007;62(1):48-51.

Full-text Exclude - No acceptable comparator

Harries P, Tomlinson C, Notley L. Randomized controlled trial to test the effectiveness of a referral prioritization decision-training tool for student occupational therapists. *Mental Health Occupational Therapy* 2010;[15](1):26-26.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Haslam D. Patients, clinical practice, and the internet. *Postgrad Med J* 2006;82(966):231-2.

Full-text Exclude - Not original peer-reviewed data

Hassan A, Haefeli WE. Appropriateness of timing of drug administration in electronic prescriptions. *Pharm World Sci* 2010.

Full-text Exclude - No electronic CDSS or KMS intervention

Hatcher I, Sullivan M, Hutchinson J, et al. An intravenous medication safety system: preventing high-risk medication errors at the point of care. *J Nurs Adm* 2004;34(10):437-9.

Full-text Exclude - No acceptable comparator

Haupts S, Ledergerber B, Boni J, et al. Impact of genotypic resistance testing on selection of salvage regimen in clinical practice. *Antivir Ther* 2003;8(5):443-54.

Full-text Exclude - No acceptable comparator

Hauser SE, Demner-Fushman D, Ford GM, et al. Preliminary comparison of three search engines for point of care access to MEDLINE citations. *AMIA Annu Symp Proc* 2006:945.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Haux R, Grothe W, Runkel M, et al. Knowledge retrieval as one type of knowledge-based decision support in medicine: results of an evaluation study. *Int J Biomed Comput* 1996;41(2):69-85.

Full-text Exclude - No acceptable comparator

Haynes RB, Johnston ME, McKibbin KA, et al. A program to enhance clinical use of MEDLINE. A randomized controlled trial. *Online J Curr Clin Trials* 1993;Doc No 56:[4005 words; 39 paragraphs].

Full-text Exclude - No acceptable comparator

Haynes RB, McDonald H, Garg AX, et al. Interventions for helping patients to follow prescriptions for medications. *Cochrane Database Syst Rev* 2002(2):CD000011.

Full-text Exclude - Not original peer-reviewed data

Haynes RB, Ramsden MF, McKibbin KA, et al. Online access to MEDLINE in clinical settings: impact of user fees. *Bull Med Libr Assoc* 1991;79(4):377-81.

Full-text Exclude - No acceptable comparator

Hayward GL, Parnes AJ, Simon SR. Using health information technology to improve drug monitoring: a systematic review. *Pharmacoevidenciol Drug Saf* 2009;18(12):1232-7.

Full-text Exclude - Not original peer-reviewed data

Hayward RS, El-Hajj M, Voth TK, et al. Patterns of use of decision support tools by clinicians. *AMIA Annu Symp Proc* 2006:329-33.

Full-text Exclude - No acceptable comparator

Headrick LA, Speroff T, Pelecanos HI, et al. Efforts to improve compliance with the National Cholesterol Education Program guidelines. Results of a randomized controlled trial. *Arch Intern Med* 1992;152(12):2490-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Heasman PA, McCracken GI, Steen N. Supportive periodontal care: the effect of periodic subgingival debridement compared with supragingival prophylaxis with respect to clinical outcomes. *J Clin Periodontol* 2002;29 Suppl 3:163-72; discussion 195-6.

Full-text Exclude - Not original peer-reviewed data

Heaven B, Murtagh M, Rapley T, et al. Patients or research subjects? A qualitative study of participation in a randomised controlled trial of a complex intervention. *Patient Educ Couns* 2006;62(2):260-70.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Hedegaard U, Damkier P. Problem-oriented drug information: physicians' expectations and impact on clinical practice. *Eur J Clin Pharmacol* 2009;65(5):515-22.

Full-text Exclude - No electronic CDSS or KMS intervention

Heglund SD. Paper or plastic? Handwritten vs. computerized clinical reminder systems: a comparative review. *Southern Online Journal of Nursing Research* 2008;8(2):1p.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Heidenreich P. Improving heart failure care with a reminder attached to the echocardiography report. *Am J Med* 2008;121(10):853-4.

Full-text Exclude - Not original peer-reviewed data

Heidenreich PA, Chacko M, Goldstein MK, et al. ACE inhibitor reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction. *Am J Med* 2005;118(9):1034-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Heiman H, Bates DW, Fairchild D, et al. Improving completion of advance directives in the primary care setting: a randomized controlled trial. *Am J Med* 2004;117(5):318-24.

Full-text Exclude - No outcome of interest

Hejlesen OK, Andreassen S, Frandsen NE, et al. Using a double blind controlled clinical trial to evaluate the function of a Diabetes Advisory System: a feasible approach? *Comput Methods Programs Biomed* 1998;56(2):165-73.

Full-text Exclude - Sample size <50

Helwig AL, Flynn C. Using palm-top computers to improve students' evidence-based decision making. *Acad Med* 1998;73(5):603-4.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Heo JH, Kim YD, Nam HS, et al. A computerized in-hospital alert system for thrombolysis in acute stroke. *Stroke* 2010;41(9):1978-83.

Full-text Exclude - No electronic CDSS or KMS intervention

Herasevich V, Yilmaz M, Khan H, et al. Validation of an electronic surveillance system for acute lung injury. *Intensive Care Med* 2009;35(6):1018-23.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Herman AD, Johnson TM, 2nd, Ritchie CS, et al. Pain management interventions in the nursing home: a structured review of the literature. *J Am Geriatr Soc* 2009;57(7):1258-67.

Full-text Exclude - Not original peer-reviewed data

Hershey CO, Porter DK, Breslau D, et al. Influence of Simple Computerized Feedback on Prescription Charges in an Ambulatory Clinic: A Randomized Clinical Trial. *Med Care* 1986;24(6):472-481.

Full-text Exclude - No electronic CDSS or KMS intervention

Heselmans A, Van de Velde S, Donceel P, et al. Effectiveness of electronic guideline-based implementation systems in ambulatory care settings - a systematic review. *Implement Sci* 2009;4(1):82.

Full-text Exclude - Not original peer-reviewed data

Hinrichsen VL, Kruskal B, O'Brien MA, et al. Using electronic medical records to enhance detection and reporting of vaccine adverse events. *J Am Med Inform Assoc* 2007;14(6):731-735.

Full-text Exclude - No acceptable comparator

Hiranaka DK, Kelly JP. Stability of simultaneous orthognathic surgery on the maxilla and mandible: a computer-assisted cephalometric study. *Int J Adult Orthodon Orthognath Surg* 1987;2(4):193-213.

Full-text Exclude - No electronic CDSS or KMS intervention

Hirsch IB, Goldberg HI, Ellsworth A, et al. A multifaceted intervention in support of diabetes treatment guidelines: a cont trial. *Diabetes Res Clin Pract* 2002;58(1):27-36.

Full-text Exclude - No acceptable comparator

Hodgkinson B, Koch S, Nay R, et al. Strategies to reduce medication errors with reference to older adults. *International Journal of Evidence-Based Healthcare* 2006;4(1):2-41.

Full-text Exclude - Not original peer-reviewed data

Holbrook A, Keshavjee K, Lee H, et al. Individualized electronic decision support and reminders can improve diabetes care in the community. *AMIA Annu Symp Proc* 2005:982.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Holden R, Karsh B. The Technology Acceptance Model: Its past and its future in health care. *Journal of Biomedical Informatics* 2010;43(1):159-172.

Full-text Exclude - Not original peer-reviewed data

Holland DJ, Bradley DW, Khoury JM. Sending men the message about preventive care: an evaluation of communication strategies. *International Journal of Men's Health* 2005;4(2):97-114.

Full-text Exclude - No electronic CDSS or KMS intervention

Holroyd-Leduc JM, Abelseth GA, Khandwala F, et al. A pragmatic study exploring the prevention of delirium among hospitalized older hip fracture patients: Applying evidence to routine clinical practice using clinical decision support. *Implementation Science* 2010;5.

Full-text Exclude - No electronic CDSS or KMS intervention

Honeybourne C, Sutton S, Ward L. Knowledge in the Palm of your hands: PDAs in the clinical setting. *Health Info Libr J* 2006;23(1):51-9.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Horowitz N, Moshkowitz M, Leshno M, et al. Clinical trial: evaluation of a clinical decision-support model for upper abdominal complaints in primary-care practice. *Aliment Pharmacol Ther* 2007;26(9):1277-83.

Full-text Exclude - No electronic CDSS or KMS intervention

Hovenga EJ. Nursing information and the use of electronic health records. *Aust Nurs J* 2001;8(11):39-40.

Full-text Exclude - Not original peer-reviewed data

Hozo I, Djulbegovic B. Using the Internet to calculate clinical action thresholds. *Comput Biomed Res* 1999;32(2):168-85.

Full-text Exclude - No electronic CDSS or KMS intervention

Humphries TL, Carroll N, Chester EA, et al. Evaluation of an electronic critical drug interaction program coupled with active pharmacist intervention. *Ann Pharmacother* 2007;41(12):1979-85.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Hunt DL, Haynes RB, Hanna SE, et al. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. *JAMA* 1998;280(15):1339-46.

Full-text Exclude - Not original peer-reviewed data

Hunt DL, Haynes RB, Hayward RS, et al. Patient-specific evidence-based care recommendations for diabetes mellitus: development and initial clinic experience with a computerized decision support system. *Int J Med Inform* 1998;51(2-3):127-35.

Full-text Exclude - No acceptable comparator

Huntman L, Ward L, Read D, et al. Analysis of allergy alerts within a computerized prescriber-order-entry system. *Am J Health Syst Pharm* 2009;66(4):373-7.

Full-text Exclude - No acceptable comparator

Hwang SH, Lee S, Koo HK, et al. Evaluation of a computer-based adverse-drug-event monitor. *Am J Health Syst Pharm* 2008;65(23):2265-72.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Hysong SJ, Sawhney MK, Wilson L, et al. Provider management strategies of abnormal test result alerts: a cognitive task analysis. *J Am Med Inform Assoc* 2010;17(1):71-7.

Full-text Exclude - No acceptable comparator

Iliffe S, Wilcock J, Griffin M, et al. Evidence-based interventions in dementia: A pragmatic cluster-randomised trial of an educational intervention to promote earlier recognition and response to dementia in primary care (EVIDEM-ED). *Trials* 2010;11:13.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Im EO, Chee W. Evaluation of the decision support computer program for cancer pain management. *Oncol Nurs Forum* 2006;33(5):977-82.

Full-text Exclude - No acceptable comparator

Insua JT. Integration of information technology (IT) for chronic diseases management in Latin America: 5 year experience, Hospital Universitario Austral(HUA), Argentina. *AMIA Annu Symp Proc* 2006:963.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Irigoyen MM, Findley S, Wang D, et al. Challenges and successes of immunization registry reminders at inner-city practices. *Ambul Pediatr* 2006;6(2):100-4.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Isaac T, Weissman JS, Davis RB, et al. Overrides of medication alerts in ambulatory care. *Arch Intern Med* 2009;169(3):305-11.

Full-text Exclude - No acceptable comparator

Ito K. Decision support for inappropriate prescribing... Terrell KM, Perkins AJ, Dexter PR et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: A randomized controlled trial. *J Am Geriatr Soc* 2009;57:1388-1394. *J Am Geriatr Soc* 2010;58(2):416-417.

Full-text Exclude - Not original peer-reviewed data

Jackson GL, Yano EM, Edelman D, et al. Veterans Affairs primary care organizational characteristics associated with better diabetes control. *Am J Manag Care* 2005;11(4):225-37.

Full-text Exclude - No acceptable comparator

Jackson R, Marshall R, Kerr A, et al. QRISK or Framingham for predicting cardiovascular risk? *Br Med J* 2009;339.

Full-text Exclude - Not original peer-reviewed data

Jacobs JL, Apatov N, Gleit M. Increasing vigilance on the medical/surgical floor to improve patient safety. *J Adv Nurs* 2007;57(5):472-81.

Full-text Exclude - No acceptable comparator

Jacobson V, Szilagyi P. Patient reminder and patient recall systems to improve immunization rates. *Cochrane Database Syst Rev* 2005(3):CD003941.

Full-text Exclude - Not original peer-reviewed data

Jadad AR, Haynes RB, Hunt D, et al. The Internet and evidence-based decision-making: a needed synergy for efficient knowledge management in health care. *CMAJ* 2000;162(3):362-5.

Full-text Exclude - Not original peer-reviewed data

Jain S, Seidman J, Blumenthal D. How Health Plans, Health Systems, And Others In The Private Sector Can Stimulate 'Meaningful Use'. *Health Aff (Millwood)* 2010;29(9):1667.

Full-text Exclude - Not original peer-reviewed data

Jamal A, McKenzie KP, Clark MP. The impact of health information technology on the quality of medical and health care: a systematic review. *HIM J* 2009;38(3):26-37.

Full-text Exclude - Not original peer-reviewed data

James AH, Britt RP. Prospective comparative study of computer programs used for management of warfarin. *J Clin Pathol* 1993;46(8):781.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Jannin P, Fitzpatrick JM, Hawkes DJ, et al. Validation of medical image processing in image-guided therapy. *IEEE Trans Med Imaging* 2002;21(12):1445-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Jannin P, Morandi X. Surgical models for computer-assisted neurosurgery. *Neuroimage* 2007;37(3):783-91.

Full-text Exclude - No electronic CDSS or KMS intervention

Jaryno SA, Zucker ML, LaDuca FM. The Hemochron Response Rx/Dx heparin and protamine dosing system. *J Extra Corpor Technol* 2004;36(3):258-62.

Full-text Exclude - No outcome of interest

Javitt JC, Rebitzer JB, Reisman L. Information technology and medical missteps: evidence from a randomized trial. *J Health Econ* 2008;27(3):585-602.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Javitt JC, Steinberg G, Locke T, et al. Using a claims data-based sentinel system to improve compliance with clinical guidelines: results of a randomized prospective study. *Am J Manag Care* 2005;11(2):93-102.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Jenkins ML, Hewitt C, Bakken S. Women's health nursing in the context of the National Health Information Infrastructure. *J Obstet Gynecol Neonatal Nurs* 2006;35(1):141-50.

Full-text Exclude - No acceptable comparator

Jensen SB, Pedersen AM, Vissink A, et al. A systematic review of salivary gland hypofunction and xerostomia induced by cancer therapies: management strategies and economic impact. *Support Care Cancer* 2010;18(8):1061-79.

Full-text Exclude - Not original peer-reviewed data

Jensen SB, Pedersen AM, Vissink A, et al. A systematic review of salivary gland hypofunction and xerostomia induced by cancer therapies: prevalence, severity and impact on quality of life. *Support Care Cancer* 2010;18(8):1039-60.

Full-text Exclude - Not original peer-reviewed data

Jerreat M, Youssouf N, Barker C, et al. Denture care of in-patients: The views of nursing staff and the development of an educational programme on denture care. *Journal of Research in Nursing* 2007;12(2):193-199.

Full-text Exclude - No electronic CDSS or KMS intervention

Jha AK, Laguette J, Seger A, et al. Can surveillance systems identify and avert adverse drug events? A prospective evaluation of a commercial application. *J Am Med Inform Assoc* 2008;15(5):647-53.

Full-text Exclude - No acceptable comparator

Jimbo M, Nease DE, Jr., Ruffin MT, et al. Information technology and cancer prevention. *CA Cancer J Clin* 2006;56(1):26-36; quiz 48-9.

Full-text Exclude - Not original peer-reviewed data

Jirapaet V. A computer expert system prototype for mechanically ventilated neonates development and impact on clinical judgment and information access capability of nurses. *Comput Nurs* 2001;19(5):194-203; quiz 203-5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

John R, Buschman P, Chaszar M, et al. Development and evaluation of a PDA-based decision support system for pediatric depression screening. *Stud Health Technol Inform* 2007;129(Pt 2):1382-6.

Full-text Exclude - No acceptable comparator

Johnston JM, Leung GM, Tin KY, et al. Evaluation of a handheld clinical decision support tool for evidence-based learning and practice in medical undergraduates. *Med Educ* 2004;38(6):628-37.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Johnston ME, Langton KB, Haynes RB, et al. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. A critical appraisal of research. *Ann Intern Med* 1994;120(2):135-42.

Full-text Exclude - Not original peer-reviewed data

Jones D, Bates S, Warrillow S, et al. Effect of an education programme on the utilization of a medical emergency team in a teaching hospital. *Intern Med J* 2006;36(4):231-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Jones KL, Hammer AL, Swenson C, et al. Improving adult immunization rates in primary care clinics. *Nurs Econ* 2008;26(6):404-7.

Full-text Exclude - No acceptable comparator

Jones RS, Richards K, Russell T. Relative contributions of surgeons and decision support systems. *Surg Clin North Am* 2006;86(1):169-79, xi.

Full-text Exclude - Not original peer-reviewed data

Jonsbu J, Aase O, Rollag A, et al. Prospective evaluation of an EDB-based diagnostic program to be used in patients admitted to hospital with acute chest pain. *Eur Heart J* 1993;14(4):441-6.

Full-text Exclude - No acceptable comparator

Juneja R, Roudebush C, Kumar N, et al. Utilization of a computerized intravenous insulin infusion program to control blood glucose in the intensive care unit. *Diabetes Technol Ther* 2007;9(3):232-40.

Full-text Exclude - No acceptable comparator

Kaczorowski J. Primary-care reform in the USA. *Lancet* 2010;376(9740):515-516.

Full-text Exclude - Not original peer-reviewed data

Kaliyadan F, Venkitakrishnan S, Manoj J, et al. Electronic medical records in dermatology: Practical implications. *Indian Journal of Dermatology, Venereology, and Leprology* 2010;75(2):157.

Full-text Exclude - No electronic CDSS or KMS intervention

Kaner E, Heaven B, Rapley T, et al. Medical communication and technology: a video-based process study of the use of decision aids in primary care consultations. *BMC Med Inform Decis Mak* 2007;7:2.

Full-text Exclude - No electronic CDSS or KMS intervention

Kaplan B. Evaluating informatics applications--clinical decision support systems literature review. *Int J Med Inform* 2001;64(1):15-37.

Full-text Exclude - Not original peer-reviewed data

Kaplan B. Evaluating informatics applications--some alternative approaches: theory, social interactionism, and call for methodological pluralism. *Int J Med Inform* 2001;64(1):39-56.

Full-text Exclude - Not original peer-reviewed data

Karbing DS, Allerod C, Thorgaard P, et al. Prospective evaluation of a decision support system for setting inspired oxygen in intensive care patients. *J Crit Care* 2010;25(3):367-74.
Full-text Exclude - Sample size <50

Karsh BT. Beyond usability: designing effective technology implementation systems to promote patient safety. *Qual Saf Health Care* 2004;13(5):388-94.
Full-text Exclude - Not original peer-reviewed data

Kastner M, Lottridge D, Marquez C, et al. Usability evaluation of a clinical decision support tool for osteoporosis disease management. *Implement Sci* 2010;5(1):96.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Kastner M, Straus SE. Clinical decision support tools for osteoporosis disease management: a systematic review of randomized controlled trials. *J Gen Intern Med* 2008;23(12):2095-105.
Full-text Exclude - Not original peer-reviewed data

Katz MS, Efstathiou JA, D'Amico AV, et al. The 'CaP Calculator': an online decision support tool for clinically localized prostate cancer. *BJU Int* 2010;105(10):1417-22.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Katz T, Fisher P, Katz A, et al. The feasibility of a randomised, placebo-controlled clinical trial of homeopathic treatment of depression in general practice. *Homeopathy* 2005;94(3):145-52.
Full-text Exclude - No acceptable comparator

Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. *Arch Intern Med* 2003;163(12):1409-16.
Full-text Exclude - Not original peer-reviewed data

Kavanagh KE, O'Brien N, Glynn LG, et al. WestREN: a description of an Irish academic general practice research network. *BMC Fam Pract* 2010;11:74.
Full-text Exclude - No electronic CDSS or KMS intervention

Kawamoto K, Houlihan CA, Balas EA, et al. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ* 2005;330(7494):765.
Full-text Exclude - Not original peer-reviewed data

Kawamoto K, Lobach DF. Clinical decision support provided within physician order entry systems: a systematic review of features effective for changing clinician behavior. *AMIA Annu Symp Proc* 2003:361-5.
Full-text Exclude - Not original peer-reviewed data

Kawamoto K, Lobach DF. Design, implementation, use, and preliminary evaluation of SEBASTIAN, a standards-based Web service for clinical decision support. *AMIA Annu Symp Proc* 2005:380-4.
Full-text Exclude - No acceptable comparator

Kaye R, Kokia E, Shalev V, et al. Barriers and success factors in health information technology: A practitioner's perspective. *Journal of Management and Marketing in Healthcare* 2010;3(2):163-175.
Full-text Exclude - Not original peer-reviewed data

Kazemi A, Fors UG, Tofighi S, et al. Physician order entry or nurse order entry? Comparison of two implementation strategies for a computerized order entry system aimed at reducing dosing medication errors. *J Med Internet Res* 2010;12(1):e5.
Full-text Exclude - No acceptable comparator

Keeffe B, Subramanian U, Tierney WM, et al. Provider response to computer-based care suggestions for chronic heart failure. *Med Care* 2005;43(5):461-5.
Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Kellett J. The impact of a bedside decision support computer program (DSCP) on coronary care. *Ir Med J* 1997;90(6):240.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Kelley CG. The effectiveness of interventions to increase opportunistic screening with hospitalized patients [Ph.D.]. Case Western Reserve University (Health Sciences); 2001.
Full-text Exclude - Not original peer-reviewed data

Kemper AR, Uren RL, Clark SJ. Adoption of electronic health records in primary care pediatric practices. *Pediatrics* 2006;118(1):e20-4.

Full-text Exclude - No acceptable comparator

Kent DM, Ruthazer R, Griffith JL, et al. A percutaneous coronary intervention-thrombolytic predictive instrument to assist choosing between immediate thrombolytic therapy versus delayed primary percutaneous coronary intervention for acute myocardial infarction. *Am J Cardiol* 2008;101(6):790-5.

Full-text Exclude - No acceptable comparator

Kent RD, Kobti Z, Snowdon A, et al. Towards a Unified Data Management and Decision Support System for Health Care. In: Tsihrintzis GA, Damiani E, Virvou M, Howlett RJ, eds. *Intelligent Interactive Multimedia Systems and Services*. Vol. 6; 2010:205-220.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Kernohan G. A patient initiated computer program improved breast cancer screening practices in primary care [commentary on Williams RB, Boles M, Johnson RE. A patient-initiated system for preventive health care. A randomized trial in community-based primary care practices. *ARCH FAM MED* 1998 Jul/Aug;7:338-45]. *Evidence-Based Nursing* 1999;2(2):57-57.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Kerr AJ, Looi JL, Garofalo D, et al. Acute Predict: a clinician-led cardiovascular disease quality improvement project (Predict-CVD 12). *Heart Lung Circ* 2010;19(5-6):378-83.

Full-text Exclude - No acceptable comparator

Kerr C, Murray E, Stevenson F, et al. Internet interventions for long-term conditions: patient and caregiver quality criteria. *J Med Internet Res* 2006;8(3):e13.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Kershaw B, White RH, Mungall D, et al. Computer-assisted dosing of heparin. Management with a pharmacy-based anticoagulation service. *Arch Intern Med* 1994;154(9):1005-11.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Kessel E, Chi IC, Feldblum P. Postmarketing surveillance of IUDs. *Contracept Deliv Syst* 1983;4(1):15-26.

Full-text Exclude - No electronic CDSS or KMS intervention

Ketcham JD, Lutfey KE, Gerstenberger E, et al. Physician clinical information technology and health care disparities. *Med Care Res Rev* 2009;66(6):658-81.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Kim C, Yoo J, Hwang A, et al. *Development of a computerized exercise intervention program based on stage of change using transtheoretical model* Rio de Janeiro, Brazil: E-papers ServiÃ§os Editoriais; 2003 e-Health for all: designing nursing agenda for the future, NI 2003: proceedings, 8th International Congress in Nursing Informatics, Rio de Janeiro, June 20-25, 2003.).

Full-text Exclude - could not obtain a copy

Kim JA, Gerdin U. A comparative study of nursing diagnosis systems using neural networks and expert systems. *Nursing informatics: the impact of nursing knowledge on health care informatics... proceedings of NI'97, Sixth Triennial International Congress of IMIA-NI, Nursing Informatics of International Medical Informatics Association*. Vol. 46. Amsterdam, NETHERLANDS: IOS Press; 1997:404-407.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Kimura M, Tani S, Watanabe H, et al. High speed clinical data retrieval system with event time sequence feature: with 10 years of clinical data of Hamamatsu University Hospital CPOE. *Methods Inf Med* 2008;47(6):560-8.

Full-text Exclude - No electronic CDSS or KMS intervention

King AB, Wolfe GS. Evaluation of a diabetes specialist-guided primary care diabetes treatment program. *J Am Acad Nurse Pract* 2009;21(1):24-30.

Full-text Exclude - No electronic CDSS or KMS intervention

Kinney WC. Web-based clinical decision support system for triage of vestibular patients. *Otolaryngol Head Neck Surg* 2003;128(1):48-53.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Kip MJ, Neumann T, Jugel C, et al. New strategies to detect alcohol use disorders in the preoperative assessment clinic of a German university hospital. *Anesthesiology* 2008;109(2):171-9.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Kirwin JL, Cunningham RJ, Sequist TD. Pharmacist recommendations to improve the quality of diabetes care: a randomized controlled trial. *J Manag Care Pharm* 2010;16(2):104-13.

Full-text Exclude - No electronic CDSS or KMS intervention

Klebe B, Irving J, Stevens PE, et al. The cost of implementing UK guidelines for the management of chronic kidney disease. *Nephrol Dial Transplant* 2007;22(9):2504-12.

Full-text Exclude - No electronic CDSS or KMS intervention

Klein MS, Eames CH, Simpson PM, et al. Information at the point of care: effect on patient care and resource consumption. *J Healthc Inf Manag* 1999;13(1):67-81.

Full-text Exclude - No acceptable comparator

Knab JH, Wallace MS, Wagner RL, et al. The use of a computer-based decision support system facilitates primary care physicians' management of chronic pain. *Anesth Analg* 2001;93(3):712-20.

Full-text Exclude - No acceptable comparator

Knackstedt C, Mischke K, Schimpf T, et al. Integration of automatic intrathoracic fluid content measurement into clinical decision making in patients with congestive heart failure. *Pacing Clin Electrophysiol* 2008;31(8):961-7.

Full-text Exclude - No acceptable comparator

Koch S. Home telehealth--current state and future trends. *Int J Med Inform* 2006;75(8):565-76.

Full-text Exclude - Not original peer-reviewed data

Koenig T, Gardiwal A, Oswald H, et al. A prospective experience with the lead integrity alert: new certainties and new uncertainties. *Europace* 2009;11(11):1549-51.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Koller M, Grutter R, Peltenburg M, et al. Use of the Internet by medical doctors in Switzerland. *Swiss Med Wkly* 2001;131(17-18):251-4.

Full-text Exclude - No electronic CDSS or KMS intervention

Konstantakos AK. Personal computers versus patient care: at the desktop or at the bedside? *Curr Surg* 2003;60(4):353-5.

Full-text Exclude - Not original peer-reviewed data

Kooij FO. At a glance. Electronic prompt improves PONV prevention. *OR Manager* 2008;24(4):32-32.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Koontz FP. Clinician utilization of rapid antibiotic susceptibility data: a prospective study. *Adv Exp Med Biol* 1994;349:27-34.

Full-text Exclude - Not original peer-reviewed data

Koski EM, Sukuvaara T, Makivirta A, et al. A knowledge-based alarm system for monitoring cardiac operated patients--assessment of clinical performance. *Int J Clin Monit Comput* 1994;11(2):79-83.

Full-text Exclude - No acceptable comparator

Krampera M, Venturini F, Benedetti F, et al. Computer-based drug management in a bone marrow transplant unit: a suitable tool for multiple prescriptions even in critical conditions. *Br J Haematol* 2004;125(1):50-7.

Full-text Exclude - No acceptable comparator

Kroth PJ, Dexter PR, Overhage JM, et al. A computerized decision support system improves the accuracy of temperature capture from nursing personnel at the bedside. *AMIA Annu Symp Proc* 2006:444-8.

Full-text Exclude - No outcome of interest

Kruyt ND, Biessels GJ, Vriesendorp TM, et al. Subjecting acute ischemic stroke patients to continuous tube feeding and an intensive computerized protocol establishes tight glycemic control. *Neurocrit Care* 2010;12(1):62-8.

Full-text Exclude - Sample size <50

Kuilboer MM, van Wijk MA, Mosseveld M, et al. Computed critiquing integrated into daily clinical practice affects physicians' behavior--a randomized clinical trial with AsthmaCritic. *Methods Inf Med* 2006;45(4):447-54.

Full-text Exclude - Sample size <50

Kuiper R. Use of personal digital assistants to support clinical reasoning in undergraduate baccalaureate nursing students. *Comput Inform Nurs* 2008;26(2):90-8.

Full-text Exclude - No acceptable comparator

Kumar S, Worley A. Clinical practice guidelines and all that jazz. *Internet Journal of Allied Health Sciences & Practice* 2010;8(3):2p.

Full-text Exclude - Not original peer-reviewed data

Kun LG, Bray DA. Information infrastructure tools for bioterrorism preparedness. Building dual- or multiple-use infrastructures is the task at hand for state and local health departments. *IEEE Eng Med Biol Mag* 2002;21(5):69-85.

Full-text Exclude - Not original peer-reviewed data

Kuo KL, Fuh CS. A Health Examination System Integrated with Clinical Decision Support System. *J Med Syst* 2010;34(5):829-842.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Kuperman GJ, Gandhi TK, Bates DW. Effective drug-allergy checking: methodological and operational issues. *J Biomed Inform* 2003;36(1-2):70-9.

Full-text Exclude - Not original peer-reviewed data

Kyriacou EC, Pattichis CS, Karaolis MA, et al. An integrated system for assessing stroke risk. *IEEE Eng Med Biol Mag* 2007;26(5):43-50.

Full-text Exclude - No electronic CDSS or KMS intervention

LaBresh KA, Reeves MJ, Frankel MR, et al. Hospital treatment of patients with ischemic stroke or transient ischemic attack using the "Get With The Guidelines" program. *Arch Intern Med* 2008;168(4):411-7.

Full-text Exclude - No acceptable comparator

Lafata JE, Kolk D, Peterson EL, et al. Improving osteoporosis screening: results from a randomized cluster trial. *J Gen Intern Med* 2007;22(3):346-51.

Full-text Exclude - No electronic CDSS or KMS intervention

Landis SE, Gaynes BN, Morrissey JP, et al. Generalist care managers for the treatment of depressed medicaid patients in North Carolina: a pilot study. *BMC Fam Pract* 2007;8:7.

Full-text Exclude - No electronic CDSS or KMS intervention

Landman A, Bernstein S, Hsiao A, et al. Emergency department information system adoption in the United States. *Acad Emerg Med* 2010;17(5):536-544.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Langton KB, Johnston ME, Haynes RB, et al. A critical appraisal of the literature on the effects of computer-based clinical decision support systems on clinician performance and patient outcomes. *Proc Annu Symp Comput Appl Med Care* 1992:626-30.

Full-text Exclude - Not original peer-reviewed data

Lapinsky SE, Wax R, Showalter R, et al. Prospective evaluation of an internet-linked handheld computer critical care knowledge access system. *Crit Care* 2004;8(6):R414-21.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Latoszek-Berendsen A, Tange H, van den Herik HJ, et al. From Clinical Practice Guidelines to Computer-interpretable Guidelines. A Literature Overview. *Methods Inf Med* 2010;49(6):550-70.

Full-text Exclude - Not original peer-reviewed data

Lattimer V, Sassi F, George S, et al. Cost analysis of nurse telephone consultation in out of hours primary care: evidence from a randomised controlled trial. *BMJ* 2000;320(7241):1053-7.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Lau J, Ioannidis JP, Balk E, et al. Evaluation of technologies for identifying acute cardiac ischemia in emergency departments. *Evid Rep Technol Assess (Summ)* 2000(26):1-4.

Full-text Exclude - Not original peer-reviewed data

Laurie-Shaw B, Taylor W, Roach C. Focus on clinical best practices, patient safety and operational efficiency. *Healthc Q* 2006;10 Spec No:50-6, 4.

Full-text Exclude - Not original peer-reviewed data

Lawrence D. Making the right decision. Now that clinical decision support is part of the meaningful use matrix, hospitals are finding it's time to step up their CDS strategy. *Healthc Inform* 2009;26(10):14, 16, 18.

Full-text Exclude - Not original peer-reviewed data

Leatt P, Shea C, Studer M, et al. IT solutions for patient safety--best practices for successful implementation in healthcare. *Healthc Q* 2006;9(1):94-104.

Full-text Exclude - Not original peer-reviewed data

Lee ES, Pickett E, Hedayati N, et al. Implementation of an aortic screening program in clinical practice: implications for the Screen For Abdominal Aortic Aneurysms Very Efficiently (SAAAVE) Act. *J Vasc Surg* 2009;49(5):1107-11.

Full-text Exclude - No acceptable comparator

Lee HJ, Hwang SI, Han SM, et al. Image-based clinical decision support for transrectal ultrasound in the diagnosis of prostate cancer: comparison of multiple logistic regression, artificial neural network, and support vector machine. *Eur Radiol* 2009.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Lee NJ, Starren J, Bakken S. A systematic review of user interface issues related to PDA-based decision support systems in health care. *AMIA Annu Symp Proc* 2005:1021.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Leibovici L, Paul M, Nielsen AD, et al. The TREAT project: decision support and prediction using causal probabilistic networks. *Int J Antimicrob Agents* 2007;30 Suppl 1:S93-102.

Full-text Exclude - Not an evaluation study

Leonard MS, Cimino M, Shaha S, et al. Risk reduction for adverse drug events through sequential implementation of patient safety initiatives in a children's hospital. *Pediatrics* 2006;118(4):e1124-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Leong JR, Sirio CA, Rotondi AJ. eICU program favorably affects clinical and economic outcomes. *Crit Care* 2005;9(5):E22.

Full-text Exclude - Not original peer-reviewed data

Lesourd F, Avril C, Boujennah A, et al. A computerized decision support system for ovarian stimulation by gonadotropins. *Fertil Steril* 2002;77(3):456-60.

Full-text Exclude - No electronic CDSS or KMS intervention

Lester WT, Grant R, Barnett GO, et al. Facilitated lipid management using interactive e-mail: preliminary results of a randomized controlled trial. *Stud Health Technol Inform* 2004;107(Pt 1):232-6.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Lester WT, Grant RW, Barnett GO, et al. Randomized controlled trial of an informatics-based intervention to increase statin prescription for secondary prevention of coronary disease. *J Gen Intern Med* 2006;21(1):22-9.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Leung GM, Johnston JM, Tin KYK, et al. Randomised controlled trial of clinical decision support tools to improve learning of evidence based medicine in medical students. *BMJ: British Medical Journal* 2003;327(7423):1090-1093.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Levine RS, Husaini BA, Emerson JS, et al. Using a nursing protocol to assure equitable delivery of cancer-related prevention services. *Cell Mol Biol (Noisy-le-grand)* 2003;49(8):1229-32.

Full-text Exclude - No electronic CDSS or KMS intervention

Levy BT, Hartz A, Woodworth G, et al. Interventions to improving osteoporosis screening: an Iowa Research Network (IRENE) study. *J Am Board Fam Med* 2009;22(4):360-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Levy HP, LoPresti L, Seibert DC. Twenty questions in genetic medicine--an assessment of World Wide Web databases for genetics information at the point of care. *Genet Med* 2008;10(9):659-67.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Liang WB, Binns CW, Lee AH. Computerised clinical decision support in rural China. *Lancet* 2009;373(9657):30-30.

Full-text Exclude - Not original peer-reviewed data

Liao KP, Cai TX, Gainer V, et al. Electronic Medical Records for Discovery Research in Rheumatoid Arthritis. *Arthritis Care Res* 2010;62(8):1120-1127.

Full-text Exclude - No electronic CDSS or KMS intervention

Libby AM, Pace W, Bryan C, et al. Comparative effectiveness research in DARTNet primary care practices: point of care data collection on hypoglycemia and over-the-counter and herbal use among patients diagnosed with diabetes. *Med Care* 2010;48(6 Suppl):S39-44.

Full-text Exclude - No electronic CDSS or KMS intervention

Lin CP, Nichol WP, Hoey P, et al. Approach for analysis of order check overrides in a computerized practitioner order entry system. *AMIA Annu Symp Proc* 2005:1033.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Lin CP, Payne TH, Nichol WP, et al. Evaluating clinical decision support systems: monitoring CPOE order check override rates in the Department of Veterans Affairs' Computerized Patient Record System. *J Am Med Inform Assoc* 2008;15(5):620-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Lin JW, Chu PL, Liou JM, et al. Applying a multiple screening program aided by a guideline-driven computerized decision support system - A pilot experience in Yun-Lin, Taiwan. *J Formos Med Assoc* 2007;106(1):58-68.

Full-text Exclude - No acceptable comparator

Lin ND, Martins SB, Chan AS, et al. Identifying barriers to hypertension guideline adherence using clinician feedback at the point of care. *AMIA Annu Symp Proc* 2006:494-8.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Lin YC, Chang CS, Yeh CJ, et al. The appropriateness and physician compliance of platelet usage by a computerized transfusion decision support system in a medical center. *Transfusion (Paris)* 2010;50(12):2565-2570.

Full-text Exclude - No acceptable comparator

Lindberg DA, Siegel ER, Rapp BA, et al. Use of MEDLINE by physicians for clinical problem solving. *JAMA* 1993;269(24):3124-9.

Full-text Exclude - No acceptable comparator

Lindberg G, Seensalu R, Nilsson LH, et al. Transferability of a computer system for medical history taking and decision support in dyspepsia. A comparison of indicants for peptic ulcer disease. *Scand J Gastroenterol Suppl* 1987;128:190-6.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Linder JA, Bates DW, Williams DH, et al. Acute infections in primary care: accuracy of electronic diagnoses and electronic antibiotic prescribing. *J Am Med Inform Assoc* 2006;13(1):61-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Lindner SA, Davoren JB, Vollmer A, et al. An electronic medical record intervention increased nursing home advance directive orders and documentation. *J Am Geriatr Soc* 2007;55(7):1001-6.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Lindquist AM, Johansson PE, Petersson GI, et al. The use of the Personal Digital Assistant (PDA) among personnel and students in health care: a review. *J Med Internet Res* 2008;10(4):e31.

Full-text Exclude - Not original peer-reviewed data

Lipman T. Computerised evidence based guidelines in primary care - Computerised decision support and reflection in action. *Br Med J* 2003;326(7398):1087-1088.

Full-text Exclude - Not original peer-reviewed data

Lipton J, Hazelzet JA. Clinical decision support systems: Important tools when appropriately used. *Pediatric Critical Care Medicine* 2009;10(1):128-129.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Liu J, Wyatt JC, Altman DG. Decision tools in health care: focus on the problem, not the solution. *BMC Med Inform Decis Mak* 2006;6:4.

Full-text Exclude - Not original peer-reviewed data

Liu JL, Wyatt JC, Deeks JJ, et al. Systematic reviews of clinical decision tools for acute abdominal pain. *Health Technol Assess* 2006;10(47):1-167, iii-iv.

Full-text Exclude - Not original peer-reviewed data

Liu Q, Abba K, Alejandria MM, et al. Reminder systems and late patient tracers in the diagnosis and management of tuberculosis. *Cochrane Database Syst Rev* 2008(4):CD006594.

Full-text Exclude - Not original peer-reviewed data

Lobach DF. Electronically distributed, computer-generated, individualized feedback enhances the use of a computerized practice guideline. *Proc AMIA Annu Fall Symp* 1996;493-7.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Lobach DF, Hammond WE. Computerized decision support based on a clinical practice guideline improves compliance with care standards. *Am J Med* 1997;102(1):89-98.

Full-text Exclude - Sample size <50

Locatelli F, Covic A, Macdougall IC, et al. ORAMA: a study to investigate EBPG impact on renal anaemia - design and baseline data. *J Nephrol* 2008;21(4):592-603.

Full-text Exclude - No outcome of interest

Lohr KN, Lohr KN. Rating the strength of scientific evidence: relevance for quality improvement programs. *Int J Qual Health Care* 2004;16(1):9-18.

Full-text Exclude - Not original peer-reviewed data

Longhurst C, Turner S, Burgos AE. Development of a Web-based decision support tool to increase use of neonatal hyperbilirubinemia guidelines. *Jt Comm J Qual Patient Saf* 2009;35(5):256-62.

Full-text Exclude - No acceptable comparator

Longhurst CA, Parast L, Sandborg CI, et al. Decrease in hospital-wide mortality rate after implementation of a commercially sold computerized physician order entry system. *Pediatrics* 2010;126(1):14-21.

Full-text Exclude - No electronic CDSS or KMS intervention

Lottridge DM, Chignell M, Danicic-Mizdrak R, et al. Group differences in physician responses to handheld presentation of clinical evidence: a verbal protocol analysis. *BMC Med Inform Decis Mak* 2007;7:22.

Full-text Exclude - No electronic CDSS or KMS intervention

Love TE, Cebul RD, Einstadter D, et al. Electronic medical record-assisted design of a cluster-randomized trial to improve diabetes care and outcomes. *J Gen Intern Med* 2008;23(4):383-91.

Full-text Exclude - No electronic CDSS or KMS intervention

Lowensteyn I, Joseph L, Levinton C, et al. Can computerized risk profiles help patients improve their coronary risk? The results of the Coronary Health Assessment Study (CHAS). *Prev Med* 1998;27(5 Pt 1):730-7.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Lu CY, Ross-Degnan D, Soumerai SB, et al. Interventions designed to improve the quality and efficiency of medication use in managed care: a critical review of the literature - 2001-2007. *BMC Health Serv Res* 2008;8:75.

Full-text Exclude - Not original peer-reviewed data

Luders S, Schrader J, Schmieder RE, et al. Improvement of hypertension management by structured physician education and feedback system: cluster randomized trial. *Eur J Cardiovasc Prev Rehabil* 2009.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Luders S, Schrader J, Schmieder RE, et al. Improvement of hypertension management by structured physician education and feedback system: cluster randomized trial. *Eur J Cardiovasc Prev Rehabil* 2010;17(3):271-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Lugtenberg M, Burgers JS, Westert GP. Effects of evidence-based clinical practice guidelines on quality of care: a systematic review. *Qual Saf Health Care* 2009;18(5):385-92.

Full-text Exclude - Not original peer-reviewed data

Luitjes SH, Wouters MG, Franx A, et al. Study protocol: Cost effectiveness of two strategies to implement the NVOG guidelines on hypertension in pregnancy: An innovative strategy including a computerised decision support system compared to a common strategy of professional audit and feedback, a randomized controlled trial. *Implement Sci* 2010;5:68.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Lyerla F, LeRouge C, Cooke DA, et al. A NURSING CLINICAL DECISION SUPPORT SYSTEM AND POTENTIAL PREDICTORS OF HEAD-OF-BED POSITION FOR PATIENTS RECEIVING MECHANICAL VENTILATION. *Am J Crit Care* 2010;19(1):39-47.

Full-text Exclude - Sample size <50

Lynch MF, Ghani KR, Frost I, et al. Preventing the forgotten ureteral stent: implementation of a web-based stent registry with automatic recall application. *Urology* 2007;70(3):423-6.

Full-text Exclude - No acceptable comparator

Lyness AL, Hravnak M, Martich D, et al. Nurses' perceptions of the impact of a computerized information system on a critical care unit. *Nursing informatics: the impact of nursing knowledge on health care informatics... proceedings of NI'97, Sixth Triennial International Congress of IMIA-NI, Nursing Informatics of International Medical Informatics Association*. Vol. 46. Amsterdam, NETHERLANDS: IOS Press; 1997:463-468.

Full-text Exclude - No electronic CDSS or KMS intervention

MacIntyre CR, Kainer MA, Brown GV. A randomised, clinical trial comparing the effectiveness of hospital and community-based reminder systems for increasing uptake of influenza and pneumococcal vaccine in hospitalised patients aged 65 years and over. *Gerontology* 2003;49(1):33-40.

Full-text Exclude - No electronic CDSS or KMS intervention

Mack EH, Wheeler DS, Embi PJ. Clinical decision support systems in the pediatric intensive care unit. *Pediatr Crit Care Med* 2009;10(1):23-8.

Full-text Exclude - Not original peer-reviewed data

MacLean CD, Littenberg B, Gagnon M. Diabetes decision support: initial experience with the Vermont diabetes information system. *Am J Public Health* 2006;96(4):593-5.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Maddox MA. Reminder interventions increased women's use of mammography and Pap smear screening [commentary on Somkin CP, Hiatt RA, Hurley LB, et al. The effect of patient and provider reminders on mammography and Papanicolaou smear screening in a large health maintenance organization. *ARCH INTERN MED* 1997 Aug 11/25;157:1658-64]. *Evidence-Based Nursing* 1998;1(2):59-59.

Full-text Exclude - Not original peer-reviewed data

Magrabi F, Coiera EW, Westbrook JI, et al. General practitioners' use of online evidence during consultations. *Int J Med Inform* 2005;74(1):1-12.

Full-text Exclude - No acceptable comparator

Magrabi F, Westbrook JI, Coiera EW. What factors are associated with the integration of evidence retrieval technology into routine general practice settings? *Int J Med Inform* 2007;76(10):701-9.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Magrabi F, Westbrook JI, Kidd MR, et al. Long-term patterns of online evidence retrieval use in general practice: a 12-month study. *J Med Internet Res* 2008;10(1):e6.

Full-text Exclude - No acceptable comparator

Majowicz SE, Edge VL, Flint J, et al. An introductory letter in advance of a telephone survey may increase response rate. *Can Commun Dis Rep* 2004;30(13):121-3.

Full-text Exclude - Not original peer-reviewed data

Majumdar SR, Ross-Degnan D, Soumerai SB. A computer-assisted management program for anti-infective agents. *N Engl J Med* 1998;338(24):1775; author reply 1776.

Full-text Exclude - Not original peer-reviewed data

Malm S, Aalberg J, Korsen N. Can helical computerized tomography be used alone to aid in the diagnosis of patients with suspected pulmonary embolism? *J Fam Pract* 2001;50(11):988.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Malotte CK, Ledsky R, Hogben M, et al. Comparison of methods to increase repeat testing in persons treated for gonorrhea and/or chlamydia at public sexually transmitted disease clinics. *Sex Transm Dis* 2004;31(11):637-42.

Full-text Exclude - No electronic CDSS or KMS intervention

Manarey CR, Westerberg BD, Marion SA. Clinical decision analysis in the treatment of acute otitis media in a child over 2 years of age. *J Otolaryngol* 2002;31(1):23-30.

Full-text Exclude - No electronic CDSS or KMS intervention

Mangione CM, Gerzoff RB, Williamson DF, et al. The association between quality of care and the intensity of diabetes disease management programs. *Ann Intern Med* 2006;145(2):107-16.

Full-text Exclude - No acceptable comparator

Mann HJ, Fuhs DW, Awang R, et al. Altered aminoglycoside pharmacokinetics in critically ill patients with sepsis. *Clin Pharm* 1987;6(2):148-53.
Full-text Exclude - No electronic CDSS or KMS intervention

Mansour H, Dilkush D, Lannigan J, et al. The impact of a computerized potassium alert on adverse drug events and pharmacists' interventions. *J Pharm Technol* 2010;26(2):55-59.
Full-text Exclude - CDSS/KMS not aimed at health care providers

Mant J, Hicks NR, Dopson S, et al. Uptake of research findings into clinical practice: a controlled study of the impact of a brief external intervention on the use of corticosteroids in preterm delivery. *J Eval Clin Pract* 1999;5(1):73-79.
Full-text Exclude - Not original peer-reviewed data

Margolis KL, Solberg LI, Asche SE, et al. Use of practice system tools by medical groups for depression. *Am J Manag Care* 2007;13(6 Part 1):305-11.
Full-text Exclude - No acceptable comparator

Mariani G, Manotti C, Dettori AG. A computerized regulation of dosage in oral anticoagulant therapy. *Ric Clin Lab* 1990;20(2):119-25.
Full-text Exclude - No electronic CDSS or KMS intervention

Markman M. Recent reminders of why the gold standard for clinical research in oncology is the well-designed and conducted randomized phase III trial. *Curr Oncol Rep* 2004;6(6):421-2.
Full-text Exclude - Not original peer-reviewed data

Markovic S. How can we prevent Adverse Drug reactions? *Zdravniški Vestnik-Slovenian Medical Journal* 2010;79(4):307-310.
Full-text Exclude - Non-English

Martin L, Gerdin U. 'Shared Care' and computer assistance in glaucoma management. *Nursing informatics: the impact of nursing knowledge on health care informatics... proceedings of NI'97, Sixth Triennial International Congress of IMIA-NI, Nursing Informatics of International Medical Informatics Association*. Vol. 46. Amsterdam, NETHERLANDS: IOS Press; 1997:288-290.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Martin S. MDs' office Internet use hits 57%. *CMAJ* 2003;168(4):475.
Full-text Exclude - No electronic CDSS or KMS intervention

Martin WE, Miller SC, Welch LC, et al. Improving access to hospice: the Physician Feedback and Reminders to Improve Access to Hospice (PFRIAH) study. *Med Health R I* 2007;90(12):388-90.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Martínez-Sánchez P, Fuentes B, Medina-Báez J, et al. Implantación de una vía clínica para la atención del ictus agudo en un hospital con unidad de ictus. *Neurologia* 2010;25(1):17-26.
Full-text Exclude - No electronic CDSS or KMS intervention

Martin-Matthews A, Tamblyn R, Keefe J, et al. Bridging Policy and Research on Aging in Canada: Recognizing an Anniversary, Realizing an Opportunity. *Canadian Journal on Aging-Revue Canadienne Du Vieillissement* 2009;28(2):185-193.
Full-text Exclude - Not original peer-reviewed data

Martins SB, Shahar Y, Galperin M, et al. Evaluation of KNAVE-II: a tool for intelligent query and exploration of patient data. *Stud Health Technol Inform* 2004;107(Pt 1):648-52.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Martuseviciene A, Navickas Z, Vainoras A. ECG Data Analysis Using the Convolution of Mealy and Moore Automata. *Elektronika Ir Elektrotechnika* 2010(4):103-106.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Mashour GA, Tremper KK, Avidan MS. Protocol for the "Michigan Awareness Control Study": A prospective, randomized, controlled trial comparing electronic alerts based on bispectral index monitoring or minimum alveolar concentration for the prevention of intraoperative awareness. *BMC Anesthesiol* 2009;9:7.
Full-text Exclude - No acceptable comparator

Maxson E, Buntin M, Mostashari F. Using Electronic Prescribing Transaction Data to Estimate Electronic Health Record Adoption. *Am J Manag Care* 2010;16(12):e320-e326.
Full-text Exclude - No electronic CDSS or KMS intervention

Maxson E, Jain S, Kendall M, et al. The Regional Extension Center program: helping physicians meaningfully use health information technology. *Ann Intern Med* 2010;153(10):666.

Full-text Exclude - Not original peer-reviewed data

Maynard GA, Morris TA, Jenkins IH, et al. Optimizing prevention of hospital-acquired venous thromboembolism (VTE): prospective validation of a VTE risk assessment model. *J Hosp Med* 2010;5(1):10-8.

Full-text Exclude - Not an evaluation study

Mayo-Smith MF, Agrawal A. Factors associated with improved completion of computerized clinical reminders across a large healthcare system. *Int J Med Inf* 2007;76(10):710-716.

Full-text Exclude - No acceptable comparator

McAlearney AS, Schweikhart SB, Medow MA. Doctors' experience with handheld computers in clinical practice: qualitative study. *BMJ* 2004;328(7449):1162.

Full-text Exclude - No electronic CDSS or KMS intervention

McAlister NH, Covvey HD, Tong C, et al. Randomised controlled trial of computer assisted management of hypertension in primary care. *Br Med J (Clin Res Ed)* 1986;293(6548):670-4.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

McCartney PR. Clinical decision support systems. *Mcn-the American Journal of Maternal-Child Nursing* 2007;32(1):58-58.

Full-text Exclude - Not original peer-reviewed data

McCaughan D, Thompson C, Cullum N, et al. Nurse practitioner and practice nurses' use of research information in clinical decision making: findings from an exploratory study. *Fam Pract* 2005;22(5):490-7.

Full-text Exclude - No electronic CDSS or KMS intervention

McCormick KA. Tools and systems for improved outcomes. Integrating outcomes into computerized information systems: it's time to get guidelines off the shelf. *Outcomes Manag Nurs Pract* 2000;4(4):151-154.

Full-text Exclude - Not original peer-reviewed data

McDaniel AM, Benson PL, Roesener GH, et al. An integrated computer-based system to support nicotine dependence treatment in primary care. *Nicotine Tob Res* 2005;7 Suppl 1:S57-66.

Full-text Exclude - No acceptable comparator

McDermott L, Yardley L, Little P, et al. Developing a computer delivered, theory based intervention for guideline implementation in general practice. *Bmc Family Practice* 2010;11.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

McDermott R, Tulip F, Sinha A. Sustaining better diabetes care in remote indigenous Australian communities. *Qual Saf Health Care* 2004;13(4):295-8.

Full-text Exclude - No electronic CDSS or KMS intervention

McDonald CJ, Wilson GA, McCabe GP, Jr. Physician response to computer reminders. *JAMA* 1980;244(14):1579-81.

Full-text Exclude - Sample size <50

McDonald MV, Pezzin LE, Feldman PH, et al. Can just-in-time, evidence-based "reminders" improve pain management among home health care nurses and their patients? *J Pain Symptom Manage* 2005;29(5):474-88.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

McDowell I, Newell C, Rosser W. A follow-up study of patients advised to obtain influenza immunizations. *Fam Med* 1990;22(4):303-6.

Full-text Exclude - No electronic CDSS or KMS intervention

McEwen A, West R, Preston A. Triggering anti-smoking advice by GPs: mode of action of an intervention stimulating smoking cessation advice by GPs. *Patient Educ Couns* 2006;62(1):89-94.

Full-text Exclude - No electronic CDSS or KMS intervention

McGee MR, Gray P. A handheld chemotherapy symptom management system: results from a preliminary outpatient field trial. *Health Informatics Journal* 2005;11(4):243-258.

Full-text Exclude - No acceptable comparator

McGowan JJ, Richwine M. Electronic information access in support of clinical decision making: a comparative study of the impact on rural health care outcomes. *Proc Amia Symp* 2000;565-9.

Full-text Exclude - No acceptable comparator

McGowan JL, Grad R, Pluye P, et al. Electronic retrieval of health information by healthcare providers to improve practice and patient care. *Cochrane Database Syst Rev* 2009(3):CD004749.

Full-text Exclude - Not original peer-reviewed data

McKendry MJ, Van Horn J. Today's hospital-based case manager: how one hospital integrated/adopted evidenced-based medicine using InterQual criteria. *Lippincotts Case Manag* 2004;9(2):61-71.

Full-text Exclude - No electronic CDSS or KMS intervention

McKinley BA, Moore FA, Sailors RM, et al. Computerized decision support for mechanical ventilation of trauma induced ARDS: results of a randomized clinical trial. *J Trauma* 2001;50(3):415-24; discussion 425.

Full-text Exclude - Mandatory compliance CDSS

McKinley BA, Valdivia A, Moore FA. Goal-oriented shock resuscitation for major torso trauma: what are we learning? *Curr Opin Crit Care* 2003;9(4):292-9.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

McKinley S, Cade JF, Evans OM, et al. Versatile and effective closed-loop control of blood pressure. *Heart Lung* 1991;20(3):301-301.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

McLachlan A, Wells S, Furness S, et al. Equity of access to CVD risk management using electronic clinical decision support in the coronary care unit. *European Journal of Cardiovascular Nursing* 2010;9(4):233-237.

Full-text Exclude - No outcome of interest

McLean S, Egan G, Connor P, et al. Collaborative decision-making between paramedics and CCU nurses based on 12-lead ECG telemetry expedites the delivery of thrombolysis in ST elevation myocardial infarction. *Emerg Med J* 2008;25(6):370-4.

Full-text Exclude - No electronic CDSS or KMS intervention

McMichael J, Lieberman R, Doyle H, et al. An intelligent and cost-effective computer dosing system for individualizing FK506 therapy in transplantation and autoimmune disorders. *J Clin Pharmacol* 1993;33(7):599-605.

Full-text Exclude - No acceptable comparator

McNiel DE, Gregory AL, Lam JN, et al. Utility of decision support tools for assessing acute risk of violence. *J Consult Clin Psychol* 2003;71(5):945-53.

Full-text Exclude - No electronic CDSS or KMS intervention

McPhee SJ, Bird JA, Fordham D, et al. Promoting cancer prevention activities by primary care physicians. Results of a randomized, controlled trial. *JAMA* 1991;266(4):538-44.

Full-text Exclude - Sample size <50

Meade V. Adapting to providing pharmaceutical care. *Am Pharm* 1994;NS34(10):37-42.

Full-text Exclude - Not original peer-reviewed data

Meaney B, Belfiglio G. Putting clinical guidelines to work. *Medicine on the Net* 2002;8(3):1-4.

Full-text Exclude - Not original peer-reviewed data

Medow MA, Arkes HR, Shaffer VA. Are Residents' Decisions Influenced More by a Decision Aid or a Specialist's Opinion? A Randomized Controlled Trial. *J Gen Intern Med* 2010;25(4):316-320.

Full-text Exclude - No electronic CDSS or KMS intervention

Meesterberends E, Halfens R, Lohrmann C, et al. Pressure ulcer guideline development and dissemination in Europe. *J Clin Nurs* 2010;19(11-12):1495-1503.

Full-text Exclude - No electronic CDSS or KMS intervention

Meigs JB, Cagliero E, Dubey A, et al. A controlled trial of web-based diabetes disease management: the MGH diabetes primary care improvement project. *Diabetes Care* 2003;26(3):750-7.

Full-text Exclude - Sample size <50

Meijer RP, Gemen EF, van Onna IE, et al. The value of an artificial neural network in the decision-making for prostate biopsies. *World J Urol* 2009;27(5):593-8.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Menachemi N, Perkins RM, van Durme DJ, et al. Examining the adoption of electronic health records and personal digital assistants by family physicians in Florida. *Inform Prim Care* 2006;14(1):1-9.

Full-text Exclude - No acceptable comparator

Mendelson RM, Bairstow PJ. Imaging pathways: will they be well trodden or less traveled? *J Am Coll Radiol* 2009;6(3):160-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Menke JA, Rich D, McClead RE. Physician response to CPOE allergy information alerts. *AMIA Annu Symp Proc* 2005:1051.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Merijohn GK. The evidence-based clinical decision support guide: mucogingival/esthetics making clinical decisions in the absence of strong evidence. *J Evid Based Dent Pract* 2007;7(3):93-101.

Full-text Exclude - No electronic CDSS or KMS intervention

Merijohn GK, Bader JD, Frantsve-Hawley J, et al. Clinical decision support chairside tools for evidence-based dental practice. *J Evid Based Dent Pract* 2008;8(3):119-32.

Full-text Exclude - No electronic CDSS or KMS intervention

Meynaar IA, Dawson L, Tangkau PL, et al. Introduction and evaluation of a computerised insulin protocol. *Intensive Care Med* 2007;33(4):591-6.

Full-text Exclude - No acceptable comparator

Michnikowski M, Rudowski R, Siugocki P, et al. Evaluation of the expert system for respiratory therapy of newborns on archival data... reprinted from *The International Journal of Artificial Organs*, Vol 20, no 12, pp 678-680, copyright 1997. *Neonatal Intensive Care* 1998;11(7):29-31.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Mille F, Schwartz C, Brion F, et al. Analysis of overridden alerts in a drug-drug interaction detection system. *Int J Qual Health Care* 2008;20(6):400-5.

Full-text Exclude - No acceptable comparator

Miller K. Using a computer-based risk assessment tool to identify risk for chemotherapy-induced febrile neutropenia. *Clin J Oncol Nurs* 2010;14(1):87-91.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Miller RA. Medical diagnostic decision support systems--past, present, and future: a threaded bibliography and brief commentary. *J Am Med Inform Assoc* 1994;1(1):8-27.

Full-text Exclude - Not original peer-reviewed data

Minniear TD, Gilmore B, Arnold SR, et al. Implementation of and barriers to routine HIV screening for adolescents. *Pediatrics* 2009;124(4):1076-84.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Mitchell E, Sullivan F. A descriptive feast but an evaluative famine: systematic review of published articles on primary care computing during 1980-97. *BMJ* 2001;322(7281):279-82.

Full-text Exclude - Not original peer-reviewed data

Mitchell E, Sullivan F, Watt G, et al. Using electronic patient records to inform strategic decision making in primary care. *Stud Health Technol Inform* 2004;107(Pt 2):1157-61.

Full-text Exclude - No electronic CDSS or KMS intervention

Mitchell N, Randell R, Foster R, et al. A national survey of computerized decision support systems available to nurses in England. *J Nurs Manag* 2009;17(7):772-780.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Mjosest J. Embedding guidelines into direct physician order entry: simple methods, powerful results. *IT Health Care Strategist* 2000;2(1):7-8.

Full-text Exclude - Not original peer-reviewed data

Moffett BS, Parham AL, Caudilla CD, et al. Oral anticoagulation in a pediatric hospital: impact of a quality improvement initiative on warfarin management strategies. *Qual Saf Health Care* 2006;15(4):240-3.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Mokashi A, Leatherbarrow B, Kincey J, et al. Patient communication during cataract surgery. *Eye (Lond)* 2004;18(2):147-51.

Full-text Exclude - No electronic CDSS or KMS intervention

Mold JW, Aspy CA, Nagykaldi Z. Implementation of evidence-based preventive services delivery processes in primary care: an Oklahoma Physicians Resource/Research Network (OKPRN) study. *J Am Board Fam Med* 2008;21(4):334-44.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Mollon B, Chong J, Jr., Holbrook AM, et al. Features predicting the success of computerized decision support for prescribing: a systematic review of randomized controlled trials. *BMC Med Inform Decis Mak* 2009;9:11.

Full-text Exclude - Not original peer-reviewed data

Mollon B, Chong JJR, Holbrook AM, et al. Features predicting the success of computerized decision support for prescribing: a systematic review of randomized controlled trials. *Bmc Medical Informatics and Decision Making* 2009;9.

Full-text Exclude - Not original peer-reviewed data

Momtahan K, Burns C. Applications of ecological interface design in supporting the nursing process. *J Healthc Inf Manag* 2004;18(4):74-82.

Full-text Exclude - Not original peer-reviewed data

Momtahan KL, Burns CM, Sherrard H, et al. Using personal digital assistants and patient care algorithms to improve access to cardiac care best practices. *Stud Health Technol Inform* 2007;129(Pt 1):117-21.

Full-text Exclude - No acceptable comparator

Monane M, Matthias DM, Nagle BA, et al. Improving prescribing patterns for the elderly through an online drug utilization review intervention: a system linking the physician, pharmacist, and computer. *JAMA* 1998;280(14):1249-52.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Montani S, Bellazzi R. Exploiting multi-modal reasoning for knowledge management and decision support: an evaluation study. *Proc Amia Symp* 2000:585-9.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Montani S, Bellazzi R, Quaglini S, et al. Meta-analysis of the effect of the use of computer-based systems on the metabolic control of patients with diabetes mellitus. *Diabetes Technol Ther* 2001;3(3):347-56.

Full-text Exclude - Not original peer-reviewed data

Montgomery A, Fahey T, Peters T. A computer-based decision support system and risk chart did not reduce cardiovascular risk or blood pressure in hypertension... commentary on Montgomery AA, Fahey T, Peters TJ et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000 Mar 11;320:686-90. *ACP J Club* 2001;134(1):9-9.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Montgomery AA, Fahey T. A systematic review of the use of computers in the management of hypertension. *J Epidemiol Community Health* 1998;52(8):520-5.

Full-text Exclude - Not original peer-reviewed data

Monticciolo DL, Sickles EA. Computerized follow-up of abnormalities detected at mammography screening. *AJR Am J Roentgenol* 1990;155(4):751-3.

Full-text Exclude - No electronic CDSS or KMS intervention

Moran LJ, Pasquali R, Teede HJ, et al. Treatment of obesity in polycystic ovary syndrome: a position statement of the Androgen Excess and Polycystic Ovary Syndrome Society. *Fertil Steril* 2009;92(6):1966-82.

Full-text Exclude - Not original peer-reviewed data

Moreno L, Peikes D, Krilla A. Necessary But Not Sufficient: The HITECH Act and Health Information Technology's Potential to Build Medical Homes. 2010.

Full-text Exclude - Not original peer-reviewed data

Morera T, Gervasini G, Carrillo JA, et al. Early detection of drug interactions utilizing a computerized drug prescription handling system-focus on cerivastatin-gemfibrozil. *Eur J Clin Pharmacol* 2004;59(12):917-21.

Full-text Exclude - No electronic CDSS or KMS intervention

Morera T, Gervasini G, Carrillo JA, et al. Using a computerized drug prescription screening system to trace drug interactions in an outpatient setting. *Ann Pharmacother* 2004;38(7-8):1301-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Morgan MB, Branstetter Bft, Lionetti DM, et al. The radiology digital dashboard: effects on report turnaround time. *J Digit Imaging* 2008;21(1):50-8.
Full-text Exclude - No electronic CDSS or KMS intervention

Morris AH, Hirshberg E, Sward KA. Computer protocols: how to implement. *Best Pract Res Clin Anaesthesiol* 2009;23(1):51-67.
Full-text Exclude - Not original peer-reviewed data

Morrissey J. Information transformation. Baylor Health Care unveils initiative to make care, doctors more computer-savvy. *Mod Healthc* 2004;34(2):17.
Full-text Exclude - Not original peer-reviewed data

Moxey A, Robertson J, Newby D, et al. Computerized clinical decision support for prescribing: provision does not guarantee uptake. *J Am Med Inform Assoc* 2010;17(1):25-33.
Full-text Exclude - Not original peer-reviewed data

Muehl JK, Portugaller HR, Stiegler PB. Towards validation for physiological models in intervention planning. *Stud Health Technol Inform* 2009;142:207-9.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Mungall DR, Anbe D, Forrester PL, et al. A prospective randomized comparison of the accuracy of computer-assisted versus GUSTO nomogram--directed heparin therapy. *Clin Pharmacol Ther* 1994;55(5):591-6.
Full-text Exclude - Mandatory compliance CDSS

Munoz M, Estevez LG, Alvarez I, et al. Evaluation of international treatment guidelines and prognostic tests for the treatment of early breast cancer. *Cancer Treat Rev* 2008;34(8):701-9.
Full-text Exclude - Not original peer-reviewed data

Murchie CJ, Kenny GN. Comparison among manual, computer-assisted, and closed-loop control of blood pressure after cardiac surgery. *J Cardiothorac Anesth* 1989;3(1):16-9.
Full-text Exclude - No electronic CDSS or KMS intervention

Murphy J. Decision support for nurses. *Health Data Manag* 2008;16(11):72.
Full-text Exclude - Not original peer-reviewed data

Murphy J. The best IT project is not an IT project. *J Healthc Inf Manag* 2009;23(1):6-8.

Full-text Exclude - Not original peer-reviewed data

Murphy SA. Clinical reminders and beta-blocker use following echocardiography. *ACC Cardiosource Review Journal* 2007;16(7):47-47.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Murray MD, Loos B, Tu W, et al. Work patterns of ambulatory care pharmacists with access to electronic guideline-based treatment suggestions. *Am J Health Syst Pharm* 1999;56(3):225-32.
Full-text Exclude - CDSS/KMS not aimed at health care providers

Murtaugh CM, Pezzin LE, McDonald MV, et al. Just-in-time evidence-based e-mail "reminders" in home health care: impact on nurse practices. *Health Serv Res* 2005;40(3):849-64.
Full-text Exclude - No acceptable comparator

Murthy BV, Lake SP, Fisher AC. Evaluation of a decision support system to predict preoperative investigations. *Br J Anaesth* 2008;100(3):315-21.
Full-text Exclude - No acceptable comparator

Myers JS, Gojraty S, Yang W, et al. A randomized-controlled trial of computerized alerts to reduce unapproved medication abbreviation use. *J Am Med Inform Assoc* 2011;18(1):17-23.
Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Myers RE, Turner B, Weinberg D, et al. Impact of a physician-oriented intervention on follow-up in colorectal cancer screening. *Prev Med* 2004;38(4):375-81.
Full-text Exclude - No electronic CDSS or KMS intervention

Mytton OT, Greaves FEC, Stanton EAI, et al. What should WHO be doing about patient safety and technology? *Quality & Safety in Health Care* 2010;19.
Full-text Exclude - Not original peer-reviewed data

Narasingarao MR, Manda R, Sridhar GR, et al. A clinical decision support system using multilayer perceptron neural network to assess well being in diabetes. *J Assoc Physicians India* 2009;57:127-33.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Naylor DF, Jr. Cures for Windows headaches and pesky program peccadilloes. *Curr Surg* 2003;60(4):383-4.

Full-text Exclude - Not original peer-reviewed data

Nekhlyudov L, Latosinsky S. The interface of primary and oncology specialty care: from symptoms to diagnosis. *JNCI Monographs* 2010;2010(40):11.

Full-text Exclude - Not original peer-reviewed data

Neumeyer-Gromen A, Lampert T, Stark K, et al. Disease management programs for depression: a systematic review and meta-analysis of randomized controlled trials. *Med Care* 2004;42(12):1211-21.

Full-text Exclude - Not original peer-reviewed data

Newitter DA, Meiers JC, Kazemi RB. Rx for caries prevention: time line for home care. A software aid for communication of patient instructions for management of dental caries. *Oper Dent* 2002;27(2):204-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Nguyen BH, Nguyen KP, McPhee SJ, et al. Promoting cancer prevention activities among Vietnamese physicians in California. *J Cancer Educ* 2000;15(2):82-5.

Full-text Exclude - No acceptable comparator

Nichols C, Holt CL, Shipp M, et al. Physician knowledge, perceptions of barriers, and patient colorectal cancer screening practices. *Am J Med Qual* 2009;24(2):116-22.

Full-text Exclude - No electronic CDSS or KMS intervention

Nies J, Colombet I, Degoulet P, et al. Determinants of success for computerized clinical decision support systems integrated in CPOE systems: a systematic review. *AMIA Annu Symp Proc* 2006:594-8.

Full-text Exclude - Not original peer-reviewed data

Nieuwlaat R, Barker L, Kim YK, et al. Underuse of evidence-based warfarin dosing methods for atrial fibrillation patients. *Thromb Res* 2010;125(4):e128-31.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Nightingale PG, Adu D, Richards NT, et al. Implementation of rules based computerised bedside prescribing and administration: intervention study. *BMJ* 2000;320(7237):750-3.

Full-text Exclude - No acceptable comparator

Nikopoulou-Smyrni P, Nikopoulos CK. A new integrated model of clinical reasoning: Development, description and preliminary assessment in patients with stroke. *Disability and Rehabilitation: An International, Multidisciplinary Journal* 2007;29(14):1129-1138.

Full-text Exclude - No electronic CDSS or KMS intervention

Nilasena DS, Lincoln MJ. A computer-generated reminder system improves physician compliance with diabetes preventive care guidelines. *Proc Annu Symp Comput Appl Med Care* 1995:640-5.

Full-text Exclude - Sample size <50

Niles D, Nysaether J, Sutton R, et al. Learning is common during in-hospital pediatric CPR, and decreased with automated corrective feedback. *Resuscitation* 2009;80(5):553-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Noel HC, Vogel DC, Erdos JJ, et al. Home telehealth reduces healthcare costs. *Telemed J E Health* 2004;10(2):170-83.

Full-text Exclude - No electronic CDSS or KMS intervention

Norman P, Conner MT, Willits DG, et al. Health checks in general practice: a comparison of two invitation letters. *Br J Gen Pract* 1991;41(351):432-3.

Full-text Exclude - Not original peer-reviewed data

Norris J, Cuddigan J, Ryan S, et al. Developing a method for validating the output of computerized expert systems in nursing. *Classification of nursing diagnoses: proceedings of the seventh conference held in St. Louis, MO, March 9-13, 1986.*: C V Mosby Company; 1987:160-167.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Nuckols TK, Bower AG, Paddock SM, et al. Programmable infusion pumps in ICUs: an analysis of corresponding adverse drug events. *J Gen Intern Med* 2008;23 Suppl 1:41-5.

Full-text Exclude - No acceptable comparator

Nylenna M, Eiring O, Strand G, et al. Wiring a nation: putting knowledge into action. *Lancet* 2010;375(9719):1048-1051.

Full-text Exclude - Not original peer-reviewed data

O'Malley A, Grossman J, Cohen G, et al. Are electronic medical records helpful for care coordination? Experiences of physician practices. *J Gen Intern Med* 2010;25(3):177-185.

Full-text Exclude - No electronic CDSS or KMS intervention

O'Connor A. Decision aids reduced decisional conflict in patients with newly diagnosed hypertension. *Evidence-Based Medicine* 2004;9(1):13-13.

Full-text Exclude - Not original peer-reviewed data

O'Connor AM, Jacobsen MJ, Stacey D. An evidence-based approach to managing women's decisional conflict. *J Obstet Gynecol Neonatal Nurs* 2002;31(5):570-81.

Full-text Exclude - No electronic CDSS or KMS intervention

O'Connor C, DeCaire K, Friedrich J. Improving patient care through the use of evidence based order sets. *AMIA Annu Symp Proc* 2005:1063.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

O'Connor R, Houghton F, Saunders J, et al. Diabetes mellitus in Irish general practice: level of care as reflected by HbA1c values. *Eur J Gen Pract* 2006;12(2):58-65.

Full-text Exclude - No electronic CDSS or KMS intervention

Oertle M, Bal R. Understanding non-adherence in chronic heart failure: a mixed-method case study. *Quality and Safety in Health Care* 2010;19(6):1.

Full-text Exclude - No electronic CDSS or KMS intervention

Ohmann C, Yang Q, Kunneke M, et al. Bayes theorem and conditional dependence of symptoms: different models applied to data of upper gastrointestinal bleeding. *Methods Inf Med* 1988;27(2):73-83.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ong RSG, Post J, van Rooij H, et al. Call-duration and triage decisions in out of hours cooperatives with and without the use of an expert system. *Bmc Family Practice* 2008;9.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Oppenheim MI, Vidal C, Velasco FT, et al. Impact of a computerized alert during physician order entry on medication dosing in patients with renal impairment. *Proc Amia Symp* 2002:577-81.

Full-text Exclude - No acceptable comparator

Oppenkowski TP, Murray ET, Sandhar H, et al. External quality assessment for warfarin dosing using computerised decision support software. *J Clin Pathol* 2003;56(8):605-7.

Full-text Exclude - No acceptable comparator

O'Reilly DA, Chaudhari M, Ballal M, et al. The Oncosurge strategy for the management of colorectal liver metastases - an external validation study. *Eur J Surg Oncol* 2008;34(5):538-40.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ornstein S, Nemeth LS, Jenkins RG, et al. Colorectal cancer screening in primary care: translating research into practice. *Med Care* 2010;48(10):900-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Oshiro BT, Henry E, Wilson J, et al. Decreasing elective deliveries before 39 weeks of gestation in an integrated health care system. *Obstet Gynecol* 2009;113(4):804-11.

Full-text Exclude - No electronic CDSS or KMS intervention

Overbeek LI, Hermens RP, van Krieken JH, et al. Electronic reminders for pathologists promote recognition of patients at risk for Lynch syndrome: cluster-randomised controlled trial. *Virchows Arch* 2010;456(6):653-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Ovretveit J, Gillies R, Rundall TG, et al. Quality of care for chronic illnesses. *Int J Health Care Qual Assur* 2008;21(2):190-202.

Full-text Exclude - No acceptable comparator

Pachler C, Plank J, Weinhandl H, et al. Tight glycaemic control by an automated algorithm with time-variant sampling in medical ICU patients. *Intensive Care Med* 2008;34(7):1224-30.

Full-text Exclude - Mandatory compliance CDSS

Pambianco DJ, Whitten CJ, Moerman A, et al. An assessment of computer-assisted personalized sedation: a sedation delivery system to administer propofol for gastrointestinal endoscopy. *Gastrointest Endosc* 2008;68(3):542-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Paneth-Pollak R, Schillinger J, Borrelli J, et al. Using STD Electronic Medical Record Data to Drive Public Health Program Decisions in New York City. *Am J Public Health* 2010;100(4):586.

Full-text Exclude - Not original peer-reviewed data

Parikh SV, Segal ZV, Grigoriadis S, et al. Canadian Network for Mood and Anxiety Treatments (CANMAT) clinical guidelines for the management of major depressive disorder in adults. II. Psychotherapy alone or in combination with antidepressant medication. *J Affect Disord* 2009;117 Suppl 1:S15-25.

Full-text Exclude - No electronic CDSS or KMS intervention

Park Y. Impact of Task, Structure, and Environment on Electronic Health Record Adoption, Use, and Interoperability in Hospitals. UNIVERSITY OF MINNESOTA; 2010.

Full-text Exclude - Not original peer-reviewed data

Parra D, Legreid AM, Beckey NP, et al. Metformin monitoring and change in serum creatinine levels in patients undergoing radiologic procedures involving administration of intravenous contrast media. *Pharmacotherapy* 2004;24(8):987-93.

Full-text Exclude - No electronic CDSS or KMS intervention

Parry D, Fitzmaurice D, Raftery J. Anticoagulation management in primary care: a trial-based economic evaluation. *Br J Haematol* 2000;111(2):530-3.

Full-text Exclude - No electronic CDSS or KMS intervention

Pasanen PA, Pikkarainen P, Alhava E, et al. Evaluation of a computer-based diagnostic score system in the diagnosis of jaundice and cholestasis. *Scand J Gastroenterol* 1993;28(8):732-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Paterno MD, Cina JL, Goldhaber SZ, et al. Preventing DVT and PE in hospitalized patients: improving a successful electronic alert. *AMIA Annu Symp Proc* 2006:1058.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Patkar V, Hurt C, Steele R, et al. Evidence-based guidelines and decision support services: A discussion and evaluation in triple assessment of suspected breast cancer. *Br J Cancer* 2006;95(11):1490-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Patterson ES, Nguyen AD, Halloran JP, et al. Human factors barriers to the effective use of ten HIV clinical reminders. *J Am Med Inform Assoc* 2004;11(1):50-9.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Patterson MS, Hoeks SE, Rijkenberg S, et al. Integration of 3D reconstruction in the SElection criteria for Excessive Crossing Times for Magnetically Supported Percutaneous Coronary Intervention. SELECT-MP. *EuroIntervention* 2009;4(4):509-16.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Patterson R. A computerized reminder for prophylaxis of deep vein thrombosis in surgical patients. *Proc Amia Symp* 1998:573-6.

Full-text Exclude - No outcome of interest

Paul M, Nielsen AD, Goldberg E, et al. Prediction of specific pathogens in patients with sepsis: evaluation of TREAT, a computerized decision support system. *J Antimicrob Chemother* 2007;59(6):1204-7.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Paulet N, Bury PC, Needleman M, et al. Drug interactions: a study and evaluation of their incidence in Victoria. *Med J Aust* 1982;1(2):80-1.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Peiris DP, Joshi R, Webster RJ, et al. An electronic clinical decision support tool to assist primary care providers in cardiovascular disease risk management: development and mixed methods evaluation. *J Med Internet Res* 2009;11(4):e51.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Peremans L, Rethans JJ, Verhoeven V, et al. Empowering patients or general practitioners? A randomised clinical trial to improve quality in reproductive health care in Belgium. *Eur J Contracept Reprod Health Care* 2010;15(4):280-9.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Perez-Gomez F. Is computer-assisted, long-term warfarin therapy safe and efficacious for patients with nonrheumatic atrial fibrillation? *Nat Clin Pract Cardiovasc Med* 2005;2(2):82-3.
Full-text Exclude - No electronic CDSS or KMS intervention

Perkins NA, Murphy JE, Malone DC, et al. Performance of drug-drug interaction software for personal digital assistants. *Ann Pharmacother* 2006;40(5):850-5.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Perl J. Artificial neural networks in motor control research. *Clin Biomech (Bristol, Avon)* 2004;19(9):873-5.
Full-text Exclude - Not original peer-reviewed data

Perry M, Draskovic I, van Achterberg T, et al. Can an EASYcare based dementia training programme improve diagnostic assessment and management of dementia by general practitioners and primary care nurses? The design of a randomised controlled trial. *BMC Health Serv Res* 2008;8:71.
Full-text Exclude - Not original peer-reviewed data

Persell SD, Denecke-Dattalo TA, Dunham DP, et al. Evidence-based medicine. Patient-directed intervention versus clinician reminders alone to improve aspirin use in diabetes: a cluster randomized trial. *Joint Commission Journal on Quality & Patient Safety* 2008;34(2):98-105.
Full-text Exclude - No acceptable comparator

Persell SD, Denecke-Dattalo TA, Dunham DP, et al. Patient-directed intervention versus clinician reminders alone to improve aspirin use in diabetes: a cluster randomized trial. *Jt Comm J Qual Patient Saf* 2008;34(2):98-105.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Persell SD, Dunne AP, Lloyd-Jones DM, et al. Electronic health record-based cardiac risk assessment and identification of unmet preventive needs. *Med Care* 2009;47(4):418-24.

Full-text Exclude - No electronic CDSS or KMS intervention

Persson M, Mjorndal T, Carlberg B, et al. Evaluation of a computer-based decision support system for treatment of hypertension with drugs: retrospective, nonintervention testing of cost and guideline adherence. *J Intern Med* 2000;247(1):87-93.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Pestotnik SL, Classen DC, Evans RS, et al. Prospective surveillance of imipenem/cilastatin use and associated seizures using a hospital information system. *Ann Pharmacother* 1993;27(4):497-501.
Full-text Exclude - No acceptable comparator

Pestotnik SL, Evans RS, Burke JP, et al. Therapeutic antibiotic monitoring: surveillance using a computerized expert system. *Am J Med* 1990;88(1):43-8.
Full-text Exclude - No acceptable comparator

Peters DH, Kohli M, Mascarenhas M, et al. Can computers improve patient care by primary health care workers in India? *Int J Qual Health Care* 2006;18(6):437-45.
Full-text Exclude - CDSS/KMS not aimed at health care providers

Pham DQ, Pham AQ, Ullah E, et al. Evaluating the appropriateness of thromboprophylaxis in an acute care setting using a computerised reminder, through order-entry system. *Int J Clin Pract* 2008;62(1):134-7.
Full-text Exclude - No electronic CDSS or KMS intervention

Phansalkar S, Weir CR, Morris AH, et al. Clinicians' perceptions about use of computerized protocols: a multicenter study. *Int J Med Inform* 2008;77(3):184-93.
Full-text Exclude - No electronic CDSS or KMS intervention

Phillips P. Multiple reminders were more effective than single reminders for increasing the rate of diabetic retinopathy examinations... commentary on Halbert RJ, Leung K, Nichol JM et al. Effect of multiple patient reminders in improving diabetic retinopathy screening: a randomized trial. *DIABETES CARE* 1999 May;22:752-5. *ACP J Club* 1999;131(3):80-80.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Piazza G, Goldhaber SZ. Computerized Decision Support for the Cardiovascular Clinician Applications for Venous Thromboembolism Prevention and Beyond. *Circulation* 2009;120(12):1133-1137.
Full-text Exclude - Not original peer-reviewed data

Piazza G, Goldhaber SZ. Improving clinical effectiveness in thromboprophylaxis for hospitalized medical patients. *Am J Med* 2009;122(3):230-2.
Full-text Exclude - Not original peer-reviewed data

Piazza G, Rosenbaum EJ, Pendergast W, et al. Physician alerts to prevent symptomatic venous thromboembolism in hospitalized patients. *Circulation* 2009;119(16):2196-201.
Full-text Exclude - Not original peer-reviewed data

Pielmeier U, Andreassen S, Juliusen B, et al. The Glucosafe system for tight glycemic control in critical care: a pilot evaluation study. *J Crit Care* 2010;25(1):97-104.
Full-text Exclude - Sample size <50

Pier C, Austin DW, Klein B, et al. A controlled trial of Internet-based cognitive-behavioural therapy for panic disorder with face-to-face support from a general practitioner or email support from a psychologist. *Mental Health in Family Medicine* 2008;5(1):29-39.
Full-text Exclude - No electronic CDSS or KMS intervention

Piso B, Wild C. Decision support in vaccination policies. *Vaccine* 2009;27(43):5923-8.
Full-text Exclude - Not original peer-reviewed data

Pizziferri L, Kittler AF, Volk LA, et al. Impact of an Electronic Health Record on oncologists' clinic time. *AMIA Annu Symp Proc* 2005:1083.
Full-text Exclude - No electronic CDSS or KMS intervention

Ploux S, Bordachar P, Deplagne A, et al. Electrocardiogram-based algorithm to predict the left ventricular lead position in recipients of cardiac resynchronization systems. *Pacing Clin Electrophysiol* 2009;32 Suppl 1:S2-7.
Full-text Exclude - No electronic CDSS or KMS intervention

Pluye P, Grad RM, Dunikowski LG, et al. Impact of clinical information-retrieval technology on physicians: A literature review of quantitative, qualitative and mixed methods studies. *Int J Med Inf* 2005;74(9):745-768.
Full-text Exclude - Not original peer-reviewed data

Poels PJ, Schermer TR, Schellekens DP, et al. Impact of a spirometry expert system on general practitioners' decision making. *Eur Respir J* 2008;31(1):84-92.
Full-text Exclude - No electronic CDSS or KMS intervention

Polacsek M, Orr J, Letourneau L, et al. Impact of a primary care intervention on physician practice and patient and family behavior: keep ME Healthy---the Maine Youth Overweight Collaborative. *Pediatrics* 2009;123 Suppl 5:S258-66.
Full-text Exclude - No electronic CDSS or KMS intervention

Polat K, Yosunkaya S, Gunes S. Comparison of different classifier algorithms on the automated detection of obstructive sleep apnea syndrome. *J Med Syst* 2008;32(3):243-50.
Full-text Exclude - No electronic CDSS or KMS intervention

Pollack CV, Jr. Wireless cardiac event alert monitoring is feasible and effective in the emergency department and adjacent waiting areas. *Crit Pathw Cardiol* 2009;8(1):7-11.
Full-text Exclude - No electronic CDSS or KMS intervention

Poller L, Keown M, Ibrahim S, et al. A multicentre randomised clinical endpoint study of PARMA 5 computer-assisted oral anticoagulant dosage. *Br J Haematol* 2008;143(2):274-83.
Full-text Exclude - Mandatory compliance CDSS

Poller L, Keown M, Ibrahim S, et al. An international multicenter randomized study of computer-assisted oral anticoagulant dosage vs. medical staff dosage. *J Thromb Haemost* 2008;6(6):935-43.
Full-text Exclude - Mandatory compliance CDSS

Poller L, Keown M, Ibrahim S, et al. A multicentre randomised assessment of the DAWN AC computer-assisted oral anticoagulant dosage program. *Thromb Haemost* 2009;101(3):487-94.
Full-text Exclude - Mandatory compliance CDSS

Poller L, Wright D, Rowlands M. Prospective comparative study of computer programs used for management of warfarin. *J Clin Pathol* 1993;46(4):299-303.

Full-text Exclude - Mandatory compliance CDSS

Poon E, Wright A, Simon S, et al. Relationship between use of electronic health record features and health care quality: results of a statewide survey. *Med Care* 2010;48(3):203.

Full-text Exclude - No electronic CDSS or KMS intervention

Poon EG, Wang SJ, Gandhi TK, et al. Design and implementation of a comprehensive outpatient Results Manager. *J Biomed Inform* 2003;36(1-2):80-91.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Popescu M, Arthur G. OntoQuest: a physician decision support system based on ontological queries of the hospital database. *AMIA Annu Symp Proc* 2006:639-43.

Full-text Exclude - No acceptable comparator

Prgomet M, Georgiou A, Westbrook JI. The Impact of Mobile Handheld Technology on Hospital Physicians' Work Practices and Patient Care: A Systematic Review. *J Am Med Inform Assoc* 2009;16(6):792-801.

Full-text Exclude - Not original peer-reviewed data

Prior M, Guerin M, Grimmer-Somers K. The effectiveness of clinical guideline implementation strategies--a synthesis of systematic review findings. *J Eval Clin Pract* 2008;14(5):888-97.

Full-text Exclude - Not original peer-reviewed data

Prosperi MC, Altmann A, Rosen-Zvi M, et al. Investigation of expert rule bases, logistic regression, and non-linear machine learning techniques for predicting response to antiretroviral treatment. *Antivir Ther* 2009;14(3):433-42.

Full-text Exclude - No electronic CDSS or KMS intervention

Proudfoot J, Ryden C, Everitt B, et al. Clinical efficacy of computerised cognitive-behavioural therapy for anxiety and depression in primary care: randomised controlled trial. *Br J Psychiatry* 2004;185:46-54.

Full-text Exclude - No electronic CDSS or KMS intervention

Quinn MM, Mannion J. Improving patient safety using interactive, evidence-based decision support tools. *Jt Comm J Qual Patient Saf* 2005;31(12):678-83.

Full-text Exclude - No acceptable comparator

Quinn MM, Mannion J, John M, Eisenberg Patient Safety and Quality Awards: improving patient safety using interactive, evidence-based decision support tools. *Joint Commission Journal on Quality & Patient Safety* 2005;31(12):678-683.

Full-text Exclude - Not original peer-reviewed data

Quinzler R, Schmitt SP, Pritsch M, et al. Substantial reduction of inappropriate tablet splitting with computerised decision support: a prospective intervention study assessing potential benefit and harm. *BMC Med Inform Decis Mak* 2009;9:30.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Rajkumar GN, Small DR, Conn IG. Computerised triage in a prostate assessment clinic. *Prostate Cancer Prostatic Dis* 2004;7(2):118-21.

Full-text Exclude - No acceptable comparator

Ramachandran SK, Kheterpal S, Haas CF, et al. Automated notification of suspected obstructive sleep apnea patients to the perioperative respiratory therapist: a pilot study. *Respir Care* 2010;55(4):414-8.

Full-text Exclude - No acceptable comparator

Ramanujam P, Guluma KZ, Castillo EM, et al. Accuracy of stroke recognition by emergency medical dispatchers and paramedics--San Diego experience. *Prehosp Emerg Care* 2008;12(3):307-13.

Full-text Exclude - No electronic CDSS or KMS intervention

Ramnarayan P, Cronje N, Brown R, et al. Validation of a diagnostic reminder system in emergency medicine: a multi-centre study. *Emerg Med J* 2007;24(9):619-24.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ramnarayan P, Tomlinson A, Kulkarni G, et al. A novel diagnostic aid (ISABEL): development and preliminary evaluation of clinical performance. *Stud Health Technol Inform* 2004;107(Pt 2):1091-5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Randell R, Dowding D. Organisational influences on nurses' use of clinical decision support systems. *Int J Med Inf* 2010;79(6):412-421.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Randell R, Mitchell N, Dowding D, et al. Effects of computerized decision support systems on nursing performance and patient outcomes: a systematic review. *J Health Serv Res Policy* 2007;12(4):242-9.
Full-text Exclude - Not original peer-reviewed data

Randell R, Mitchell N, Thompson C, et al. Supporting nurse decision making in primary care: exploring use of and attitude to decision tools. *Health Informatics J* 2009;15(1):5-16.
Full-text Exclude - No electronic CDSS or KMS intervention

Rao G. Practice corner: clinical practice guidelines and handheld computers. *ACP J Club* 2003;138(3):A11-2.
Full-text Exclude - Not original peer-reviewed data

Rapley T, May C, Heaven B, et al. Doctor-patient interaction in a randomised controlled trial of decision-support tools. *Soc Sci Med* 2006;62(9):2267-78.
Full-text Exclude - No electronic CDSS or KMS intervention

Raschke RA, Gollihare B, Wunderlich TA, et al. A computer alert system to prevent injury from adverse drug events: development and evaluation in a community teaching hospital. *JAMA* 1998;280(15):1317-20.
Full-text Exclude - No acceptable comparator

Ravdin PM, Davis GJ. A method for making estimates of the benefit of the late use of letrozole in patients completing 5 years of tamoxifen. *Clin Breast Cancer* 2004;5(4):313-6.
Full-text Exclude - Not original peer-reviewed data

Ravdin PM, Siminoff LA, Davis GJ, et al. Computer program to assist in making decisions about adjuvant therapy for women with early breast cancer. *J Clin Oncol* 2001;19(4):980-91.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ray MN, Houston TK, Yu FB, et al. Development and testing of a scale to assess physician attitudes about handheld computers with decision support. *J Am Med Inform Assoc* 2006;13(5):567-72.

Full-text Exclude - No electronic CDSS or KMS intervention

Rebitzer JB, Rege M, Shepard C. Influence, information overload, and information technology in health care. *Adv Health Econ Health Serv Res* 2008;19:43-69.
Full-text Exclude - Not original peer-reviewed data

Reekie D, Devlin H. Preventing failed appointments in general dental practice: a comparison of reminder methods. *Br Dent J* 1998;185(9):472-4.
Full-text Exclude - No electronic CDSS or KMS intervention

Regalado S. Current research. *Journal of the Canadian Health Libraries Association (JCHLA)* 2008;29(4):151-153.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Reiter HI, Neville AJ, Norman G. Medline for medical students? Searching for the right answer. *Advances in Health Sciences Education* 2000;5(3):221-232.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Resetar E, Reichley RM, Noiro LA, et al. Strategies for reducing nuisance alerts in a dose checking application. *AMIA Annu Symp Proc* 2005:624-8.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Reuben DB, Roth CP, Frank JC, et al. Assessing care of vulnerable elders--Alzheimer's disease: a pilot study of a practice redesign intervention to improve the quality of dementia care. *J Am Geriatr Soc* 2010;58(2):324-329.
Full-text Exclude - No electronic CDSS or KMS intervention

Revere D, Turner AM, Madhavan A, et al. Understanding the information needs of public health practitioners: a literature review to inform design of an interactive digital knowledge management system. *J Biomed Inform* 2007;40(4):410-21.
Full-text Exclude - Not original peer-reviewed data

Rhew DC, Glassman PA, Goetz MB. Improving pneumococcal vaccine rates. Nurse protocols versus clinical reminders. *J Gen Intern Med* 1999;14(6):351-6.
Full-text Exclude - No electronic CDSS or KMS intervention

Richards MJ, Robertson MB, Dartnell JG, et al. Impact of a web-based antimicrobial approval system on broad-spectrum cephalosporin use at a teaching hospital. *Med J Aust* 2003;178(8):386-90.

Full-text Exclude - No electronic CDSS or KMS intervention

Richards SH, Bankhead C, Peters TJ, et al. Cluster randomised controlled trial comparing the effectiveness and cost-effectiveness of two primary care interventions aimed at improving attendance for breast screening. *J Med Screen* 2001;8(2):91-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Riddell T, Wells S, Jackson R, et al. Performance of Framingham cardiovascular risk scores by ethnic groups in New Zealand: PREDICT CVD-10. *N Z Med J* 2010;123(1309):50-61.

Full-text Exclude - No acceptable comparator

Rinfret S, Lussier MT, Peirce A, et al. The Impact of a Multidisciplinary Information Technology-Supported Program on Blood Pressure Control in Primary Care. *Circulation-Cardiovascular Quality and Outcomes* 2009;2(3):170-177.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Roberts JD, Poffenroth LA, Roos LL, et al. Monitoring childhood immunizations: a Canadian approach. *Am J Public Health* 1994;84(10):1666-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Robertson J, Walkom E, Pearson SA, et al. The impact of pharmacy computerised clinical decision support on prescribing, clinical and patient outcomes: a systematic review of the literature. *Int J Pharm Pract* 2010;18(2):69-87.

Full-text Exclude - Not original peer-reviewed data

Rohrig R, Beutefuhr H, Hartmann B, et al. Summative software evaluation of a therapeutic guideline assistance system for empiric antimicrobial therapy in ICU. *J Clin Monit Comput* 2007;21(4):203-10.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Rolley J, Salamonson Y, Dennison C, et al. Development of clinical practice guidelines for the nursing care of people undergoing percutaneous coronary interventions: an Australian & New Zealand collaboration. *Aust Crit Care* 2010.

Full-text Exclude - No electronic CDSS or KMS intervention

Rollins G. Online calculator reduces nutrition-related pediatric adverse drug events. *Rep Med Guidel Outcomes Res* 2004;15(9):10, 12.

Full-text Exclude - No acceptable comparator

Rollins G. The prompt, the alert, and the legal record: documenting clinical decision support systems. *J AHIMA* 2005;76(2):24-8; quiz 31-2.

Full-text Exclude - Not original peer-reviewed data

Rollman BL, Fischer GS, Zhu F, et al. Comparison of electronic physician prompts versus waitroom case-finding on clinical trial enrollment. *J Gen Intern Med* 2008;23(4):447-50.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Rollman BL, Hanusa BH, Belnap BH, et al. Race, quality of depression care, and recovery from major depression in a primary care setting. *Gen Hosp Psychiatry* 2002;24(6):381-90.

Full-text Exclude - No outcome of interest

Rollman BL, Hanusa BH, Lowe HJ, et al. A randomized trial using computerized decision support to improve treatment of major depression in primary care. *J Gen Intern Med* 2002;17(7):493-503.

Full-text Exclude - No electronic CDSS or KMS intervention

Rose AJ, Shimada SL, Rothendler JA, et al. The accuracy of clinician perceptions of "usual" blood pressure control. *J Gen Intern Med* 2008;23(2):180-3.

Full-text Exclude - No electronic CDSS or KMS intervention

Rose GL, Plante DA, Thomas CS, et al. Utility of prompting physicians for brief alcohol consumption intervention. *Subst Use Misuse* 2010;45(6):936-50.

Full-text Exclude - No electronic CDSS or KMS intervention

Rose L, Presneill JJ, Cade JF. Update in computer-driven weaning from mechanical ventilation. *Anaesth Intensive Care* 2007;35(2):213-21.

Full-text Exclude - No electronic CDSS or KMS intervention

Rose L, Presneill JJ, Johnston L, et al. A randomised, controlled trial of conventional versus automated weaning from mechanical ventilation using

SmartCare/PS. Intensive Care Med 2008;34(10):1788-95.

Full-text Exclude - No electronic CDSS or KMS intervention

Rosenbloom ST, Geissbuhler AJ, Dupont WD, et al. Effect of CPOE user interface design on user-initiated access to educational and patient information during clinical care. J Am Med Inform Assoc 2005;12(4):458-73.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Rosenman M, Wang J, Dexter P, et al. Computerized reminders for syphilis screening in an urban emergency department. AMIA Annu Symp Proc 2003;987.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Rosenstein AH. Measuring the benefit of performance improvement and decision support. Am J Med Qual 1999;14(6):262-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Rosenthal DA, Layman EJ. Utilization of information technology in eastern North Carolina physician practices: determining the existence of a digital divide. Perspect Health Inf Manag 2008;5:3.

Full-text Exclude - No electronic CDSS or KMS intervention

Ross JJ, Denai MA, Mahfouf M. A hybrid hierarchical decision support system for cardiac surgical intensive care patients. Part II. Clinical implementation and evaluation. Artif Intell Med 2009;45(1):53-62.

Full-text Exclude - Not an evaluation study

Rousseau N, McColl E, Newton J, et al. Practice based, longitudinal, qualitative interview study of computerised evidence based guidelines in primary care. BMJ: British Medical Journal 2003;326(7384):314-321.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Rothschild AS, Lehmann HP. Information retrieval performance of probabilistically generated, problem-specific computerized provider order entry pick-lists: a pilot study. J Am Med Inform Assoc 2005;12(3):322-30.

Full-text Exclude - No electronic CDSS or KMS intervention

Rothschild J. Computerized physician order entry in the critical care and general inpatient setting: a narrative review. J Crit Care 2004;19(4):271-8.

Full-text Exclude - Not original peer-reviewed data

Rothschild JM, Fang E, Liu V, et al. Use and perceived benefits of handheld computer-based clinical references. J Am Med Inform Assoc 2006;13(6):619-626.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Rotman BL, Sullivan AN, McDonald TW, et al. A randomized controlled trial of a computer-based physician workstation in an outpatient setting: implementation barriers to outcome evaluation. J Am Med Inform Assoc 1996;3(5):340-8.

Full-text Exclude - Sample size <50

Roumie CL, Elsay TA, Wallston KA, et al. Clinical inertia: a common barrier to changing provider prescribing behavior. Joint Commission Journal on Quality & Patient Safety 2007;33(5):277-285.

Full-text Exclude - No acceptable comparator

Roumie CL, Grogan EL, Falbe W, et al. A three-part intervention to change the use of hormone replacement therapy in response to new evidence. Ann Intern Med 2004;141(2):118-25.

Full-text Exclude - No acceptable comparator

Rousseau N, McColl E, Newton J, et al. Practice based, longitudinal, qualitative interview study of computerised evidence based guidelines in primary care. BMJ 2003;326(7384):314.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Rubin MA, Bateman K, Donnelly S, et al. Use of a personal digital assistant for managing antibiotic prescribing for outpatient respiratory tract infections in rural communities. J Am Med Inform Assoc 2006;13(6):627-34.

Full-text Exclude - No acceptable comparator

Ruiz-Pena JL, Duque P, Izquierdo G. Optimization of treatment with interferon beta in multiple sclerosis. Usefulness of automatic system application criteria. BMC Neurol 2008;8:3.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ruland CM, Holte HH, Roislien J, et al. Effects of a computer-supported interactive tailored patient assessment tool on patient care, symptom distress, and patients' need for symptom management support: a randomized clinical trial. *J Am Med Inform Assoc* 2010;17(4):403-410.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Ryan C, O'Mahony D, Kennedy J, et al. Appropriate prescribing in the elderly: an investigation of two screening tools, Beers criteria considering diagnosis and independent of diagnosis and improved prescribing in the elderly tool to identify inappropriate use of medicines in the elderly in primary care in Ireland. *J Clin Pharm Ther* 2009;34(4):369-76.

Full-text Exclude - No electronic CDSS or KMS intervention

Ryan PJ, Gilbert M, Rose PE. Computer control of anticoagulant dose for therapeutic management. *BMJ* 1989;299(6709):1207-9.

Full-text Exclude - No acceptable comparator

Saager L, Collins GL, Burnside B, et al. A randomized study in diabetic patients undergoing cardiac surgery comparing computer-guided glucose management with a standard sliding scale protocol. *Cardiothorac Vasc Anesth* 2008;22(3):377-82.

Full-text Exclude - Sample size <50

Sachdeva RC. SureSmile technology in a patient--centered orthodontic practice. *J Clin Orthod* 2001;35(4):245-53.

Full-text Exclude - Not original peer-reviewed data

Sackett DL, Straus SE. Finding and applying evidence during clinical rounds: the "evidence cart". *JAMA* 1998;280(15):1336-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Sadik M, Hamadeh I, Nordblom P, et al. Computer-assisted interpretation of planar whole-body bone scans. *J Nucl Med* 2008;49(12):1958-65.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Saginur M, Graham ID, Forster AJ, et al. The uptake of technologies designed to influence medication safety in Canadian hospitals. *J Eval Clin Pract* 2008;14(1):27-35.

Full-text Exclude - No electronic CDSS or KMS intervention

Sahapong S, Manmart L, Ayuvat D, et al. Information use behavior of clinicians in evidence-based medicine process in Thailand. *J Med Assoc Thai* 2009;92(3):435-41.

Full-text Exclude - No electronic CDSS or KMS intervention

Sakallaris BR, Jastremski CA, Von Rueden KT. Clinical decision support systems for outcome measurement and management. *AACN Clin Issues* 2000;11(3):351-62.

Full-text Exclude - Not original peer-reviewed data

Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing - A randomized trial. *Jama-Journal of the American Medical Association* 2005;294(18):2305-2314.

Full-text Exclude - No acceptable comparator

Sandberg WS, Sandberg EH, Seim AR, et al. Real-time checking of electronic anesthesia records for documentation errors and automatically text messaging clinicians improves quality of documentation. *Anesth Analg* 2008;106(1):192-201, table of contents.

Full-text Exclude - No electronic CDSS or KMS intervention

Sanders DL, Aronsky D. Biomedical informatics applications for asthma care: a systematic review. *J Am Med Inform Assoc* 2006;13(4):418-27.

Full-text Exclude - No electronic CDSS or KMS intervention

Sandler SG. Effectiveness of the RhIg dose calculator. *Arch Pathol Lab Med* 2010;134(7):967-8.

Full-text Exclude - Not original peer-reviewed data

Satiani B, Miller S, Patel D. No-show rates in the vascular laboratory: analysis and possible solutions. *J Vasc Interv Radiol* 2009;20(1):87-91.

Full-text Exclude - No electronic CDSS or KMS intervention

Sawa T, Okahara M, Santo M, et al. Preoperative information management system using wireless PDAs. *AMIA Annu Symp Proc* 2003:995.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Sawyer WT. Comparing warfarin-dosage-prediction techniques. *Clin Pharm* 1987;6(10):758-9.

Full-text Exclude - Not original peer-reviewed data

Saywell RM, Jr., Champion VL, Skinner CS, et al. Cost-effectiveness comparison of five interventions to increase mammography screening. *Prev Med* 1999;29(5):374-82.

Full-text Exclude - No electronic CDSS or KMS intervention

Schadow G. Structured product labeling improves detection of drug-intolerance issues. *J Am Med Inform Assoc* 2009;16(2):211-9.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Schechter J, Stone MB. Emergency ultrasound diagnosis of lobar consolidation. *Acad Emerg Med* 2010;17(4):e27.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Schedlbauer A, Prasad V, Mulvaney C, et al. What evidence supports the use of computerized alerts and prompts to improve clinicians' prescribing behavior? *J Am Med Inform Assoc* 2009;16(4):531-8.

Full-text Exclude - Not original peer-reviewed data

Schedlbauer A, Prasad V, Mulvaney C, et al. What Evidence Supports the Use of Computerized Alerts and Prompts to Improve Clinicians' Prescribing Behavior? *J Am Med Inform Assoc* 2009;16(4):531-538.

Full-text Exclude - Not original peer-reviewed data

Scheuermann RH, Milgrom H. Personalized care, comparative effectiveness research and the electronic health record. *Curr Opin Allergy Clin Immunol* 2010;10(3):168-70.

Full-text Exclude - Not original peer-reviewed data

Schmidt-Kraepelin C, Janssen B, Gaebel W. Prevention of rehospitalization in schizophrenia: results of an integrated care project in Germany. *Eur Arch Psychiatry Clin Neurosci* 2009;259 Suppl 2:S205-12.

Full-text Exclude - No electronic CDSS or KMS intervention

Schmitt BP. A nurse-led clinic and computer decision-support software for anticoagulation decisions were as effective as a hospital clinic... commentary on Fitzmaurice DA, Hobbs FD, Murray ET et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized,

controlled trial. *ARCH INTERN MED* 2000 Aug 14/28;160:2343-8. *ACP J Club* 2001;134(2):73-73.

Full-text Exclude - Not original peer-reviewed data

Schmitt J, Balser M, Reif W. Verification of medical guidelines in KIV. *Stud Health Technol Inform* 2008;139:253-62.

Full-text Exclude - Not original peer-reviewed data

Schneider P. Wrestling over best practices. The rise of computer-aided decision-making. *Healthc Inform* 1997;14(5):25-6, 28, 30-3.

Full-text Exclude - Not original peer-reviewed data

Schnipper JL, Liang CL, Ndumele CD, et al. Effects of a computerized order set on the inpatient management of hyperglycemia: a cluster-randomized controlled trial. *Endocr Pract* 2010;16(2):209-18.

Full-text Exclude - No electronic CDSS or KMS intervention

Schwartz MD, Tercyak KP, Peshkin BN, et al. Can a computer-based system be used to educate women on genetic testing for breast cancer susceptibility? *Nat Clin Pract Oncol* 2005;2(1):24-5.

Full-text Exclude - Not original peer-reviewed data

Schwarz V, Hohenberger P, Kohler CO, et al. Setting up a decision support system with decision tables. *Methods Inf Med* 1989;28(3):126-32.

Full-text Exclude - Not original peer-reviewed data

Sciamanna CN, Ford DE, Flynn JA, et al. An evidence-based interactive computer program to assist physicians in counseling smokers to quit. *MD Comput* 1999;16(5):54-60.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Sciamanna CN, Gifford DR, Smith RJ. Design and acceptability of patient-oriented computerized diabetes care reminders for use at the point of care. *Med Inform Internet Med* 2004;29(2):157-68.

Full-text Exclude - No acceptable comparator

Scott IA, Denaro CP, Bennett CJ, et al. Towards more effective use of decision support in clinical practice: what the guidelines for guidelines don't tell you. *Intern Med J* 2004;34(8):492-500.

Full-text Exclude - Not original peer-reviewed data

Scott P, Prytherch D, Briggs J. Health informatics: Where's the evidence? 2010.

Full-text Exclude - Not original peer-reviewed data

Seger AC, Jha AK, Bates DW. Adverse drug event detection in a community hospital utilising computerised medication and laboratory data. *Drug Saf* 2007;30(9):817-24.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Selmi PM, Klein MH, Greist JH, et al. Computer-administered therapy for depression. *MD Comput* 1991;8(2):98-102.

Full-text Exclude - No electronic CDSS or KMS intervention

Sequist TD, Cullen T, Hays H, et al. Implementation and use of an electronic health record within the Indian Health Service. *J Am Med Inform Assoc* 2007;14(2):191-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Sequist TD, Zaslavsky AM, Colditz GA, et al. Electronic Patient Messages to Promote Colorectal Cancer Screening: A Randomized, Controlled Trial. *Arch Intern Med* 2010.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Seres KA, Kirkpatrick AC, Tierney WM. The utility of an evidence-based lecture and clinical prompt as methods to improve quality of care in colorectal cancer screening. *Am J Gastroenterol* 2009;104(2):420-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Sermeus W, Vanhaecht K. WISECARE to support evidence in practice. *Appl Nurs Res* 2000;13(3):159-61.

Full-text Exclude - Not original peer-reviewed data

Seroussi B, Bouaud J. Using OncoDoc as a computer-based eligibility screening system to improve accrual onto breast cancer clinical trials. *Artif Intell Med* 2003;29(1-2):153-67.

Full-text Exclude - No acceptable comparator

Seroussi B, Bouaud J, Sauquet D, et al. Why GPs do not follow computerized guidelines: an attempt of explanation involving usability with ASTI guiding mode. *Stud Health Technol Inform* 2010;160(Pt 2):1236-40.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Shakespeare TP, Gebiski V, Tang J, et al. Influence of the way results are presented on research interpretation and medical decision making: the PRIMER collaboration randomized studies. *Med Decis Making* 2008;28(1):127-37.

Full-text Exclude - No electronic CDSS or KMS intervention

Shandro MT, Pick ME, Gruninger A, et al. Diabetes care: interventions in the community. *Diabetes Care* 2002;25(5):941; author reply 941-2.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Shannon KC, Sinacore JM, Bennett SG, et al. Improving delivery of preventive health care with the comprehensive annotated reminder tool (CART). *J Fam Pract* 2001;50(9):767-71.

Full-text Exclude - No electronic CDSS or KMS intervention

Shapiro JS, Baumlin KM, Chawla N, et al. Emergency Department Information System Implementation and Process Redesign Result in Rapid and Sustained Financial Enhancement at a Large Academic Center. *Acad Emerg Med* 2010;17(5):527-535.

Full-text Exclude - No electronic CDSS or KMS intervention

Shapiro NI, Wolfe RE, Wright SB, et al. Who needs a blood culture? A prospectively derived and validated prediction rule. *J Emerg Med* 2008;35(3):255-64.

Full-text Exclude - No electronic CDSS or KMS intervention

Shapiro SE, Driever MJ. Clinical decision rules as tools for evidence-based nursing. *West J Nurs Res* 2004;26(8):930-7.

Full-text Exclude - Not original peer-reviewed data

Shaw GM, Chase JG, Wong J, et al. Rethinking glycaemic control in critical illness--from concept to clinical practice change. *Crit Care Resusc* 2006;8(2):90-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Shaw JS, Samuels RC, Larusso EM, et al. Impact of an encounter-based prompting system on resident vaccine administration performance and immunization knowledge. *Pediatrics* 2000;105(4 Pt 2):978-83.

Full-text Exclude - No electronic CDSS or KMS intervention

Shea S, DuMouchel W, Bahamonde L. A meta-analysis of 16 randomized controlled trials to evaluate computer-based clinical reminder systems for preventive care in the ambulatory setting. *J Am Med Inform Assoc* 1996;3(6):399-409.

Full-text Exclude - Not original peer-reviewed data

Shea S, Sideli RV, DuMouchel W, et al. Computer-generated informational messages directed to physicians: effect on length of hospital stay. *J Am Med Inform Assoc* 1995;2(1):58-64.

Full-text Exclude - No electronic CDSS or KMS intervention

Shebl NA, Franklin BD, Barber N. Clinical decision support systems and antibiotic use. *Pharm World Sci* 2007;29(4):342-9.

Full-text Exclude - Not original peer-reviewed data

Shekelle PG, Morton SC, Keeler EB. Costs and benefits of health information technology. *Evid Rep Technol Assess (Full Rep)* 2006(132):1-71.

Full-text Exclude - Not original peer-reviewed data

Sherman SE, Chapman A, Garcia D, et al. Improving recognition of depression in primary care: a study of evidence-based quality improvement. *Jt Comm J Qual Saf* 2004;30(2):80-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Shevlin JD, Summers-Bean C, Thomas D, et al. A systematic approach for increasing pneumococcal vaccination rates at an inner-city public hospital. *Am J Prev Med* 2002;22(2):92-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Shiach CR, Campbell B, Poller L, et al. Reliability of point-of-care prothrombin time testing in a community clinic: a randomized crossover comparison with hospital laboratory testing. *Br J Haematol* 2002;119(2):370-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Shoemaker WC, Bayard DS, Wo CC, et al. Outcome prediction in chest injury by a mathematical search and display program. *Chest* 2005;128(4):2739-48.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Shojania KG, Jennings A, Mayhew A, et al. Effect of point-of-care computer reminders on physician behaviour: a systematic review. *Can Med Assoc J* 2010;182(5):E216-E225.

Full-text Exclude - Not original peer-reviewed data

Short D, Frischer M, Bashford J. Barriers to the adoption of computerised decision support systems in general practice consultations: a qualitative study of GPs' perspectives. *Int J Med Inform* 2004;73(4):357-62.

Full-text Exclude - No electronic CDSS or KMS intervention

Shulman R, Finney SJ, O'Sullivan C, et al. Tight glycaemic control: a prospective observational study of a computerised decision-supported intensive insulin therapy protocol. *Crit Care* 2007;11(4):R75.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Sidorov J. Computer-assisted technology: not if, not when, but how. A systematic review of interactive computer-assisted technology in diabetes care. *J Gen Intern Med* 2006;21(2):201-2.

Full-text Exclude - Not original peer-reviewed data

Siebers MJ, Hunt VB. Increasing the pneumococcal vaccination rate of elderly patients in a general internal medicine clinic. *J Am Geriatr Soc* 1985;33(3):175-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Sim KM, Wang SY. Flexible negotiation agent with relaxed decision rules. *IEEE Trans Syst Man Cybern B Cybern* 2004;34(3):1602-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Siminerio LM, Piatt G, Zgibor JC. Implementing the chronic care model for improvements in diabetes care and education in a rural primary care practice. *Diabetes Educ* 2005;31(2):225-34.

Full-text Exclude - No electronic CDSS or KMS intervention

Simon GE, Ludman E, Unutzer J, et al. Design and implementation of a randomized trial evaluating systematic care for bipolar disorder. *Bipolar Disord* 2002;4(4):226-36.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Simon GE, VonKorff M, Rutter C, et al. Randomised trial of monitoring, feedback, and management of care by telephone to improve treatment of depression in primary care. *BMJ* 2000;320(7234):550-4.

Full-text Exclude - CDSS/KMS not aimed at health care providers

Simon SR, Kaushal R, Cleary PD, et al. Physicians and electronic health records: a statewide survey. *Arch Intern Med* 2007;167(5):507-12.

Full-text Exclude - No electronic CDSS or KMS intervention

Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-8.

Full-text Exclude - No acceptable comparator

Simonaitis L, Belsito A, Overhage JM. Enhancing an ePrescribing system by adding medication histories and formularies: the Regenstrief Medication Hub. *AMIA Annu Symp Proc* 2008;677-81.

Full-text Exclude - No electronic CDSS or KMS intervention

Singer J, Lou JQ, Malecki J, et al. Outcome assessment of preventive medicine guidelines compliance in providers using a computerized reminder system. *AMIA Annu Symp Proc* 2006;1100.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Singh H, Arora HS, Vij MS, et al. Communication outcomes of critical imaging results in a computerized notification system. *J Am Med Inform Assoc* 2007;14(4):459-66.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Singh H, Thomas EJ, Mani S, et al. Timely follow-up of abnormal diagnostic imaging test results in an outpatient setting: are electronic medical records achieving their potential? *Arch Intern Med* 2009;169(17):1578-86.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Singh H, Thomas EJ, Sittig DF, et al. Notification of abnormal lab test results in an electronic medical record: do any safety concerns remain? *Am J Med* 2010;123(3):238-44.

Full-text Exclude - No acceptable comparator

Sintchenko V, Coiera E, Gilbert GL. Decision support systems for antibiotic prescribing. *Current Opinion in Infectious Diseases* 2008;21(6):573-579.

Full-text Exclude - Not original peer-reviewed data

Sintchenko V, Magrabi F, Tipper S. Are we measuring the right end-points? Variables that affect the impact of computerised decision support on patient outcomes: a systematic review. *Med Inform Internet Med* 2007;32(3):225-40.

Full-text Exclude - Not original peer-reviewed data

Sipkoff M. Plans go directly to patients, describing treatment options. *Manag Care* 2004;13(4):27-30.

Full-text Exclude - Not original peer-reviewed data

Sipkoff M. HIT decisions lie on the horizon, but savings remain elusive. *Manag Care* 2010;19(2):24-7.

Full-text Exclude - Not original peer-reviewed data

Sissons B, Gray WA, Bater A, et al. Using artificial intelligence to bring evidence-based medicine a step closer to making the individual difference. *Med Inform Internet Med* 2007;32(1):11-8.

Full-text Exclude - Not original peer-reviewed data

Sittig DF, Gardner RM, Morris AH, et al. Clinical evaluation of computer-based respiratory care algorithms. *Int J Clin Monit Comput* 1990;7(3):177-85.

Full-text Exclude - Not original peer-reviewed data

Sixou JL, Marie-Cousin A, Huet A, et al. Pain assessment by children and adolescents during intraosseous anaesthesia using a computerized system (QuickSleeper). *Int J Paediatr Dent* 2009;19(5):360-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Sketris IS, Langille Ingram EM, Lummis HL. Strategic opportunities for effective optimal prescribing and medication management. *Can J Clin Pharmacol* 2009;16(1):e103-25.

Full-text Exclude - Not original peer-reviewed data

Slade K, Lambert MJ, Harmon SC, et al. Improving psychotherapy outcome: the use of immediate electronic feedback and revised clinical support tools. *Clin Psychol Psychother* 2008;15(5):287-303.
Full-text Exclude - No electronic CDSS or KMS intervention

Sliwka D, Fang MC. Venous Thromboembolism Prophylaxis in the United States: Still Room for Improvement. *J Gen Intern Med* 2010;25(6):484-486.
Full-text Exclude - Not original peer-reviewed data

Sloane EB. Using a decision support system tool for healthcare technology assessments. *IEEE Eng Med Biol Mag* 2004;23(3):42-55.
Full-text Exclude - Not original peer-reviewed data

Smith KL. Improving guideline adherence with clinical decision support systems. *Nurse Pract* 2008;2-3.
Full-text Exclude - Not original peer-reviewed data

Smith MY, Depue JD, Rini C. Computerized decision-support systems for chronic pain management in primary care. *Pain Medicine* 2007;8:S155-S166.
Full-text Exclude - Not original peer-reviewed data

Sneiderman CA, Demner-Fushman D, Fiszman M, et al. Knowledge-based methods to help clinicians find answers in MEDLINE. *J Am Med Inform Assoc* 2007;14(6):772-80.
Full-text Exclude - No electronic CDSS or KMS intervention

Snooks H, Cheung WY, Close J, et al. Support and Assessment for Fall Emergency Referrals (SAFER 1) trial protocol. Computerised on-scene decision support for emergency ambulance staff to assess and plan care for older people who have fallen: evaluation of costs and benefits using a pragmatic cluster randomised trial. *BMC Emerg Med* 2010;10:2.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Somkin CP, Hiatt RA, Hurley LB, et al. The effect of patient and provider reminders on mammography and Papanicolaou smear screening in a large health maintenance organization. *Arch Intern Med* 1997;157(15):1658-64.
Full-text Exclude - No electronic CDSS or KMS intervention

Soper J, Chan GT, Skinner JR, et al. Management of oral anticoagulation in a population of children with cardiac disease using a computerised system to support decision-making. *Cardiol Young* 2006;16(3):256-60.
Full-text Exclude - Sample size <50

Stark R, Helenius IM, Schimming LM, et al. Real-time EBM: from bed board to keyboard and back. *J Gen Intern Med* 2007;22(12):1656-60.
Full-text Exclude - No electronic CDSS or KMS intervention

Stein W. Modified Sainsbury tool: an initial risk assessment tool for primary care mental health and learning disability services. *J Psychiatr Ment Health Nurs* 2005;12(5):620-33.
Full-text Exclude - No electronic CDSS or KMS intervention

Steurbaat K, Van Hoecke S, Colpaert K, et al. Use of web services for computerized medical decision support, including infection control and antibiotic management, in the intensive care unit. *J Telemed Telecare* 2010;16(1):25-9.
Full-text Exclude - No electronic CDSS or KMS intervention

Stewart K, Loftus S, DeLisle S. Prescription of amiodarone through a computerized template that includes both decision support and executive functions improves the monitoring for toxicities. *AMIA Annu Symp Proc* 2003:1020.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Stewart KL. Reducing medical liability risk. Live decision support-enabled EMR reduces obstetric medical professional liability with best-practice protocol. *Health Manag Technol* 2007;28(12):30-3.
Full-text Exclude - Not original peer-reviewed data

Stiell IG, Clement CM, Grimshaw JM, et al. A prospective cluster-randomized trial to implement the Canadian CT Head Rule in emergency departments. *CMAJ* 2010;182(14):1527-32.
Full-text Exclude - No electronic CDSS or KMS intervention

Stone RA, Mor MK, Lave JR, et al. Implementation of an inpatient management and discharge strategy for patients with community-acquired pneumonia. *Am J Manag Care* 2005;11(8):491-9.
Full-text Exclude - No electronic CDSS or KMS intervention

Strack T, Bergeler J, Beyer J, et al. Computer assisted conventional insulin therapy. *Life Support Syst* 1985;3 Suppl 1:568-72.

Full-text Exclude - No electronic CDSS or KMS intervention

Straus SE. Individualizing treatment decisions. The likelihood of being helped or harmed. *Eval Health Prof* 2002;25(2):210-24.

Full-text Exclude - No electronic CDSS or KMS intervention

Strayer SM, Pelletier SL, Martindale JR, et al. A PDA-based counseling tool for improving medical student smoking cessation counseling. *Fam Med* 2010;42(5):350-7.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Swislocki A, Noth RH, Volpp B, et al. Computer confirmation of improved blood pressure control in diabetic patients. *Prev Cardiol* 2009;12(3):149-54.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Tagil K, Bondouy M, Chaborel JP, et al. A decision support system improves the interpretation of myocardial perfusion imaging. *European Journal of Nuclear Medicine and Molecular Imaging* 2008;35(9):1602-1607.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Takala J, Dellinger RP, Koskinen K, et al. Development and simultaneous application of multiple care protocols in critical care: a multicenter feasibility study. *Intensive Care Med* 2008;34(8):1401-10.

Full-text Exclude - No electronic CDSS or KMS intervention

Tamblyn R, Huang A, Kawasumi Y, et al. The development and evaluation of an integrated electronic prescribing and drug management system for primary care. *J Am Med Inform Assoc* 2006;13(2):148-59.

Full-text Exclude - No acceptable comparator

Tan K, Dear PR, Newell SJ. Clinical decision support systems for neonatal care. *Cochrane Database Syst Rev* 2009(2):CD004211.

Full-text Exclude - Not original peer-reviewed data

Tang WL, Wang YM, Du WM, et al. Study of the process of secondary failure of sulphonylurea by a Markov model. *Pharmacoepidemiol Drug Saf* 2008;17(5):511-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Taylor B, Robertson D, Wiratunga N, et al. Using computer aided case based reasoning to support clinical reasoning in community occupational therapy. *Comput Methods Programs Biomed* 2007;87(2):170-9.

Full-text Exclude - Not original peer-reviewed data

Tehrani FT, Abbasi S. Evaluation of a computerized system for mechanical ventilation of infants. *J Clin Monit Comput* 2009;23(2):93-104.

Full-text Exclude - Sample size <50

Terraz O, Wietlisbach V, Jeannot JG, et al. The EPAGE internet guideline as a decision support tool for determining the appropriateness of colonoscopy. *Digestion* 2005;71(2):72-7.

Full-text Exclude - No electronic CDSS or KMS intervention

Terrell KM, Perkins AJ, Dexter PR, et al. 'Decision support for inappropriate prescribing': Response letter to Dr. Ito. *J Am Geriatr Soc* 2010;58(2).

Full-text Exclude - Not original peer-reviewed data

Terrell KM, Perkins AJ, Dexter PR, et al. Response letter to Dr. Ito... Ito K. 2010. Decision support for inappropriate prescribing. *J Am Geriatr Soc*; 58(2): 416-7. *J Am Geriatr Soc* 2010;58(2):417-417.

Full-text Exclude - Not original peer-reviewed data

Thakkestian A, Tran H, Reeves G, et al. A clinical decision rule to aid ordering of serum and urine protein electrophoresis for case-finding of paraproteins in hospitalized inpatients. *J Gen Intern Med* 2008;23(10):1688-92.

Full-text Exclude - No electronic CDSS or KMS intervention

Theocharopoulos N, Chatzakis G, Damilakis J. Is radiography justified for the evaluation of patients presenting with cervical spine trauma? *Med Phys* 2009;36(10):4461-70.

Full-text Exclude - No electronic CDSS or KMS intervention

Thiru K, Rowe S, Shaw N, et al. Survey of clinical information system usage by paediatric intensive care units in the UK. *Intensive Care Med* 2010;36(9):1616-1617.

Full-text Exclude - Not original peer-reviewed data

Thomas MJ, Simpson J, Riley R, et al. The impact of home-based physiotherapy interventions on breathlessness during activities of daily living in severe COPD: a systematic review. *Physiotherapy* 2010;96(2):108-19.

Full-text Exclude - Not original peer-reviewed data

Thomas RE, Croal BL, Ramsay C, et al. Effect of enhanced feedback and brief educational reminder messages on laboratory test requesting in primary care: a cluster randomised trial. *Lancet* 2006;367(9527):1990-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Thompson A, Sullivan SA, Barley M, et al. The DEBIT trial: an intervention to reduce antipsychotic polypharmacy prescribing in adult psychiatry wards - a cluster randomized controlled trial. *Psychol Med* 2008;38(5):705-15.

Full-text Exclude - No electronic CDSS or KMS intervention

Thompson BT, Orme JF, Zheng H, et al. Multicenter validation of a computer-based clinical decision support tool for glucose control in adult and pediatric intensive care units. *J Diabetes Sci Technol* 2008;2(3):357-68.

Full-text Exclude - No acceptable comparator

Thompson J. Treatment Guidelines for Hepatic Encephalopathy. *Pharmacotherapy* 2010;30(5, part 2):4-9.

Full-text Exclude - Not original peer-reviewed data

Thungjaroenkul P, Kunaviktikul W. Possibilities for cost containment in intensive care. *Nurs Health Sci* 2006;8(4):237-40.

Full-text Exclude - Not original peer-reviewed data

Tierney WM, Dexter PR, Gramelspacher GP, et al. The effect of discussions about advance directives on patients' satisfaction with primary care. *J Gen Intern Med* 2001;16(1):32-40.

Full-text Exclude - No electronic CDSS or KMS intervention

Ting SL, Wang WM, Kwok SK, et al. RACER: Rule-Associated CasE-based Reasoning for supporting General Practitioners in prescription making. *Expert Systems with Applications* 2010;37(12):8079-8089.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Tolman C, Richardson D, Bartlett C, et al. Structured conversion from thrice weekly to weekly erythropoietic regimens using a computerized decision-support system: a randomized clinical study. *J Am Soc Nephrol* 2005;16(5):1463-70.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Toohar R, Middleton P, Pham C, et al. A systematic review of strategies to improve prophylaxis for venous thromboembolism in hospitals. *Ann Surg* 2005;241(3):397-415.

Full-text Exclude - Not original peer-reviewed data

Tortajada S, Garcia-Gomez JM, Vicente J, et al. Prediction of postpartum depression using multilayer perceptrons and pruning. *Methods Inf Med* 2009;48(3):291-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Toth-Pal E, Wardh I, Strender LE, et al. Implementing a clinical decision-support system in practice: a qualitative analysis of influencing attitudes and characteristics among general practitioners. *Inform Health Soc Care* 2008;33(1):39-54.

Full-text Exclude - No acceptable comparator

Trafton J, Martins S, Michel M, et al. Evaluation of the acceptability and usability of a decision support system to encourage safe and effective use of opioid therapy for chronic, noncancer pain by primary care providers. *Pain Med* 2010;11(4):575-85.

Full-text Exclude - No acceptable comparator

Trafton JA, Martins SB, Michel MC, et al. Designing an automated clinical decision support system to match clinical practice guidelines for opioid therapy for chronic pain. *Implementation Science* 2010;5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Travers DA, Downs SM. Comparing user acceptance of a computer system in two pediatric offices: a qualitative study. *Proc Amia Symp* 2000:853-7.

Full-text Exclude - No acceptable comparator

Trivedi MH. Remission of depression and the Texas Medication Algorithm Project. *Manag Care Interface* 2003;Suppl B:9-13.

Full-text Exclude - Not original peer-reviewed data

Trivedi MH, Claassen CA, Grannemann BD, et al. Assessing physicians' use of treatment algorithms: Project IMPACTS study design and rationale. *Contemp Clin Trials* 2007;28(2):192-212.

Full-text Exclude - Not original peer-reviewed data

Trivedi MH, Daly EJ. Measurement-based care for refractory depression: A clinical decision support model for clinical research and practice. *Drug Alcohol Depend* 2007;88(Suppl 2):S61-S71.

Full-text Exclude - Not original peer-reviewed data

Trivedi MH, Rush AJ, Gaynes BN, et al. Maximizing the adequacy of medication treatment in controlled trials and clinical practice: STAR(*)D measurement-based care. *Neuropsychopharmacology* 2007;32(12):2479-89.

Full-text Exclude - Not original peer-reviewed data

Trop I, Stolberg HO, Nahmias C. Estimates of diagnostic accuracy efficacy: how well can this test perform the classification task? *Can Assoc Radiol J* 2003;54(2):80-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Turner C. Incorporating evidence at the point of care. *CIN: Computers, Informatics, Nursing* 2009;27(5):337-338.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Twiggs JE, Fifield J, Jackson E, et al. Treating asthma by the guidelines: developing a medication management information system for use in primary care. *Dis Manag* 2004;7(3):244-60.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Ueno K, Kasai T, Brewer G, et al. Evaluation of the apnea-hypopnea index determined by the S8 auto-CPAP, a continuous positive airway pressure device, in patients with obstructive sleep apnea-hypopnea syndrome. *J Clin Sleep Med* 2010;6(2):146-51.

Full-text Exclude - No electronic CDSS or KMS intervention

Ulbricht C, Basch E, Vora M, et al. Chaparral monograph: a clinical decision support tool. *J Herb Pharmacother* 2003;3(1):121-33.

Full-text Exclude - Not original peer-reviewed data

Undeland DK, Kowalski TJ, Berth WL, et al. Appropriately prescribing antibiotics for patients with pharyngitis: a physician-based approach vs a nurse-only triage and treatment algorithm. *Mayo Clin Proc* 2010;85(11):1011-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Valdes K. Overcoming the challenges to incorporate evidence-based medicine into clinical practice. *J Hand Ther* 2010;23(3):239-40.

Full-text Exclude - Not original peer-reviewed data

Valerio LG, Yang C, Arvidson KB, et al. A structural feature-based computational approach for toxicology predictions. *Expert Opin Drug Metab Toxicol* 2010;6(4):505-518.

Full-text Exclude - Not original peer-reviewed data

Valles-Fernandez R, Rosell-Murphy M, Correcher-Aventin O, et al. A quality improvement plan for hypertension control: the INCOTECA Project (INterventions for Control of hyperTension in CATalonia). *BMC Public Health* 2009;9:89.

Full-text Exclude - Not original peer-reviewed data

van Ast JF, Renier WO, Talmon JL, et al. Diagnostic reference frames for seizures: A validation study. *J Neurol* 2006;253(3):372-6.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

van der Sijs H, Aarts J, van Gelder T, et al. Turning off frequently overridden drug alerts: limited opportunities for doing it safely. *J Am Med Inform Assoc* 2008;15(4):439-48.

Full-text Exclude - No acceptable comparator

van der Sijs H, Bouamar R, van Gelder T, et al. Functionality test for drug safety alerting in computerized physician order entry systems. *Int J Med Inform* 2010;79(4):243-51.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

van der Sijs H, Mulder A, van Gelder T, et al. Drug safety alert generation and overriding in a large Dutch university medical centre. *Pharmacoepidemiol Drug Saf* 2009;18(10):941-7.

Full-text Exclude - No acceptable comparator

Van Duppen D, Aertgeerts B, Hannes K, et al. Online on-the-spot searching increases use of evidence during consultations in family practice. *Patient Educ Couns* 2007;68(1):61-65.

Full-text Exclude - No electronic CDSS or KMS intervention

Van Erps J, Aapro M, MacDonald K, et al. Promoting evidence-based management of anemia in cancer patients: concurrent and discriminant validity of RESPOND, a web-based clinical guidance system based on the EORTC guidelines for supportive care in cancer. *Support Care Cancer* 2010;18(7):847-58.

Full-text Exclude - No outcome of interest

van Steenkiste B, van der Weijden T, Stoffers HE, et al. Improving cardiovascular risk management: a randomized, controlled trial on the effect of a decision support tool for patients and physicians. *Eur J Cardiovasc Prev Rehabil* 2007;14(1):44-50.

Full-text Exclude - No electronic CDSS or KMS intervention

Van Wyk JT, Van Wijk MA, Moorman PW, et al. Cholgate - a randomized controlled trial comparing the effect of automated and on-demand decision support on the management of cardiovascular disease factors in primary care. *AMIA Annu Symp Proc* 2003:1040.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Varonen H, Kortteisto T, Kaila M, et al. What may help or hinder the implementation of computerized decision support systems (CDSSs): a focus group study with physicians. *Fam Pract* 2008;25(3):162-167.

Full-text Exclude - No electronic CDSS or KMS intervention

Vashitz G, Meyer J, Gilutz H. General practitioners' adherence with clinical reminders for secondary prevention of dyslipidemia. *AMIA Annu Symp Proc* 2007:766-70.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Vaughan NJ, Potts A. Implementation and evaluation of a decision support system for type II diabetes. *Comput Methods Programs Biomed* 1996;50(3):247-51.

Full-text Exclude - No electronic CDSS or KMS intervention

Vedsted P, Nielsen JN, Olesen F. Does a computerized price comparison module reduce prescribing costs in general practice? *Fam Pract* 1997;14(3):199-203.

Full-text Exclude - No electronic CDSS or KMS intervention

Veloski J, Boex JR, Grasberger MJ, et al. Systematic review of the literature on assessment, feedback and physicians' clinical performance: BEME Guide No. 7. *Med Teach* 2006;28(2):117-28.

Full-text Exclude - Not original peer-reviewed data

Venkat A, Chan-Tompkins NH, Hegde GG, et al. Feasibility of integrating a clinical decision support tool into an existing computerized physician order entry system to increase seasonal influenza vaccination in the emergency department. *Vaccine* 2010;28(37):6058-64.

Full-text Exclude - No acceptable comparator

Venkatesh AK, Lankford MG, Rooney DM, et al. Use of electronic alerts to enhance hand hygiene compliance and decrease transmission of vancomycin-resistant *Enterococcus* in a hematology unit. *Am J Infect Control* 2008;36(3):199-205.

Full-text Exclude - No electronic CDSS or KMS intervention

Verstappen SM, Jacobs JW, van der Veen MJ, et al. Intensive treatment with methotrexate in early rheumatoid arthritis: aiming for remission. Computer Assisted Management in Early Rheumatoid Arthritis (CAMERA, an open-label strategy trial). *Ann Rheum Dis* 2007;66(11):1443-9.

Full-text Exclude - Mandatory compliance CDSS

Vinker S, Nakar S, Rosenberg E, et al. The role of family physicians in increasing annual fecal occult blood test screening coverage: a prospective intervention study. *Isr Med Assoc J* 2002;4(6):424-5.

Full-text Exclude - No electronic CDSS or KMS intervention

Vogelsmeier AA, Halbesleben JR, Scott-Cawiezell JR. Technology implementation and workarounds in the nursing home. *J Am Med Inform Assoc* 2008;15(1):114-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Vora S, Verber L, Potts S, et al. Effect of a novel birth intervention and reminder-recall on on-time immunization compliance in high-risk children. *Hum Vaccin* 2009;5(6):395-402.

Full-text Exclude - No electronic CDSS or KMS intervention

Vozeh S, Uematsu T, Ritz R, et al. Computer-assisted individualized lidocaine dosage: clinical evaluation and comparison with physician performance. *Am Heart J* 1987;113(4):928-33.

Full-text Exclude - Mandatory compliance CDSS

Waisel DB, Fackler JC, Brunner JX, et al. PEFIOS: an expert closed-loop oxygenation algorithm. *Medinfo* 1995;8 Pt 2:1132-6.

Full-text Exclude - No electronic CDSS or KMS intervention

Walker FO. Assessing muscle function at the bedside: can we do better? *Muscle and Nerve* 2010;42(4):466-8.

Full-text Exclude - Not original peer-reviewed data

Wallace C, Hatzakis M, Legro MW, et al. Understanding a VA preventive care clinical reminder: lessons learned. *SCI Nurs* 2004;21(3):149-52.

Full-text Exclude - Not original peer-reviewed data

Walsh JM, McDonald KM, Shojania KG, et al. Quality improvement strategies for hypertension management: a systematic review. *Med Care* 2006;44(7):646-57.

Full-text Exclude - Not original peer-reviewed data

Walton R, Dovey S, Harvey E, et al. Computer support for determining drug dose: systematic review and meta-analysis. *BMJ* 1999;318(7189):984-90.

Full-text Exclude - Not original peer-reviewed data

Walton RT, Harvey E, Dovey S, et al. Computerised advice on drug dosage to improve prescribing practice. *Cochrane Database Syst Rev* 2001(1):CD002894.

Full-text Exclude - Not original peer-reviewed data

Wan Q, Harris M, Zwar N, et al. Experience in implementation of cardiovascular absolute risk assessment and management in Australian general practice. *Int J Clin Pract* 2010;64(8):1166-1167.

Full-text Exclude - Not original peer-reviewed data

Wang S, Xie J, Sada M, et al. TACHY: an expert system for the management of supraventricular tachycardia in the elderly. *Am Heart J* 1998;135(1):82-7.

Full-text Exclude - No acceptable comparator

Warady BA, Watkins SL, Fivush BA, et al. Validation of PD Adequest 2.0 for pediatric dialysis patients. *Pediatr Nephrol* 2001;16(3):205-11.

Full-text Exclude - No electronic CDSS or KMS intervention

Ward MD. Decision support information for health care delivery and management. *Inside Case Management* 1999;6(1):9-11.

Full-text Exclude - Not original peer-reviewed data

Waring WS, McDonald SH, Good AM, et al. Interpretation of clinical guidelines for poisoned patients: positive and negative effects of standard phrases used in TOXBASE. *Eur J Clin Pharmacol* 2009;65(10):1007-12.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Warren JJ, Stoupa R, Dail JE, et al. The design of an expert system for ambulatory nursing data management using a nursing diagnosis focus. *Classification of nursing diagnoses: proceedings of the tenth conference held on April 25-29, 1992 in San Diego, CA*. Philadelphia: J.B. Lippincott; 1994:302-303.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Weaver A, Young AM, Rowntree J, et al. Application of mobile phone technology for managing chemotherapy-associated side-effects. *Ann Oncol* 2007;18(11):1887-92.

Full-text Exclude - No acceptable comparator

Weaver FM, Smith B, LaVela S, et al. Interventions to increase influenza vaccination rates in veterans with spinal cord injuries and disorders. *J Spinal Cord Med* 2007;30(1):10-9.

Full-text Exclude - No acceptable comparator

Weber V, Bloom F, Pierdon S, et al. Employing the electronic health record to improve diabetes care: a multifaceted intervention in an integrated delivery system. *J Gen Intern Med* 2008;23(4):379-82.

Full-text Exclude - No acceptable comparator

Weekley J, Smith B. Review: computer-based clinical decision support systems can improve physician performance in some areas... commentary on Hunt DL, Haynes RB, Hanna SE, Smith K. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. *JAMA* 1998 Oct 21;280:1339-46. *ACP J Club* 1999;130(3):79-79.

Full-text Exclude - Not original peer-reviewed data

Weeks D, Corbett C, Stream G. Beliefs of Ambulatory Care Physicians about Accuracy of Patient Medication Records and Technology Enhanced Solutions to Improve Accuracy. *J Healthc Qual* 2010;32(5):12-21.

Full-text Exclude - No electronic CDSS or KMS intervention

Weiner SG, Brown SF, Goetz JD, et al. Weekly E-mail reminders influence emergency physician behavior: a case study using the Joint Commission and Centers for Medicare and Medicaid Services Pneumonia Guidelines. *Acad Emerg Med* 2009;16(7):626-31.

Full-text Exclude - No electronic CDSS or KMS intervention

Weingart SN, Massagli M, Cyrulik A, et al. Assessing the value of electronic prescribing in ambulatory care: a focus group study. *Int J Med Inform* 2009;78(9):571-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Weingart SN, Simchowitz B, Shiman L, et al. Clinicians' assessments of electronic medication safety alerts in ambulatory care. *Arch Intern Med* 2009;169(17):1627-32.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Weingart SN, Toth M, Sands DZ, et al. Physicians' decisions to override computerized drug alerts in primary care. *Arch Intern Med* 2003;163(21):2625-31.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Weingarten MA, Bazel D, Shannon HS. Computerized protocol for preventive medicine: a controlled self-audit in family practice. *Fam Pract* 1989;6(2):120-4.

Full-text Exclude - No electronic CDSS or KMS intervention

Weingarten SR, Riedinger MS, Conner L, et al. Practice guidelines and reminders to reduce duration of hospital stay for patients with chest pain. An interventional trial. *Ann Intern Med* 1994;120(4):257-63.

Full-text Exclude - No electronic CDSS or KMS intervention

Weiss JP, Froelicher VF, Myers JN, et al. Health-care costs and exercise capacity. *Chest* 2004;126(2):608-13.

Full-text Exclude - No electronic CDSS or KMS intervention

Wells S, Furness S, Rafter N, et al. Integrated electronic decision support increases cardiovascular disease risk assessment four fold in routine primary care practice. *Eur J Cardiovasc Prev Rehabil* 2008;15(2):173-8.

Full-text Exclude - No outcome of interest

Wells S, Whittaker R, Dorey E, et al. Harnessing Health IT for Improved Cardiovascular Risk Management. *Plos Medicine* 2010;7(8).

Full-text Exclude - Not original peer-reviewed data

Wenger NS, Roth CP, Hall WJ, et al. Practice redesign to improve care for falls and urinary incontinence: primary care intervention for older patients. *Arch Intern Med* 2010;170(19):1765-72.

Full-text Exclude - No acceptable comparator

Went K, Antoniewicz P, Corner DA, et al. Reducing prescribing errors: can a well-designed electronic system help? *J Eval Clin Pract* 2010;16(3):556-559.

Full-text Exclude - No electronic CDSS or KMS intervention

Were MC, Abernathy G, Hui SL, et al. Using computerized provider order entry and clinical decision support to improve referring physicians' implementation of consultants' medical recommendations. *J Am Med Inform Assoc* 2009;16(2):196-202.

Full-text Exclude - Sample size <50

Wess ML, Schauer DP, Johnston JA, et al. Application of a decision support tool for anticoagulation in patients with non-valvular atrial fibrillation. *J Gen Intern Med* 2008;23(4):411-7.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Westbrook JI, Gosling AS, Westbrook MT. Use of point-of-care online clinical evidence by junior and senior doctors in New South Wales public hospitals. *Intern Med J* 2005;35(7):399-404.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

White RH, Hong R, Venook AP, et al. Initiation of warfarin therapy: comparison of physician dosing with computer-assisted dosing. *J Gen Intern Med* 1987;2(3):141-8.

Full-text Exclude - Mandatory compliance CDSS

White RH, Mungall D. Outpatient management of warfarin therapy: comparison of computer-predicted dosage adjustment to skilled professional care. *Ther Drug Monit* 1991;13(1):46-50.

Full-text Exclude - Closed loop system

Whitley HP, Fermo JD, Chumney EC. 5-year evaluation of electronic medical record flag alerts for patients warranting secondary prevention of coronary heart disease. *Pharmacotherapy* 2006;26(5):682-8.

Full-text Exclude - No outcome of interest

Whitty P, Eccles MP, Hawthorne G, et al. Improving services for people with diabetes: lessons from setting up the DREAM trial. *Practical Diabetes International* 2004;21(9):323-328.

Full-text Exclude - Not an evaluation study

Wiecek A, Covic A, Locatelli F, et al. Renal anemia: comparing current Eastern and Western European management practice (ORAMA). *Ren Fail* 2008;30(3):267-76.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Wilkes JJ, Zaoutis TE, Keren R, et al. Treatment with oseltamivir in children hospitalized with community-acquired, laboratory-confirmed influenza: review of five seasons and evaluation of an electronic reminder. *J Hosp Med* 2009;4(3):171-8.

Full-text Exclude - No electronic CDSS or KMS intervention

Wilkinson K. A proposed algorithm on when to switch opioid. *European Journal of Palliative Care* 2009;16(4):162-165.

Full-text Exclude - No electronic CDSS or KMS intervention

Will EJ, Richardson D, Tolman C, et al. Development and exploitation of a clinical decision support system for the management of renal anaemia. *Nephrol Dial Transplant* 2007;22 Suppl 4:iv31-iv36.

Full-text Exclude - Not original peer-reviewed data

Williams LK, Peterson EL, Wells K, et al. A cluster-randomized trial to provide clinicians inhaled corticosteroid adherence information for their patients with asthma. *J Allergy Clin Immunol* 2010;126(2):225-U6.

Full-text Exclude - No electronic CDSS or KMS intervention

Williams MG, Dittmer A. Textbooks on tap: using electronic books housed in handheld devices in nursing clinical courses. *Nurs Educ Perspect* 2009;30(4):220-5.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Wilson A, Duszynski A, Turnbull D, et al. Investigating patients' and general practitioners' views of computerised decision support software for the assessment and management of cardiovascular risk. *Inform Prim Care* 2007;15(1):33-44.

Full-text Exclude - CDSS/KMS not implemented in clinical setting

Wilson BJ, Torrance N, Mollison J, et al. Improving the referral process for familial breast cancer genetic counselling: findings of three randomised controlled trials of two interventions. *Health Technol Assess* 2005;9(3):iii-iv, 1-126.

Full-text Exclude - Not original peer-reviewed data

Winters JM, Wang Y. Wearable sensors and telerehabilitation. *IEEE Eng Med Biol Mag* 2003;22(3):56-65.

Full-text Exclude - No electronic CDSS or KMS intervention

Woerdeman PA, Willems PW, Noordmans HJ, et al. The impact of workflow and volumetric feedback on frameless image-guided neurosurgery. *Neurosurgery* 2009;64(3 Suppl):170-5; discussion 176.

Full-text Exclude - No electronic CDSS or KMS intervention

Wolf M, Chung CK, Kordy H. MEM's search for meaning: a rejoinder. *Psychother Res* 2010;20(1):93-9.

Full-text Exclude - No electronic CDSS or KMS intervention

Wolfstadt JI, Gurwitz JH, Field TS, et al. The effect of computerized physician order entry with clinical decision support on the rates of adverse drug events: a systematic review. *J Gen Intern Med* 2008;23(4):451-8.

Full-text Exclude - Not original peer-reviewed data

Wolski CA. Get real. A virtual rehabilitation technology. *Rehab Manag* 2004;17(9):14, 16-7.
Full-text Exclude - Not original peer-reviewed data

Wozar JA, Worona PC. The use of online information resources by nurses. *J Med Libr Assoc* 2003;91(2):216-21.
Full-text Exclude - No electronic CDSS or KMS intervention

Wright A, Sittig DF. A framework and model for evaluating clinical decision support architectures. *J Biomed Inform* 2008;41(6):982-90.
Full-text Exclude - No electronic CDSS or KMS intervention

Wright AA, Maydom BW. Improving the implementation of community-acquired pneumonia guidelines. *Intern Med J* 2004;34(8):507-9.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Wright S. A nurse led clinic and computer decision support system for anticoagulation decisions was at least as effective as a hospital clinic... commentary on Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *ARCH INTERN MED* 2000 Aug 14-28;160:2343-8.
Evidence-Based Nursing 2001;4(2):57-57.
Full-text Exclude - Poster (or other publication type providing insufficient detail)

Wu R. Computerized physician order entry and clinical decision support systems: Early stages in demonstrating improvements in patient outcomes. *Am J Manag Care* 2006;12(7):365-366.
Full-text Exclude - Not original peer-reviewed data

Wurster M, Doran T. Anticoagulation management: a new approach. *Dis Manag* 2006;9(4):201-9.
Full-text Exclude - Sample size <50

Wyatt JC. Decision support systems. *J R Soc Med* 2000;93(12):629-33.
Full-text Exclude - Not original peer-reviewed data

Yamamoto L, Kanemori J. Comparing errors in ED computer-assisted vs conventional pediatric drug dosing and administration. *Am J Emerg Med* 2010;28(5):588-92.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Yang CS, Lee MY. Parametric data mining and diagnostic rules for digital thermographs in breast cancer. *Conf Proc IEEE Eng Med Biol Soc* 2008;2008:98-101.
Full-text Exclude - No electronic CDSS or KMS intervention

Yong MK, Buising KL, Cheng AC, et al. Improved susceptibility of Gram-negative bacteria in an intensive care unit following implementation of a computerized antibiotic decision support system. *J Antimicrob Chemother* 2010;65(5):1062-9.
Full-text Exclude - No acceptable comparator

Younai FS, Messadi DV. E-mail-based oral medicine consultation. *J Calif Dent Assoc* 2000;28(2):144-51.
Full-text Exclude - No electronic CDSS or KMS intervention

Young O, Shahar Y. Applying Hybrid-Asbru clinical guidelines using the Spock system. *AMIA Annu Symp Proc* 2005:854-8.
Full-text Exclude - Not original peer-reviewed data

Young O, Shahar Y, Liel Y, et al. Runtime application of Hybrid-Asbru clinical guidelines. *J Biomed Inform* 2007;40(5):507-26.
Full-text Exclude - Not original peer-reviewed data

Yourman L, Concato J, Agostini JV. Use of computer decision support interventions to improve medication prescribing in older adults: a systematic review. *Am J Geriatr Pharmacother* 2008;6(2):119-29.
Full-text Exclude - Not original peer-reviewed data

Yousef ZR, Tandy SC, Tudor V, et al. Warfarin for non-rheumatic atrial fibrillation: five year experience in a district general hospital. *Heart* 2004;90(11):1259-62.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Yu F, Houston TK, Bay MN, et al. Patterns of use of handheld clinical decision support tools in the clinical setting. *Med Decis Making* 2007;27(6):744-753.
Full-text Exclude - No acceptable comparator

Yu H, Kaufman D. A cognitive evaluation of four online search engines for answering definitional questions posed by physicians. *Pac Symp Biocomput* 2007:328-39.
Full-text Exclude - CDSS/KMS not implemented in clinical setting

Zaidi STR, Marriott JL, Nation RL. The role of perceptions of clinicians in their adoption of a web-based antibiotic approval system: Do perceptions translate into actions? *Int J Med Inf* 2008;77(1):33-40.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Zapka JG, Puleo E, Taplin S, et al. Breast and cervical cancer screening: clinicians' views on health plan guidelines and implementation efforts. *J Natl Cancer Inst Monogr* 2005(35):46-54.

Full-text Exclude - No electronic CDSS or KMS intervention

Zheng K, Padman R, Johnson MP, et al. Understanding technology adoption in clinical care: Clinician adoption behavior of a point-of-care reminder system. *Int J Med Inf* 2005;74(7-8):535-543.

Full-text Exclude - No acceptable comparator

Zheng K, Padman R, Johnson MP, et al. An adoption study of a clinical reminder system in ambulatory care using a developmental trajectory approach. In: Fieschi MCELYCJ, ed. *Medinfo 2004: Proceedings of the 11th World Congress on Medical Informatics, Pt 1 and 2*. Vol. 107; 2004:1115-1119.

Full-text Exclude - No acceptable comparator

Ziemer DC, Tsui C, Caudle J, et al. An informatics-supported intervention improves diabetes control in a primary care setting. *AMIA Annu Symp Proc* 2006:1160.

Full-text Exclude - Poster (or other publication type providing insufficient detail)

Zimmerman RK, Nowalk MP, Raymund M, et al. Tailored interventions to increase influenza vaccination in neighborhood health centers serving the disadvantaged. *Am J Public Health* 2003;93(10):1699-705.

Full-text Exclude - CDSS/KMS not used to aid decision-making at point of care/for a specific care situation

Zura RD, Kahler DM. A transverse acetabular nonunion treated with computer-assisted percutaneous internal fixation. A case report. *J Bone Joint Surg Am* 2000;82(2):219-24.

Full-text Exclude - Not original peer-reviewed data

Zwarenstein MF, Dainty KN, Quan S, et al. A cluster randomized trial evaluating electronic prescribing in an ambulatory care setting. *Trials* 2007;8:28.

Full-text Exclude - Not original peer-reviewed data

Appendix G: Summary Tables for Key Question 1

Table G-1. Prevalence of outcome categories by study type

Study type	Study subtype	N	Percentage of total number of studies	Clinical	Health care process	Workload, efficiency, and organization of health care delivery	Relationship-centered	Economic	Health care provider use and implementation
RCT	Cluster	50	16%	6	44	2	2	8	23
	Crossover	3	1%	0	3	0	0	0	2
	Parallel	92	30%	23	79	5	4	17	27
	Other	3	1%	0	2	0	0	1	0
Total for RCT		148	48%						
Total number of studies for each outcome				29	128	7	6	26	52
% of studies over total number of RCT				20%	86%	5%	4%	18%	35%
Quasi-experimental	Nonrandomized	12	4%	6	10	2	0	1	2
	Before/after	75	24%	28	56	17	0	11	20
	Time series	28	9%	8	22	6	2	6	12
	Other	6	2%	1	3	1	1	0	2
Total for quasi-experimental		121	39%						
Total number of studies for each outcome				43	91	26	3	18	36
% of studies over total number of quasi-experimental				36%	75%	21%	2%	15%	30%
Observational	Cohort	29	9%	14	23	1	0	2	7
	Case-control	8	3%	2	4	1	0	0	2
	Case series	3	1%	1	1	0	0	0	1
	Other	2	1%	0	1	0	0	1	0
Total for observational		42	14%						
Total number of studies for each outcome				17	29	2	0	3	10
% of studies over total number of observational				40%	69%	5%	0%	7%	24%
Total number of studies		311							

Table G-2. Detailed Breakdown of Outcome Categories for Each Study Type

Study type	Study subtype	N	Length of stay	Morbidity	Mortality	Health-related quality of life or functional status	Adverse events	Recommended preventive care ordered/completed	Recommended clinical study ordered/completed	Recommended treatment ordered/prescribed	Impact on user knowledge	Number of patients seen/unit time	Clinician workload	Efficiency	Patient satisfaction	Cost	Cost-effectiveness	Health care provider acceptance	Health care provider satisfaction	Health care provider use	Implementation of CDSS/KMS
RCT	Cluster	50	2	5	2	1	2	11	15	26	2	0	0	2	2	8	2	8	9	11	2
	Crossover	3	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	1	0	1
	Parallel	92	4	17	5	5	3	29	14	39	3	0	0	5	4	13	4	16	9	6	2
	Other	3	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0
Total for RCT		148	6	22	7	6	5	43	29	67	5	0	0	7	6	22	6	24	19	17	5
Quasi-experimental	Nonrandomized	12	0	0	4	1	1	6	6	5	0	0	0	2	0	1	0	1	0	1	0
	Before/after	75	12	14	11	0	1	11	11	38	3	1	2	17	0	11	0	11	7	11	0
	Time series	28	3	4	1	0	4	2	6	16	1	1	0	5	2	6	0	6	4	5	0
	Other	6	0	0	0	1	0	1	0	2	0	0	0	1	1	0	0	2	0	0	0
Total for quasi-experimental		121	15	18	16	2	1	20	23	61	4	2	2	25	3	18	0	20	11	17	0
Observational	Cohort	29	3	8	4	1	4	6	1	14	1	1	0	0	0	1	1	3	0	5	0
	Case-control	8	1	1	1	0	1	1	1	2	1	0	1	0	0	0	0	2	1	0	2
	Case series	3	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1
	Other	2	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Total for observational		42	5	9	5	1	6	8	2	16	3	1	1	0	0	2	2	5	1	6	3
Total		311																			

Appendix H: Summary Tables for Key Question 2

Table H-1. Factors/Features: length of stay

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Paul et al., 2006 ¹	0.9082 (0.8392 to 0.9828)	✓	✓			✓		✓	✓			✓			
Overhage et al., 1997 ²	0.9307 (0.8032 to 1.078)	✓	✓	✓		✓		✓	✓	✓	✓	✓			
McGregor et al., 2006 ³	0.9760 (0.7292 to 1.306)	✓	✓	✓		✓		✓	✓			✓			
Khan et al., 2010 ⁴ and Maclean et al., 2009 ⁵	0.9000 (0.811 to 0.999)							✓					✓	✓	
Roukema et al., 2008 ⁶	1.141 (0.9944 to 1.309)		✓	✓		✓		✓				✓			
Kline et al., 2009 ⁷	NA												✓		

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table H-2. Factors/Features: morbidity

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
McCowan et al., 2001 ⁸	0.4114 (0.09349 to 1.810)		✓			✓		✓				✓	✓		
Cavalcanti et al., 2009 ⁹	0.5006 (0.2006 to 1.249)		✓			✓		✓	✓						
Kline et al., 2009 ⁷	0.5029 (0.2421 to 1.045)												✓		
Kucher et al., 2005 ¹⁰	0.6043 (0.4341 to 0.8412)	✓	✓	✓		✓		✓	✓	✓	✓	✓			
Zanetti et al., 2003 ¹¹	0.6211 (0.2087 to 1.848)	✓	✓	✓		✓		✓				✓			
McDonald et al., 1984 ¹²	0.6889 (0.5233 to 0.9069)		✓			✓				✓	✓	✓			
Khan et al., 2010 ⁴ and Maclean et al., 2009 ⁵	0.750 (0.700 to 0.803)							✓					✓	✓	
Roumie et al., 2006 ¹³	0.8343 (0.3984 to 1.747)	✓	✓	✓				✓			✓				
Paul et al., 2006 ¹	0.9020 (0.7293 to 1.116)	✓	✓			✓		✓	✓			✓			
Ansari et al., 2003 ¹⁴	0.9262 (0.6272 to 1.368)	✓	✓	✓		✓		✓	✓						
Holt et al., 2006 ¹⁵ and Holt et al., 2010 ¹⁶	0.9600 (0.848 to 1.087)	✓	✓	✓		✓		✓							
Graumlich et al., 2009 ¹⁷ and Graumlich et al., 2009 ¹⁸	0.9788 (0.7043 to 1.360)	✓	✓			✓			✓				✓		

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Heidenreich et al., 2007 ¹⁹	0.9900 (0.8303 to 1.180)	✓		✓		✓								✓	
Tierney et al., 2005 ²⁰	0.9924 (0.9560 to 1.030)	✓	✓			✓		✓	✓	✓	✓	✓	✓		✓
Tierney et al., 2003 ²¹	0.9949 (0.5739 to 1.725)	✓	✓	✓			✓	✓	✓		✓	✓			
Gilutz et al., 2009 ²²	1.006 (0.9387 to 1.079)							✓							
Brier et al., 2010 ²³	NA							✓							
Hamilton et al., 2004 ²⁴	NA					✓									
McDonald et al., 1992 ²⁵	NA		✓					✓							
Murray et al., 2004 ²⁶	NA	✓	✓	✓		✓		✓	✓	✓	✓	✓			
Sequist et al., 2009 ²⁷	NA	✓	✓	✓		✓	✓	✓	✓	✓					
Subramanian et al., 2004 ²⁸	NA	✓	✓	✓		✓						✓			

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table H-3. Factors/Features: mortality

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Ansari et al., 2003 ¹⁴	0.1182 (0.01598 to 0.8744)	✓	✓	✓		✓		✓	✓						✓
Roumie et al., 2006 ¹³	0.2356 (0.06311 to 0.8794)	✓	✓	✓				✓			✓				
Kuperman et al., 1999 ²⁹	0.5616 (0.2344 to 1.346)	✓	✓	✓	✓			✓	✓			✓			
Paul et al., 2006 ¹	0.9020 (0.7293 to 1.116)	✓	✓			✓		✓	✓			✓			
Kucher et al., 2005 ¹⁰	1.025 (0.5710 to 1.838)	✓	✓	✓		✓		✓	✓	✓	✓	✓			
McGregor et al., 2006 ³	1.106 (0.7977 to 1.532)	✓	✓	✓		✓		✓	✓			✓			
Brier et al., 2010 ²³	NA							✓							

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, RR = relative risk

Table H-4. Factors/Features: adverse events

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
McGregor et al., 2006 ³	0.8592 (0.6833 to 1.080)	✓	✓	✓		✓		✓	✓			✓			
Graumlich et al., 2009 ¹⁷ and Graumlich et al., 2009 ¹⁸	0.9968 (0.5714 to 1.739)	✓	✓			✓			✓				✓		
Gurwitz et al., 2008 ³⁰	1.060 (0.9168 to 1.226)	✓	✓	✓		✓		✓				✓			
Fihn et al., 1994 ³¹	1.100 (0.5129 to 2.359)	✓	✓			✓		✓				✓			
Kuperman et al., 1999 ²⁹	1.197 (0.7770 to 1.843)	✓	✓	✓	✓			✓	✓			✓			

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, RR = relative risk

Table H-5. Factors/Features: preventive care adherence

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
McDowell et al., 1986 ³²	8.856 (5.809 to 13.50)	✓	✓	✓		✓		✓							
Cannon et al., 2000 ³³	4.090 (1.320 to 12.67)					✓			✓	✓	✓	✓			
Taylor et al., 1999 ³⁴	3.435 (1.918 to 6.151)		✓			✓		✓							✓
Price, 2005 ³⁵	2.975 (1.191 to 7.430)					✓						✓			
Kucher et al., 2005 ¹⁰	2.965 (2.437 to 3.607)	✓	✓	✓		✓		✓	✓	✓	✓	✓			
McDonald et al., 1992 ²⁵	2.590 (2.157 to 3.109)		✓					✓							
Dexter et al., 2001 ³⁶	2.038 (1.859 to 2.234) 1.502 (1.380 to 1.634)	✓	✓	✓		✓	✓	✓	✓	✓		✓			
Frank et al., 2004 ³⁷	1.920 (1.617 to 2.279) 0.8904 (0.7277 to 1.090)		✓			✓									
Demakis et al., 2000 ³⁸	1.569 (1.466 to 1.679)	✓	✓	✓		✓		✓		✓	✓	✓			✓
Burack et al., 2003 ³⁹	1.445 (1.207 to 1.730) 0.9670 (0.8228 to 1.136)			✓		✓		✓	✓				✓		
Litzelman et al., 1993 ⁴⁰	1.390 (1.247 to 1.549)		✓	✓	✓	✓	✓		✓	✓		✓			

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Chambers et al., 1989 ⁴¹	1.356 (1.053 to 1.745)	✓	✓	✓		✓									
Dykes et al., 2010 ⁴²	1.318 (0.956 to 1.817)		✓			✓						✓	✓		
Gilutz et al., 2009 ²²	1.277 (1.166 to 1.399)							✓							
Apkon et al., 2005 ⁴³	1.222 (1.071 to 1.394)	✓	✓			✓		✓	✓						
Fretheim et al., 2006 ⁴⁴ and Fretheim et al., 2006 ⁴⁵	1.218 (0.9317 to 1.592)	✓	✓	✓		✓		✓	✓				✓	✓	✓
Burack et al., 1998 ⁴⁶	1.208 (0.9940 to 1.469)			✓		✓		✓	✓				✓		
McDowell et al., 1989 ⁴⁷	1.204 (0.7387 to 1.963)	✓	✓	✓		✓		✓	✓						
Sequist et al., 2009 ²⁷	1.073 (1.016 to 1.132)	✓	✓	✓		✓	✓	✓	✓	✓					
Eccles et al., 2002 ⁴⁸	0.9637 (0.6225, 1.492)	✓	✓	✓		✓		✓				✓			
Overhage et al., 1996 ⁴⁹	0.9486 (0.7540 to 1.193)	✓	✓	✓		✓		✓	✓			✓			
Bertoni et al., 2009 ⁵⁰	0.9311 (0.8332 to 1.041)					✓		✓	✓	✓	✓			✓	✓
Tierney et al., 2005 ²⁰	0.9157 (0.5030, 1.6667)	✓	✓			✓		✓	✓	✓	✓	✓	✓		✓
Dexter et al., 2004 ⁵¹	0.7524 (0.5627, 1.006)	✓	✓	✓		✓	✓	✓	✓			✓			
Unrod et al.,	0.6395		✓	✓		✓		✓	✓				✓		✓

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
2007 ⁵²	(0.1311, 3.120)														
Burack et al., 1997 ⁵³ and Burack et al., 1994 ⁵⁴	NA				✓	✓		✓	✓						✓
Fiks et al., 2009 ⁵⁵	NA	✓	✓	✓		✓		✓	✓						✓
Flanagan et al., 1999 ⁵⁶	NA					✓		✓	✓			✓			
Fordham et al., 1990 ⁵⁷ and McPhee et al., 1989 ⁵⁸	NA	✓	✓	✓		✓		✓	✓			✓			✓
Gill et al., 2009 ⁵⁹	NA	✓	✓	✓		✓									
Hobbs et al., 1996 ⁶⁰	NA					✓		✓				✓			
Holbrook et al., 2009 ⁶¹	NA	✓	✓	✓		✓		✓				✓	✓		
Kenealy et al., 2005 ⁶²	NA	✓	✓	✓		✓		✓							✓
Lobach et al., 1994 ⁶³	NA		✓	✓		✓		✓				✓			
McDonald et al., 1984 ¹²	NA		✓			✓				✓	✓	✓			
Ornstein et al., 1991 ⁶⁴	NA		✓	✓	✓	✓		✓							✓
Peterson et al., 2008 ⁶⁵	NA	✓	✓	✓		✓						✓			

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Reeve et al., 2008	NA	✓	✓	✓		✓		✓	✓	✓	✓	✓			
Rosser et al., 1992 ⁶⁶	NA	✓	✓			✓		✓							
Rosser, et al., 1991 ⁶⁷	NA	✓	✓			✓		✓							
Sequist et al., 2005 ⁶⁸	NA	✓	✓	✓		✓		✓							
Tierney et al., 1986 ⁶⁹	NA		✓	✓	✓	✓		✓			✓	✓		✓	
van Wyk et al., 2008 ⁷⁰	NA	✓	✓	✓		✓		✓				✓			

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table H-6. Factors/Features: clinical study adherence

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Bell et al., 2010 ⁷¹	15.29 (3.75 to 62.26) 1.16 (0.89 to 1.50)	✓	✓			✓		✓	✓	✓	✓	✓			✓
Lee et al., 2009 ⁷²	12.54 (6.48 to 24.26)					✓		✓			✓	✓		✓	
Roukema et al., 2008 ⁶	5.86 (2.83 to 12.15)		✓	✓		✓		✓				✓			
Mc Donald, 1976 ⁷³	4.64 (3.20 to 6.74)		✓					✓			✓				
Roy et al., 2009 ⁷⁴	3.45 (2.80 to 4.25)		✓			✓		✓							✓
Bates et al., 1999 ⁷⁵	2.87 (2.18 to 3.78)	✓	✓	✓	✓	✓		✓	✓						
Greiver et al., 2005 ⁷⁶	2.37 (0.83 to 6.72) 2.04 (0.49 to 8.43)		✓			✓		✓							
Schriefer et al., 2009 ⁷⁷	2.07 (1.31 to 3.25)	✓	✓	✓		✓									
McDowell et al., 1989 ⁷⁸	1.93 (1.39 to 2.66)	✓	✓	✓		✓		✓	✓						
Sundaram et al., 2009 ⁷⁹	1.88 (1.37 to 2.57)	✓	✓	✓		✓		✓	✓	✓				✓	✓
Raebel et al., 2005 ⁸⁰	1.60 (1.44 to 1.78)	✓	✓	✓			✓	✓	✓			✓	✓		
Wilson et al., 2006 ⁸¹	1.46 (0.63 to 3.40)											✓	✓		✓

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Player et al., 2010 ⁸²	1.330 (1.13 to 1.56)	✓	✓	✓		✓		✓							✓
Raebel et al., 2006 ⁸³	1.28 (1.18 to 1.39)	✓	✓	✓			✓	✓	✓			✓	✓		
Walker et al., 2010 ⁸⁴	1.270 (1.11 to 1.45)	✓	✓	✓		✓									✓
Khan et al., 2010 ⁴ and Maclean et al., 2009 ⁵	1.17 (0.80 to 1.72)							✓					✓	✓	
Flottorp et al., 2002 ⁸⁵	1.10 (1.00 to 1.20) 0.81 (0.73 to 0.90)					✓						✓			✓
Lo et al., 2009 ⁸⁶	1.07 (0.94 to 1.23)		✓	✓		✓			✓			✓			
Tierney et al., 2005 ²⁰	1.02 (0.28 to 3.76)	✓	✓			✓		✓	✓	✓	✓	✓	✓		✓
Palen et al., 2006 ⁸⁷	0.98 (0.94 to 1.02)	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓
Downs et al., 2006 ⁸⁸	NA	✓	✓			✓									
Emery et al., 2007 ⁸⁹	NA					✓									✓
Feldstein et al., 2006 ⁹⁰	NA	✓	✓	✓		✓		✓	✓		✓	✓	✓		

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Harpole et al., 1997 ⁹¹	NA	✓	✓			✓	✓	✓	✓	✓	✓	✓			
Matheny et al., 2008 ⁹²	NA	✓	✓			✓		✓				✓			
Palen et al., 2010 ⁹³	NA	✓	✓	✓		✓		✓							✓
Stiell et al., 2009 ⁹⁴	NA	✓	✓	✓	✓	✓									
Tierney et al., 1987 ⁹⁵	NA	✓	✓			✓			✓						
van Wijk et al., 2001 ⁹⁶	NA	✓	✓			✓		✓		✓	✓	✓			

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table H-7. Factors/Features: treatment adherence

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Rossi et al., 1997 ⁹⁷	45.570 (6.635, 312.900)	✓	✓	✓	✓	✓		✓			✓				
Feldstein et al., 2006 ⁹⁸	16.78 (6.743 to 41.770)	✓	✓	✓		✓		✓	✓		✓	✓	✓		
Strom et al., 2010 ⁹⁹	8.559 (4.936 to 14.842)	✓	✓	✓		✓		✓	✓	✓					
van Wyk et al., 2008 ⁷⁰	7.309 (5.979 to 8.936)	✓	✓	✓		✓		✓				✓			
Vissers et al., 1996 ¹⁰⁰ and Vissers et al., 1995 ¹⁰¹	4.247 (1.398 to 12.900)					✓				✓					
Terrell et al., 2010 ¹⁰²	3.839 (1.716 to 8.589)	✓	✓	✓		✓		✓	✓		✓	✓			
Krall et al., 2004 ¹⁰³	3.417 (2.637 to 4.428)	✓	✓	✓		✓	✓	✓	✓			✓			
Zanetti et al., 2003 ¹¹	3.113 (1.896 to 5.111)	✓	✓	✓		✓		✓				✓			
Overhage et al., 1997 ²	3.074 (1.280, 7.380)	✓	✓	✓		✓		✓	✓	✓	✓	✓			
Bell et al., 2010 ⁷¹	2.675 (2.098 to 3.410) 0.876 (0.723 to 1.062)	✓	✓			✓		✓	✓	✓	✓	✓			✓
McGregor et al., 2006 ³	2.389 (1.959 to 2.913)	✓	✓	✓		✓		✓	✓			✓			
Cobos et al., 2005 ¹⁰⁴	2.100 (1.641 to 2.686)				✓	✓		✓	✓	✓	✓	✓			
Co et al., 2010 ¹⁰⁵	2.083	✓	✓	✓	✓	✓						✓			

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
	(1.384 to 3.133)														
Rood et al., 2005 ¹⁰⁶	1.904 (1.679 to 2.159)	✓	✓	✓		✓		✓	✓						
Linder et al., 2009 ¹⁰⁷	1.864 (1.208 to 2.874)	✓				✓			✓	✓					
McCowan et al., 2001 ⁸	1.684 (1.078 to 2.632)		✓			✓		✓				✓	✓		
Fretheim et al., 2006 ⁴⁴ and Fretheim et al., 2006 ⁴⁵	1.680 (1.405 to 2.010)	✓	✓	✓		✓		✓	✓				✓	✓	✓
Field et al., 2009 ¹⁰⁸	1.548 (1.095 to 2.188)	✓	✓	✓		✓		✓				✓			
Paul et al., 2006 ¹	1.470 (1.030 to 2.098)	✓	✓			✓		✓	✓			✓			
Tamblyn et al., 2009 ¹⁰⁹	1.461 (1.162 to 1.836)	✓	✓	✓		✓									
Heidenreich et al., 2007 ¹⁹	1.457 (1.145 to 1.855)		✓	✓		✓		✓							
Bourgeois et al., 2010 ¹¹⁰	1.430 (1.161 to 1.761)	✓	✓			✓		✓							✓
Hicks et al., 2008 ¹¹¹	1.441 (0.975 to 2.130)	✓	✓	✓		✓		✓				✓			
Gill et al., 2009 ⁵⁹	1.386 (1.002 to 1.918)	✓	✓	✓		✓									
Filippi et al., 2003 ¹¹²	1.356 (1.207 to 1.523)	✓	✓	✓		✓		✓							✓
Montgomery et al., 2000 ¹¹³	1.324 (0.885 to 1.979)	✓	✓									✓			
Smith et al., 2008 ¹¹⁴	1.277	✓	✓	✓		✓	✓	✓	✓		✓		✓		

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
	(0.696 to 2.342)														
Gilutz et al., 2009 ²²	1.246 (1.137, 1.366)							✓							
Tamblyn et al., 2003 ¹¹⁵	1.202 (1.089 to 1.327)	✓	✓	✓		✓	✓								
Subramanian et al., 2004 ²⁸	1.137 (0.833 to 1.552)	✓	✓	✓		✓						✓			
Strom et al., 2010 ¹¹⁶	1.160 (0.877 to 1.535)	✓	✓	✓		✓		✓	✓	✓					
Player et al., 2010 ⁸²	1.110 (0.861 to 1.431)	✓	✓	✓		✓		✓							✓
Davis et al., 2007 ¹¹⁷	1.086 (0.464, 2.541)	✓	✓	✓		✓				✓	✓				
Tierney et al., 2005 ²⁰	1.082 (0.829 to 1.412)	✓	✓			✓		✓	✓	✓	✓	✓	✓		✓
Tierney et al., 2003 ²¹	1.059 (0.604, 1.856)	✓	✓	✓			✓	✓	✓		✓	✓			
Bertoni et al., 2009 ⁵⁰	1.041 (0.6555 to 1.653)					✓		✓	✓	✓	✓			✓	✓
Weir et al., 2003 ¹¹⁸	0.984 (0.512 to 1.893)	✓		✓											
Brier et al., 2010 ²³	0.977 (0.552 to 1.729)							✓							
Murray et al., 2004 ²⁶	0.867 (0.518, 1.452)	✓	✓	✓		✓		✓	✓	✓	✓	✓			
Roumie et al., 2006 ¹³	0.844 (0.626, 1.137)	✓	✓	✓				✓			✓				
Raebel et al., 2007 ¹¹⁹	0.830 (0.739 to 0.9314)	✓	✓	✓	✓			✓	✓			✓			

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Apkon et al., 2005 ⁴³	0.790 (0.554 to 1.126)	✓	✓			✓		✓	✓						
Locatelli et al., 2009 ¹²⁰	0.723 (0.511 to 1.021)		✓			✓		✓		✓					
Terrell et al., 2009 ¹²¹	0.6296 (0.4672 to 0.8486)	✓	✓	✓	✓	✓	✓	✓	✓			✓			
Ansari et al., 2003 ¹⁴	0.490 (0.197 to 1.219)	✓	✓	✓		✓		✓	✓						✓
Mc Donald, 1976 ⁷³	0.426 (0.2211 to 0.8203)		✓					✓			✓				
Christakis et al., 2001 ¹²²	NA	✓	✓	✓		✓		✓		✓	✓				
Fihn et al., 1994 ³¹	NA	✓	✓			✓		✓				✓			
Fitzmaurice et al., 2000 ¹²³	NA							✓							✓
Flottorp et al., 2002 ⁸⁵	NA					✓						✓			✓
Fortuna et al., 2009 ¹²⁴	NA	✓	✓			✓		✓	✓		✓	✓	✓		✓
Goud et al., 2009 ¹²⁵	NA	✓	✓		✓	✓		✓	✓	✓	✓	✓			✓
Kuperman et al., 1999 ²⁹	NA	✓	✓	✓	✓			✓	✓			✓			
Manotti et al., 2001 ¹²⁶	NA		✓	✓				✓	✓						
Marco et al., 2003 ¹²⁷	NA		✓					✓	✓						
Martens et al., 2006 ¹²⁸ and Martens et al., 2007 ¹²⁹	NA	✓	✓			✓		✓				✓			
Peterson et al., 2007 ¹³⁰	NA	✓	✓	✓		✓		✓	✓						

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Phillips et al., 2005 ¹³¹ and Ziemer et al., 2006 ¹³²	NA	✓	✓			✓		✓				✓			✓
Rothschild et al., 2007 ¹³³	NA	✓			✓	✓		✓			✓	✓			
Samore et al., 2005 ¹³⁴	NA		✓			✓		✓							
Sequist et al., 2005 ⁶⁸	NA	✓	✓	✓		✓		✓							
Shojania et al., 1998 ¹³⁵	NA	✓	✓	✓	✓	✓									
Simon et al., 2006 ¹³⁶	NA	✓	✓			✓	✓	✓	✓						✓
Tamblyn et al, 2008 ¹³⁷	NA	✓	✓	✓	✓	✓			✓						
Vadher et al, 1997 ¹³⁸	NA		✓			✓		✓							
Vadher et al, 1997 ¹³⁹	NA					✓		✓							
White et al., 1984 ¹⁴⁰	NA	✓	✓	✓				✓				✓			

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table H-8. Factors/Features: health care provider use

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Tamblyn et al., 2008 ¹³⁷	1.194 (1.150 to 1.241)	✓	✓	✓	✓	✓			✓						
Strom et al., 2010 ⁹⁹	0.12 (0.045 to 0.33)	✓	✓	✓		✓		✓	✓	✓					
Bosworth et al., 2009 ¹⁴¹ and Bosworth et al., 2005 ¹⁴²	NA	✓	✓	✓		✓		✓	✓	✓	✓			✓	
Bourgeois et al., 2010 ¹¹⁰	NA	✓	✓			✓		✓							
Del Fiol et al., 2008 ¹⁴³	NA	✓	✓			✓		✓			✓	✓			
Eccles et al., 2002 ⁴⁸	NA	✓	✓	✓		✓		✓				✓			
Emery et al., 2007 ⁸⁹	NA					✓		✓							✓
Filippi et al., 2003 ¹¹²	NA	✓	✓	✓		✓		✓							✓
Fortuna et al., 2009 ¹²⁴	NA	✓	✓			✓		✓	✓		✓	✓	✓		✓
Hetlevik et al., 1999 ¹⁴⁴ and Hetlevik et al., 1998 ¹⁴⁵	NA					✓		✓	✓					✓	✓
Hetlevik et al., 2000 ¹⁴⁶	NA					✓		✓	✓					✓	✓
Hobbs et al., 1996 ⁶⁰	NA					✓		✓				✓			

Study	RR (95% CI)	Integration with charting or order entry system	Automatic provision of decision support	No need for additional data entry	Request documentation of the reason for not following	Provision of decision support at time and location of decisionmaking	Recommendations executed by noting agreement	Provision of a recommendation, not just an assessment	Promotion of action rather than inaction	Justification of decision support via provision of reasoning	Justification of decision support via provision of research evidence	Local user involvement in development process	Provision of decision support results to patients as well as providers	CDSS accompanied by periodic performance feedback	CDSS accompanied by conventional education
Linder et al., 2009 ¹⁰⁷	NA	✓				✓			✓	✓					
Maviglia et al., 2006 ¹⁴⁷	NA	✓	✓	✓		✓					✓	✓			
Samore et al., 2005 ¹³⁴	NA		✓			✓		✓							
Sequist et al., 2005 ⁶⁸	NA	✓	✓	✓		✓		✓							
van Wijk et al., 2001 ⁹⁶	NA	✓	✓			✓		✓		✓	✓	✓			

Abbreviations: CDSS = clinical decision support system, CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

References Cited in Appendix H

1. Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58(6):1238-45.
2. Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4(5):364-75.
3. McGregor JC, Weekes E, Forrest GN, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(4):378-84.
4. Khan S, Maclean CD, Littenberg B. The effect of the Vermont Diabetes Information System on inpatient and emergency room use: results from a randomized trial. *Health Outcomes Res Med* 2010;1(1):e61-e66.
5. Maclean CD, Gagnon M, Callas P, et al. The vermont diabetes information system: a cluster randomized trial of a population based decision support system. *J Gen Intern Med* 2009;24(12):1303-10.
6. Roukema J, Steyerberg EW, van der Lei J, et al. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. *J Am Med Inform Assoc* 2008;15(1):107-13.
7. Kline JA, Zeitouni RA, Hernandez-Nino J, et al. Randomized trial of computerized quantitative pretest probability in low-risk chest pain patients: effect on safety and resource use. *Ann Emerg Med* 2009;53(6):727-35 e1.
8. McCowan C, Neville RG, Ricketts IW, et al. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26(3):191-201.
9. Cavalcanti AB, Silva E, Pereira AJ, et al. A randomized controlled trial comparing a computer-assisted insulin infusion protocol with a strict and a conventional protocol for glucose control in critically ill patients. *J Crit Care* 2009;24(3):371-8.
10. Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352(10):969-77.
11. Zanetti G, Flanagan HL, Jr., Cohn LH, et al. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24(1):13-6.
12. McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Ann Intern Med* 1984;100(1):130-8.
13. Roumie CL, Elasy TA, Greevy R, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. *Ann Intern Med* 2006;145(3):165-75.
14. Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107(22):2799-804.
15. Holt TA, Thorogood M, Griffiths F, et al. Protocol for the 'e-Nudge trial': a randomised controlled trial of electronic feedback to reduce the cardiovascular risk of individuals in general practice [ISRCTN64828380]. *Trials* 2006;7:11.
16. Holt TA, Thorogood M, Griffiths F, et al. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60(573):e137-43.
17. Graumlich JF, Novotny NL, Nace GS, et al. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2009;4(6):356-63.
18. Graumlich JF, Novotny NL, Nace GS, et al. Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial. *J Hosp Med* 2009;4(7):E11-9.

19. Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115(22):2829-34.
20. Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40(2):477-97.
21. Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18(12):967-76.
22. Gilutz H, Novack L, Shvartzman P, et al. Computerized community cholesterol control (4C): meeting the challenge of secondary prevention. *Isr Med Assoc J* 2009;11(1):23-9.
23. Brier ME, Gaweda AE, Dailey A, et al. Randomized trial of model predictive control for improved anemia management. *Clin J Am Soc Nephrol* 2010;5(5):814-20.
24. Hamilton E, Platt R, Gauthier R, et al. The effect of computer-assisted evaluation of labor on cesarean rates. *J Healthc Qual* 2004;26(1):37-44.
25. McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Comput* 1992;9(5):304-12.
26. Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24(3):324-37.
27. Sequist TD, Zaslavsky AM, Marshall R, et al. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169(4):364-71.
28. Subramanian U, Fihn SD, Weinberger M, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. *Am J Med* 2004;116(6):375-84.
29. Kuperman GJ, Teich JM, Tanasijevic MJ, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6(6):512-22.
30. Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56(12):2225-33.
31. Fihn SD, McDonnell MB, Vermes D, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. *J Gen Intern Med* 1994;9(3):131-9.
32. McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. *CMAJ* 1986;135(9):991-7.
33. Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. *J Am Med Inform Assoc* 2000;7(2):196-203.
34. Taylor V, Thompson B, Lessler D, et al. A clinic-based mammography intervention targeting inner-city women. *J Gen Intern Med* 1999;14(2):104-11.
35. Price M. Can hand-held computers improve adherence to guidelines? A (Palm) Pilot study of family doctors in British Columbia. *Can Fam Physician* 2005;51:1506-7.
36. Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345(13):965-70.
37. Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33(1-2):87-90.
38. Demakis JG, Beauchamp C, Cull WL, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. *JAMA* 2000;284(11):1411-6.

39. Burack RC, Gimotty PA, Simon M, et al. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. *Prev Med* 2003;36(5):547-54.
40. Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med* 1993;8(6):311-7.
41. Chambers CV, Balaban DJ, Carlson BL, et al. Microcomputer-generated reminders. Improving the compliance of primary care physicians with mammography screening guidelines. *J Fam Pract* 1989;29(3):273-80.
42. Dykes PC, Carroll DL, Hurley A, et al. Fall Prevention in Acute Care Hospitals A Randomized Trial. *Jama-Journal of the American Medical Association* 2010;304(17):1912-1918.
43. Apkon M, Mattera JA, Lin Z, et al. A randomized outpatient trial of a decision-support information technology tool. *Arch Intern Med* 2005;165(20):2388-94.
44. Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. *PLoS Med* 2006;3(6):e216.
45. Fretheim A, Oxman AD, Havelsrud K, et al. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. *PLoS Med* 2006;3(6):e134.
46. Burack RC, Gimotty PA, George J, et al. How reminders given to patients and physicians affected pap smear use in a health maintenance organization: results of a randomized controlled trial. *Cancer* 1998;82(12):2391-400.
47. McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *J Fam Pract* 1989;28(4):420-4.
48. Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002;325(7370):941.
49. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156(14):1551-6.
50. Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med* 2009;169(7):678-86.
51. Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA* 2004;292(19):2366-71.
52. Unrod M, Smith M, Spring B, et al. Randomized controlled trial of a computer-based, tailored intervention to increase smoking cessation counseling by primary care physicians. *J Gen Intern Med* 2007;22(4):478-84.
53. Burack RC, Gimotty PA. Promoting screening mammography in inner-city settings. The sustained effectiveness of computerized reminders in a randomized controlled trial. *Med Care* 1997;35(9):921-31.
54. Burack RC, Gimotty PA, George J, et al. Promoting screening mammography in inner-city settings: a randomized controlled trial of computerized reminders as a component of a program to facilitate mammography. *Med Care* 1994;32(6):609-24.
55. Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124(1):159-69.
56. Flanagan JR, Doebbeling BN, Dawson J, et al. Randomized study of online vaccine reminders in adult primary care. *Proc Amia Symp* 1999:755-9.
57. Fordham D, McPhee SJ, Bird JA, et al. The Cancer Prevention Reminder System. *MD Comput* 1990;7(5):289-95.
58. McPhee SJ, Bird JA, Jenkins CN, et al. Promoting cancer screening. A randomized, controlled trial of three interventions. *Arch Intern Med* 1989;149(8):1866-72.

59. Gill JM, Chen YX, Glutting JJ, et al. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12(5):221-6.
60. Hobbs FD, Delaney BC, Carson A, et al. A prospective controlled trial of computerized decision support for lipid management in primary care. *Fam Pract* 1996;13(2):133-7.
61. Holbrook A, Thabane L, Keshavjee K, et al. Individualized electronic decision support and reminders to improve diabetes care in the community: COMPETE II randomized trial. *CMAJ* 2009;181(1-2):37-44.
62. Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20(10):916-21.
63. Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. *Proc Annu Symp Comput Appl Med Care* 1994:787-91.
64. Ornstein SM, Garr DR, Jenkins RG, et al. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. *J Fam Pract* 1991;32(1):82-90.
65. Peterson KA, Radosevich DM, O'Connor PJ, et al. Improving Diabetes Care in Practice: findings from the TRANSLATE trial. *Diabetes Care* 2008;31(12):2238-43.
66. Rosser WW, Hutchison BG, McDowell I, et al. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992;146(6):911-7.
67. Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. *CMAJ* 1991;145(7):807-14.
68. Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12(4):431-7.
69. Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care* 1986;24(8):659-66.
70. van Wyk JT, van Wijk MA, Sturkenboom MC, et al. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117(3):371-8.
71. Bell LM, Grundmeier R, Localio R, et al. Electronic Health Record-Based Decision Support to Improve Asthma Care: A Cluster-Randomized Trial. *Pediatrics* 2010;125(4):E770-E777.
72. Lee NJ, Chen ES, Currie LM, et al. The effect of a mobile clinical decision support system on the diagnosis of obesity and overweight in acute and primary care encounters. *ANS Adv Nurs Sci* 2009;32(3):211-21.
73. Mc Donald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med* 1976;84(2):162-7.
74. Roy PM, Durieux P, Gillaizeau F, et al. A computerized handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151(10):677-86.
75. Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106(2):144-50.
76. Greiver M, Drummond N, White D, et al. Angina on the Palm: randomized controlled pilot trial of Palm PDA software for referrals for cardiac testing. *Can Fam Physician* 2005;51:382-3.
77. Schrieffer SP, Landis SE, Turbow DJ, et al. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41(7):502-7.
78. McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. *Med Care* 1989;27(3):297-305.
79. Sundaram V, Lazzeroni LC, Douglass LR, et al. A randomized trial of computer-based reminders and audit and feedback to

- improve HIV screening in a primary care setting. *Int J STD AIDS* 2009;20(8):527-33.
80. Raebel MA, Lyons EE, Chester EA, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. *Arch Intern Med* 2005;165(20):2395-401.
81. Wilson BJ, Torrance N, Mollison J, et al. Cluster randomized trial of a multifaceted primary care decision-support intervention for inherited breast cancer risk. *Fam Pract* 2006;23(5):537-44.
82. Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18(4):223-9.
83. Raebel MA, Chester EA, Newsom EE, et al. Randomized trial to improve laboratory safety monitoring of ongoing drug therapy in ambulatory patients. *Pharmacotherapy* 2006;26(5):619-26.
84. Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37(7):445-50.
85. Flottorp S, Oxman AD, Havelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325(7360):367.
86. Lo HG, Matheny ME, Seger DL, et al. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16(1):66-71.
87. Palen TE, Raebel M, Lyons E, et al. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. *Am J Manag Care* 2006;12(7):389-95.
88. Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332(7543):692-6.
89. Emery J, Morris H, Goodchild R, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. *Br J Cancer* 2007;97(4):486-93.
90. Feldstein AC, Smith DH, Perrin N, et al. Improved therapeutic monitoring with several interventions: a randomized trial. *Arch Intern Med* 2006;166(17):1848-54.
91. Harpole LH, Khorasani R, Fiskio J, et al. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4(6):511-21.
92. Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15(4):424-9.
93. Palen TE, Price DW, Snyder AJ, et al. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16(11):e267-75.
94. Stiell IG, Clement CM, Grimshaw J, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.
95. Tierney WM, McDonald CJ, Martin DK, et al. Computerized display of past test results. Effect on outpatient testing. *Ann Intern Med* 1987;107(4):569-74.
96. van Wijk MA, van der Lei J, Mosseveld M, et al. Assessment of decision support for blood test ordering in primary care. a randomized trial. *Ann Intern Med* 2001;134(4):274-81.
97. Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. *J Gen Intern Med* 1997;12(11):672-8.
98. Feldstein A, Elmer PJ, Smith DH, et al. Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. *J Am Geriatr Soc* 2006;54(3):450-7.
99. Strom BL, Schinnar R, Aberra F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized

- controlled trial. *Arch Intern Med* 2010;170(17):1578-83.
100. Vissers MC, Biert J, van der Linden CJ, et al. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. *Comput Methods Programs Biomed* 1996;49(2):177-84.
 101. Vissers MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. *Comput Methods Programs Biomed* 1995;48(1-2):53-8.
 102. Terrell KM, Perkins AJ, Hui SL, et al. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56(6):623-9.
 103. Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107(Pt 1):135-9.
 104. Cobos A, Vilaseca J, Asenjo C, et al. Cost effectiveness of a clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Disease Management & Health Outcomes* 2005;13(6):421-432.
 105. Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126(2):239-46.
 106. Rood E, Bosman RJ, van der Spoel JI, et al. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. *J Am Med Inform Assoc* 2005;12(2):172-80.
 107. Linder JA, Rigotti NA, Schneider LI, et al. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169(8):781-7.
 108. Field TS, Rochon P, Lee M, et al. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16(4):480-5.
 109. Tamblyn R, Reidel K, Huang A, et al. Increasing the Detection and Response to Adherence Problems with Cardiovascular Medication in Primary Care through Computerized Drug Management Systems: A Randomized Controlled Trial. *Med Decis Making* 2009.
 110. Bourgeois FC, Linder J, Johnson SA, et al. Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clin Pediatr (Phila)* 2010;49(10):976-83.
 111. Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23(4):429-41.
 112. Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26(5):1497-500.
 113. Montgomery AA, Fahey T, Peters TJ, et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000;320(7236):686-90.
 114. Smith SA, Shah ND, Bryant SC, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83(7):747-57.
 115. Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169(6):549-56.
 116. Strom BL, Schinnar R, Bilker W, et al. Randomized clinical trial of a customized electronic alert requiring an affirmative response compared to a control group receiving a commercial passive CPOE alert: NSAID--warfarin co-prescribing as a test case. *J Am Med Inform Assoc* 2010;17(4):411-5.

117. Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2(5):e25.
118. Weir CJ, Lees KR, MacWalter RS, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM* 2003;96(2):143-53.
119. Raebel MA, Charles J, Dugan J, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. *J Am Geriatr Soc* 2007;55(7):977-85.
120. Locatelli F, Covic A, Macdougall IC, et al. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22(5):662-74.
121. Terrell KM, Perkins AJ, Dexter PR, et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57(8):1388-94.
122. Christakis DA, Zimmerman FJ, Wright JA, et al. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics* 2001;107(2):E15.
123. Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *Arch Intern Med* 2000;160(15):2343-8.
124. Fortuna RJ, Zhang F, Ross-Degnan D, et al. Reducing the prescribing of heavily marketed medications: a randomized controlled trial. *J Gen Intern Med* 2009;24(8):897-903.
125. Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.
126. Manotti C, Moia M, Palareti G, et al. Effect of computer-aided management on the quality of treatment in anticoagulated patients: a prospective, randomized, multicenter trial of APROAT (Automated PProgram for Oral Anticoagulant Treatment). *Haematologica* 2001;86(10):1060-70.
127. Marco F, Sedano C, Bermudez A, et al. A prospective controlled study of a computer-assisted acenocoumarol dosage program. *Pathophysiol Haemost Thromb* 2003;33(2):59-63.
128. Martens JD, van der Aa A, Panis B, et al. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. *Stud Health Technol Inform* 2006;124:617-23.
129. Martens JD, van der Weijden T, Severens JL, et al. The effect of computer reminders on GPs' prescribing behaviour: a cluster-randomised trial. *Int J Med Inform* 2007;76 Suppl 3:S403-16.
130. Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129(Pt 2):1037-40.
131. Phillips LS, Ziemer DC, Doyle JP, et al. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. *Diabetes Care* 2005;28(10):2352-60.
132. Ziemer DC, Doyle JP, Barnes CS, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting: Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. *Arch Intern Med* 2006;166(5):507-13.
133. Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion (Paris)* 2007;47(2):228-39.

134. Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA* 2005;294(18):2305-14.
135. Shojania KG, Yokoe D, Platt R, et al. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5(6):554-62.
136. Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-968.
137. Tamblyn R, Huang A, Taylor L, et al. A randomized trial of the effectiveness of on-demand versus computer-triggered drug decision support in primary care. *J Am Med Inform Assoc* 2008;15(4):430-8.
138. Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997;314(7089):1252-6.
139. Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. *Clin Lab Haematol* 1997;19(3):203-7.
140. White KS, Lindsay A, Pryor TA, et al. Application of a computerized medical decision-making process to the problem of digoxin intoxication. *J Am Coll Cardiol* 1984;4(3):571-6.
141. Bosworth HB, Olsen MK, Dudley T, et al. Patient education and provider decision support to control blood pressure in primary care: a cluster randomized trial. *Am Heart J* 2009;157(3):450-6.
142. Bosworth HB, Olsen MK, Goldstein MK, et al. The veterans' study to improve the control of hypertension (V-STITCH): design and methodology. *Contemp Clin Trials* 2005;26(2):155-68.
143. Del Fiol G, Haug PJ, Cimino JJ, et al. Effectiveness of topic-specific infobuttons: a randomized controlled trial. *J Am Med Inform Assoc* 2008;15(6):752-9.
144. Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. *Scand J Prim Health Care* 1999;17(1):35-40.
145. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of hypertension in general practice. *Blood Press* 1998;7(5-6):270-6.
146. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. *Int J Technol Assess Health Care* 2000;16(1):210-27.
147. Maviglia SM, Yoon CS, Bates DW, et al. KnowledgeLink: impact of context-sensitive information retrieval on clinicians' information needs. *J Am Med Inform Assoc* 2006;13(1):67-73.

Appendix I: Summary Tables for Key Question 3

Table I-1. Outcome measure: length of stay

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Khan et al., 2010 ¹ and Maclean et al., 2009 ²	USA	Community	Outpatient	NR	Local	Chronic disease management	Async	NR, assume no response	Paper	System (push)	Good
Kline et al., 2009 ³	USA	Academic	ED	2 years	Local	Diagnosis	Sync	No response	Paper	System (push)	Good
McGregor et al., 2006 ⁴	USA	Academic	Inpatient	12 wk	Com	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Good
Overhage et al., 1997 ⁵	USA	Academic	Inpatient	30 wk	Local	Pharmacology Lab test ordering	Sync	Noncommittal ack	Integrated	System (push)	Good
Paul et al., 2006 ⁶	Germany Israel Italy	Academic	Inpatient	7 mo	Local	Diagnosis Pharmacology	Sync	No response	Standalone	System (push)	Good
Roukema et al., 2008 ⁷	Europe	NR	ED	28 mo	Local	Diagnosis Lab test ordering	Sync	NR, assume no response	Integrated	System (push)	Good

Abbreviations: ack = acknowledgment, com = commercial, ED = emergency department, mo = month/months, NR = not reported, sync = synchronous, wk = week/weeks

Table I-2. Outcome measure: morbidity

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Ansari et al., 2003 ⁸	USA	VA	Outpatient	1 year	Local	Pharmacology Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Good
Brier et al., 2010 ⁹	USA	NR	NR	8 mo	Local	Pharmacology	Async	NR, unclear	Standalone	NR	Fair
Cavalcanti et al., 2009 ¹⁰	Brazil	Academic and Community	Inpatient	18 mo	Local	Pharmacology	Sync	NR	Standalone	NR	Fair
Gilutz et al., 2009 ¹¹	Europe	Community	Outpatient	6 to 36 mo	Local	Pharmacology Chronic disease management Preventive	NR, not clearly described	NR, assume no response	Paper	System (push)	Poor
Graumlich et al., 2009 ¹²	USA	Academic	Inpatient	26 mo	Local	Discharge planning	Sync	NR, unclear	Standalone	NR	Good
Hamilton et al., 2004 ¹³	USA Canada	Academic	Inpatient, Long-term care facility	25 mo	Local	Diagnosis	Sync	No response	Standalone	User (pull)	Fair
Heidenreich et al., 2007 ¹⁴	USA	VA	Academic and community	4.5 years	Local	Pharmacology	Sync	NR, assume no response	Paper	System (push)	Good
Holt et al., 2006 ¹⁵ and Holt et al., 2010 ¹⁶	Europe	Community	Outpatient	24 mo	Com	Diagnosis Preventive	Sync and async	Noncommittal ack	Integrated	System (push)	Fair
Khan et al., 2010 ¹ and Maclean et al., 2009 ²	USA	Community	Outpatient	NR	Local	Chronic disease management	Async	NR, assume no response	Paper	System (push)	Good
Kline et al., 2009 ³	USA	Academic	ED	2 years	Local	Diagnosis	Sync	No response	Paper	System (push)	Good
Kucher et al., 2005 ¹⁷	USA	Academic	Inpatient	40 mo	Local	Preventive	Sync	Mandatory	Integrated	System (push)	Good
McCowan et al., 2001 ¹⁸	Europe	Community	Outpatient	NR	Local	Chronic disease management	Sync	NR, assume no response	Standalone	User (pull)	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
McDonald et al., 1984 ¹⁹	USA	Academic	Outpatient	2 years	Local	Immunization Pharmacology Lab test ordering Chronic disease management Preventive	Sync	Noncommittal ack	Paper	System (push)	Good
McDonald et al., 1992 ²⁰	USA	Academic	Outpatient	3 years	Local	Immunization	Async	NR, assume no response	Paper	System (push)	Good
Murray et al., 2004 ²¹	USA	Academic	Outpatient	1 year	Local	Chronic disease management	Sync	Noncommittal ack	Integrated	System (push)	Good
Paul et al., 2006 ⁶	Germany Israel Italy	Academic	Inpatient	7 mo	Local	Diagnosis Pharmacology	Sync	No response	Standalone	System (push)	Good
Roumie et al., 2006 ²²	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology	Not clearly defined	NR, assume no response	Integrated	System (push)	Good
Sequist et al., 2009 ²³	USA	Community	Outpatient	15 mo	Com	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Fair
Subramanian et al., 2004 ²⁴	USA	VA	Outpatient	1 year	Local	Chronic disease management	Sync	No response	Paper	System (push)	Fair
Tierney et al., 2003 ²⁵	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	Noncommittal ack	Integrated, Paper	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor
Zanetti et al., 2003 ²⁷	USA	Academic	Inpatient	3 mo	Local	Pharmacology	Sync	Mandatory	Integrated,	System (push)	Good

Abbreviations: ack = acknowledgment, com = commercial, ED = emergency department, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-3. Outcome measure: mortality

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Ansari et al., 2003 ⁸	USA	VA	Outpatient	1 year	Local	Pharmacology Chronic disease management	Sync	NR unclear	Integrated	System (push)	Good
Brier et al., 2010 ⁹	USA	NR	NR	8 mo	Local	Pharmacology	Async	NR, unclear	Standalone	NR	Fair
Kucher et al., 2005 ¹⁷	USA	Academic	Inpatient	40 mo	Local	Preventive	Sync	Mandatory	Integrated	System (push)	Good
Kuperman et al., 1999 ²⁸	USA	Academic	Inpatient	4 mo	Local	Action in response to a critical lab value	Sync	Mandatory	Integrated	System (push)	Good
McGregor et al., 2006 ⁴	USA	Academic	Inpatient	12 wk	Com	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Good
Paul et al., 2006 ⁶	Germany Israel Italy	Academic	Inpatient	7 mo	Local	Diagnosis Pharmacology	Sync	No response	Standalone	System (push)	Good
Roumie et al., 2006 ²²	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology	Not clearly defined	NR, assume no response	Integrated	System (push)	Good

Abbreviations: ack = acknowledgment, com = commercial, ED = emergency department, mo = month/months, NR = not reported, sync = synchronous, wk = week/weeks

Table I-4. Outcome measure: health-related quality of life

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Khan et al., 2010 ¹ and Maclean et al., 2009 ²	USA	Community	Outpatient	NR	Local	Chronic disease management	Async	NR, assume no response	Paper	System (push)	Good
Murray et al., 2004 ²¹	USA	Academic	Outpatient	1 year	Local	Chronic disease management	Sync	Noncommittal ack	Integrated	System (push)	Good
Subramanian et al., 2004 ²⁴	USA	VA	Outpatient	1 year	Local	Chronic disease management	Sync	No response	Paper	System (push)	Fair
Thomas et al., 2004 ²⁹	Europe	Community	Outpatient	6 mo	Local	More effective mental health treatment	Async	No response	Paper	System (push)	Fair
Tierney et al., 2003 ²⁵	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	Noncommittal ack	Integrated, Paper	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor

Abbreviations: ack = acknowledgment, async = asynchronous, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-5. Outcome measure: adverse events

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Fihn et al., 1994 ³⁰	USA	Academic	Outpatient	NR	Local	Scheduling next clinic visit	Sync	NR unclear	Not clearly described	System (push)	Poor
Graumlich et al., 2009 ¹²	USA	Academic	Inpatient	26 mo	Local	Discharge planning	Sync	NR unclear	Standalone	NR	Good
Gurwitz et al., 2008 ³¹	USA, Canada	Academic	Long-term care facility	6-12 mo	Local	Pharmacology Planning	Sync	No response	Integrated	User (pull)	Fair
Kuperman et al., 1999 ²⁸	USA	Academic	Inpatient	4 mo	Local	Action in response to a critical lab value	Sync	Mandatory	Integrated	System (push)	Good
McGregor et al., 2006 ⁴	USA	Academic	Inpatient	12 wk	Com	Pharmacology	Sync	NR unclear	Integrated	System (push)	Good

Abbreviations: com = commercial, ED = emergency department, mo = month/months, NR = not reported, sync = synchronous, wk = week/weeks

Table I-6. Outcome measure: preventive care adherence

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Apkon et al., 2005 ³²	USA	Community	Outpatient	NR	Com	Diagnosis Chronic disease management Preventive	Sync	No response	Integrated	System (push)	Good
Bertoni et al., 2009 ³³	USA	Community	Outpatient	NR	Local	Chronic disease management	Sync	No response	Standalone	User et al., pull)	Good
Burack et al., 1994 ³⁴ and Burack et al., 1997 ³⁵	USA	Community	Outpatient	2 years	Local	Preventive	Sync	Justification	Paper	System (push)	Good
Burack et al., 1998 ³⁶	USA	Community	Outpatient	1 year	Local	Preventive	Sync	No response	Paper	System (push)	Good
Burack et al., 2003 ³⁷	USA	Community	Outpatient	1 year	Local	Preventive	Sync	No response	Paper	System (push)	Good
Cannon et al., 2000 ³⁸	USA	Academic	Outpatient	9 mo	Local	Diagnosis	Sync	Mandatory	Standalone	System (push)	Fair
Chambers et al., 1989 ³⁹	USA	Academic	Outpatient	6 mo	Local	Preventive	Sync	NR, assume no response	Paper	System (push)	Good
Demakis et al., 2000 ⁴⁰	USA	VA	Outpatient	17 mo	Local	Immunization Chronic disease management Preventive	Sync	NR, assume no response	Integrated, Paper	System (push)	Good
Dexter et al., 2001 ⁴¹	USA	Academic	Inpatient	18 mo	Local	Immunization Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Dexter et al., 2004 ⁴²	USA	Academic	Inpatient	14 mo	Local	Immunization	Sync	NR, unclear	Integrated	System (push)	Good
Dykes et al., 2010 ⁴³	USA	Academic and Community	Inpatient	6 mo	Local	Diagnosis Preventive	Sync	NR, assume no response	Online, Paper	User (pull)	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Eccles et al., 2002 ⁴⁴	Europe	Community	Outpatient	12 mo	Com	Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Fair
Fiks et al., 2009 ⁴⁵	USA	Academic and Community	Outpatient	6 mo	Com	Immunization	Sync	NR unclear	Integrated	System (push)	Fair
Flanagan et al., 1999 ⁴⁶	USA	Academic	Outpatient	10 mo	Local	Immunization	Sync	Noncommittal ack	Online	User (pull)	Poor
Frank et al., 2004 ⁴⁷	Australia	Community	Outpatient	NR	NR	Immunization Preventive	NR	NR, unclear	Integrated	NR	Fair
Fretheim et al., 2006 ⁴⁸ and Fretheim et al., 2006 ⁴⁹	Europe	Community	Outpatient	1 year	Com	Pharmacology	Sync	No response	Integrated	System (push)	Fair
Gill et al., 2009 ⁵⁰	USA	Academic and Community	Outpatient	1 year	Com	Pharmacology Lab test ordering Chronic disease management Preventive	Sync	Noncommittal ack	Integrated	System (push)	Poor
Gilutz et al., 2009 ¹¹	Europe	Community	Outpatient	6 to 36 mo	Local	Pharmacology Chronic disease management Preventive	NR, not clearly described	NR, assume no response	Paper	System (push)	Poor
Hobbs et al., 1996 ⁵¹	Europe	NR	Outpatient	6 mo	NR	Diagnosis Lab test ordering Preventive	Sync	NR, unclear	Standalone	User (pull)	Poor
Holbrook et al., 2009 ⁵²	Canada	Community	Outpatient	NR	NR, not clearly described	Chronic disease management Initiating discussion	Sync	NR, assume no response	Online	NR, not clearly defined	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Kenealy et al., 2005 ⁵³	New Zealand	Community	Outpatient	2 mo	Com	Preventive	Sync	No response	Integrated	User (pull)	Good
Kucher et al., 2005 ¹⁷	USA	Academic	Inpatient	40 mo	Local	Preventive	Sync	Mandatory	Integrated	System (push)	Good
Litzelman et al., 1993 ⁵⁴	USA	Academic	Outpatient	6 mo	Local	Lab test ordering Preventive	Sync	Mandatory, justification required	Paper	System (push)	Fair
Lobach et al., 1994 ⁵⁵	USA	Academic	Outpatient	6 mo	Local	Lab test ordering Chronic disease management Preventive	Sync	No response	Paper	System (push)	Good
McDowell et al., 1986 ⁵⁶	Canada	Academic	Outpatient	10 wk	NR, not clearly described	Immunization Preventive	Sync	NR, unclear	Paper	System (push)	Fair
McDowell et al., 1989 ⁵⁷	Canada	Academic	Outpatient	1 year	Local	Preventive	Sync	No response	Paper	System (push)	Fair
McPhee et al., 1989 ⁵⁸	USA	Academic	Outpatient	9 mo	Local	Preventive	Sync	Justification	Paper	System (push)	Fair
Ornstein et al., 1991 ⁵⁹	USA	Academic	Outpatient	1 year	NR, not clearly described	Lab test ordering preventive	Sync	Justification	Paper	System (push)	Fair
Overhage et al., 1996 ⁶⁰	USA	Academic	Inpatient	6 mo	Local	Preventive	Sync	Noncommittal ack	Paper	System (push)	Good
Peterson et al., 2008 ⁶¹	USA	Community	Outpatient	12 mo	NR, not clearly described	Chronic disease management	Sync	NR, assume no response	Paper	System (push)	Good
Price, 2005 ⁶²	Canada	NR	Outpatient	2 mo	Com	Preventive	Sync	NR, unclear	Standalone	User (pull)	Poor
Reeve et al., 2007 ⁶³	Australia	Academic	Outpatient	6 wk	Com	Pharmacology	Sync	NR, unclear	Standalone	System (push)	Good
Rosser et al., 1991 ⁶⁴	Canada	Academic	Outpatient	12 mo	Local	Immunization Preventive	Sync	No response	Paper	System (push)	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Rosser et al., 1992 ⁶⁵	Canada	Academic	Outpatient	12 mo	Local	Immunization	Sync	No response	Paper	System (push)	Fair
Sequist et al., 2005 ⁶⁶	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology Preventive	Sync	No response	Integrated, Paper	System (push)	Poor
Sequist et al., 2009 ²³	USA	Community	Outpatient	15 mo	Com	Lab test ordering Preventive	Sync	Mandatory	Integrated	System (push)	Fair
Taylor et al., 1999 ⁶⁷	USA	Academic and Community	Outpatient	15 mo	NR, not clearly described	Lab test ordering Initiating discussion Preventive	Sync	NR, unclear	Paper	System (push)	Good
Tierney et al., 1986 ⁶⁸	USA	Academic	Outpatient	7 mo	Local	Immunization Lab test ordering Preventive	Sync	Noncommittal ack	Paper	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor
Unrod et al., 2007 ⁶⁹	USA	Community	Outpatient	NR	Local	Initiating discussion	Sync	NR, assume no response	Paper	System (push)	Fair
van Wyk et al., 2008 ⁷⁰	Europe	Community	Outpatient	NR	Com	Diagnosis Preventive Screening and treatment of dyslipidemia	Sync	NR, assume no response	Integrated	System (push)	Good
McDonald et al., 1984 ¹⁹	USA	Academic	Outpatient	2 years	Local	Immunization Pharmacology Lab test ordering Chronic disease management Preventive	Sync	Noncommittal ack	Paper	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
McDonald et al., 1992 ²⁰	USA	Academic	Outpatient	3 years	Local	Immunization	Async	NR, assume no response	Paper	System (push)	Good

Abbreviations: ack = acknowledgment, com = commercial, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-7. Outcome measure: clinical study adherence

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Bates et al., 1999 ⁷¹	USA	Academic	Inpatient	4 mo	Local	Lab test ordering	Sync	Justification	Integrated	System (push)	Fair
Bell et al., 2009 ⁷²	USA	Academic and Community	Outpatient	2.4 years	Local	Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Good
Downs et al., 2006 ⁷³	Europe	Community	Outpatient	NR	Com	Diagnosis Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Good
Emery et al., 2007 ⁷⁴	Europe	Community	Outpatient	12 mo	Com	Referral for genetic counseling	Sync	NR, assume no response	NR, unclear	NR	Fair
Feldstein et al., 2006	NR	NR	Outpatient	14 wk	Local	Lab test ordering	Sync	No response	Integrated	System (push)	Good
Flottorp et al., 2002 ⁷⁵	Europe	Community	Outpatient	7 to 8 mo	Com	Acute disease management	Sync	NR	NR, unclear	NR	Poor
Greiver et al., 2005 ⁷⁶	Canada	Academic and Community	Outpatient	7 mo	Local	Diagnosis Lab test ordering	Sync	NR, unclear	Standalone	User (pull)	Poor
Harpole et al., 1997 ⁷⁷	USA Canada	Academic	Inpatient	19 wk	Local	Diagnosis Radiograph ordering	Sync	Mandatory	Integrated	User (pull)	Fair
Khan et al., 2010 ¹ and Maclean et al., 2009 ²	USA	Community	Outpatient	NR	Local	Chronic disease management	Async	NR, assume no response	Paper	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Lee et al., 2009 ⁷⁸	USA	Academic	Outpatient	8 mo	Local	Diagnosis	Sync	NR, assume no response	Standalone	NR, not clearly described	Fair
Lo et al., 2009 ⁷⁹	USA	Academic and Community	Outpatient	6 mo	Local	Lab test ordering	Sync	No response	Integrated	System (push)	Good
Matheny et al., 2008 ⁸⁰	USA	Academic and Community	Outpatient	6 mo	Local	Lab test ordering	Sync	No response	Integrated	System (push)	Good
Mc Donald, 1976 ⁸¹	USA	Academic	Outpatient	8 mo	Local	Pharmacology Lab test ordering	Async	NR, assume no response	Paper	System (push)	Good
McDowell et al., 1989 ⁸²	Canada	Academic	Outpatient	15 mo	Local	Diagnosis	Sync	No response	Paper	System (push)	Fair
Palen et al., 2006 ⁸³	USA	NR	Outpatient	12 mo	Com	Lab test ordering	Sync	Noncommittal ack	Integrated	System (push)	Good
Palen et al., 2010 ⁸⁴	USA	Community	Outpatient	19 mo	Com	Lab test ordering	Sync	NR, unclear	Integrated	System (push)	Fair
Player et al., 2010 ⁸⁵	USA	NR	Outpatient	NR	Com	Diagnosis Pharmacology	Sync	NR, assume no response	Integrated	System (push)	Fair
Raebel et al., 2005 ⁸⁶	USA	Academic	Outpatient	16 mo	NR	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Good
Raebel et al., 2006 ⁸⁷	USA	Academic	Outpatient	14 mo	Local	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Good
Roukema et al., 2008 ⁷	Europe	NR	ED	28 mo	Local	Diagnosis Lab test ordering	Sync	NR, assume no response	Integrated	System (push)	Good
Roy et al., 2009 ⁸⁸	Europe	Community	ED	7 mo	Local	Diagnosis	Sync	NR, unclear	Standalone	User (pull)	Fair
Schriefer et al., 2009 ⁸⁹	USA	Academic	Outpatient	2 mo	NR	Diagnosis Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Stiell et al., 2009 ⁹⁰	Canada	Academic and Community	ED	2 years	Local	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Good
Sundaram et al., 2009	USA	VA	Outpatient	9 mo	Local	Lab test ordering	Sync	Justification	Integrated	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Chronic	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor
Tierney et al., 1987 ⁹¹	USA	Academic	Outpatient	16 weeks	Local	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Fair
Van Wijk et al., 2001 ⁹²	Europe	Community	Outpatient	12 mo	Local	Lab test ordering	Sync	No response	Integrated	User (pull)	Good
Walker et al., 2010 ⁹³	Australia	Community	Outpatient	12 mo	Com	Lab test ordering Initiating discussion	Sync	Mandatory	Integrated	System (push)	Good
Wilson et al., 2006 ⁹⁴	Europe	Community	Outpatient	8 mo	Local	Initiating discussion providing information to GP	Sync	NR, unclear	NR, not clearly described	User (pull)	Poor

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-8. Outcome measure: treatment adherence

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Ansari et al., 2003 ⁸	USA	VA	Outpatient	1 year	Local	Pharmacology Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Good
Apkon et al., 2005 ³²	USA	Community	Outpatient	NR	Com	Diagnosis Chronic disease management Preventive	Sync	No response	Integrated	System (push)	Good
Bell et al., 2009 ⁷²	USA	Academic and Community	Outpatient	2.4 years	Local	Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Good
Bertoni et al., 2009 ³³	USA	Community	Outpatient	NR	Local	Chronic disease management	Sync	No response	Standalone	User (pull)	Good
Bourgeois et al., 2010 ⁹⁵	USA	Community	Outpatient	6 mo	Local	Pharmacology Lab test ordering Acute and chronic disease management	Sync	NR, unclear	Integrated	User (pull)	Fair
Brier et al., 2010 ⁹	USA	NR	NR	8 mo	Local	Pharmacology	Async	NR, unclear	Standalone	NR	Fair
Christakis et al., 2001 ⁹⁶	USA	Academic	Outpatient	8 mo	Local	Pharmacology	Sync	No response	Integrated	System (push)	Fair
Co et al., 2010 ⁹⁷	USA	Community	Outpatient	6 mo	Local	Diagnosis Chronic disease management	Sync	Justification	Integrated	System (push)	Fair
Cobos et al., 2005 ⁹⁸	Europe	Community	Outpatient	1 year	Local	Chronic disease management	Sync	Justification	Standalone	System (push)	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Davis et al., 2007 ⁹⁹	USA	Academic and Community	Outpatient	18 mo 50 mo	Local	Pharmacology	Sync	No response	Integrated	System (push)	Fair
Feldstein et al., 2006 ¹⁰⁰	USA	Community	Outpatient	6 mo	Local	Chronic disease management	Sync	No response	Integrated	System (push)	Good
Field et al., 2009 ¹⁰¹	Canada	Academic	Long-term care facility	12 mo	Com	Pharmacology	Sync	Noncommittal ack	Integrated	System (push)	Good
Fihn et al., 1994 ³⁰	USA	Academic	Outpatient	NR	Local	Scheduling next clinic visit	Sync	NR, unclear	Not clearly described	System (push)	Poor
Fillippi et al., 2003 ¹⁰²	Europe	Community	Outpatient	6 mo	NR	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Fair
Fitzmaurice et al., 2000 ¹⁰³	Europe	Community	Outpatient	12 mo	Com	Chronic disease management	Sync	NR, unclear	NR, not clear	NR	Poor
Flottorp et al., 2002 ⁷⁵	Europe	Community	Outpatient	7 to 8 mo	Com	Acute disease management	Sync	NR	NR, not clear	NR	Poor
Fortuna et al., 2009 ¹⁰⁴	USA	Academic and Community	Outpatient	12 mo	Com	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Fretheim et al., 2006 ⁴⁸ and Fretheim et al., 2006 ⁴⁹	Europe	Community	Outpatient	1 year	Com	Pharmacology Preventive	Sync	No response	Integrated	System (push)	Fair
Gill et al., 2009 ⁵⁰	USA	Academic and Community	Outpatient	1 year	Com	Pharmacology Lab test ordering Chronic disease management Preventive	Sync	Noncommittal ack	Integrated	System (push)	Poor
Gilutz et al., 2009 ¹¹	Europe	Community	Outpatient	6 to 36 mo	Local	Pharmacology Chronic disease management Preventive	NR, not clearly described	NR, assume no response	Paper	System (push)	Poor

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Goud et al., 2009 ¹⁰⁵	Europe	Academic and Community	Outpatient	NR	Local	Chronic disease management Preventive	Sync and async	Justification	Integrated, Paper	User (pull)	Good
Heidenreich et al., 2007 ¹⁴	USA	VA	Both-academic and community	4.5 years	Local	Pharmacology	Sync	NR, assume no response	Paper	System (push)	Good
Hicks et al., 2009 ¹⁰⁶	USA	Academic and Community	Outpatient	18 mo	Local	Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Good
Krall et al., 2004 ¹⁰⁷	USA	Community	Outpatient	1 mo	Com	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Kuperman et al., 1999 ²⁸	USA	Academic	Inpatient	4 mo	Local	Action in response to a critical lab value	Sync	Mandatory	Integrated	System (push)	Good
Linder et al., 2009 ¹⁰⁸	USA	Academic and Community	Outpatient	9 mo	Local	Diagnosis Pharmacology Chronic disease management	Sync	NR, assume no response	Integrated	Both System (push) and System (pull)	Good
Locatelli et al., 2009 ¹⁰⁹	Europe	Academic and Community	Outpatient	6 to 8 mo	NR	Chronic disease management	Sync	NR, unclear	Standalone	NR	Fair
Manotti et al., 2001 ¹¹⁰	Europe	Community	Outpatient	NR	Local	Pharmacology Chronic disease management	Sync	NR, assume no response	Standalone	User (pull)	Good
Marco et al., 2003	Europe	Academic	Outpatient	20 wk	Com	Pharmacology	Sync	NR, assume no response	Standalone	User (pull)	Fair
Martens et al., 2006 ¹¹¹ and Martens et al., 2007 ¹¹²	Europe	Academic and Community	Outpatient	NR	Local	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
McCowan et al., 2001 ¹⁸	Europe	Community	Outpatient	NR	Local	Chronic disease management	Sync	NR, assume no response	Standalone	User (pull)	Fair
Mc Donald, 1976 ⁸¹	USA	Academic	Outpatient	8 mo	Local	Pharmacology Lab test ordering	Async	NR, assume no response	Paper	System (push)	Good
McGregor et al., 2006 ⁴	USA	Academic	Inpatient	12 wk	Com	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Good
Montgomery et al., 2000 ¹¹³	Europe	Community	Outpatient	NR	Com	Pharmacology	Not clearly defined	NR, assume no response	Integrated	User (pull)	Fair
Murray et al., 2004 ²¹	USA	Academic	Outpatient	1 year	Local	Chronic disease management	Sync	Noncommittal ack	Integrated	System (push)	Good
Overhage et al., 1997 ⁵	USA	Academic	Inpatient	30 wk	Local	Pharmacology Lab test ordering	Sync	Noncommittal ack	Integrated	System (push)	Good
Paul et al., 2006 ⁶	Germany Israel Italy	Academic	Inpatient	7 mo	Local	Diagnosis Pharmacology	Sync	No response	Standalone	System (push)	Good
Peterson et al., 2007 ¹¹⁴	USA	Academic	Inpatient	9 mo	Local	Pharmacology	Sync	Noncommittal ack	Integrated	System (push)	Poor
Phillips et al., 2005 ¹¹⁵ and Zeimer et al., 2006 ¹¹⁶ and	USA	Academic	Outpatient	3 years	Local	Pharmacology Chronic disease management	Sync	No response	Paper	System (push)	Fair
Player et al., 2010 ⁸⁵	USA	NR	Outpatient	NR	Com	Diagnosis Pharmacology	Sync	NR, assume no response	Integrated	System (push)	Fair
Raebel et al., 2007 ¹¹⁷	USA	Academic	Outpatient	1 year	NR	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Rood et al., 2005 ¹¹⁸	Europe	Academic	Inpatient	10 wk	Local	Chronic disease management	Sync	No response	Integrated	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Rossi et al., 1997 ¹¹⁹	USA	VA	Outpatient	6 mo	Local	Pharmacology	Sync	Justification	Paper	System (push)	Poor
Rothschild et al., 2007 ¹²⁰	USA	Academic	Inpatient	4 mo	Local	Transfusion ordering	Sync	Justification	Integrated	System (push)	Good
Roumie et al., 2006 ²²	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology	Not clearly defined	NR, assume no response	Integrated	System (push)	Good
Samore et al., 2005 ¹²¹	USA	Community	Outpatient	2 years	Local	Diagnosis Pharmacology	Sync	NR, assume no response	Standalone	User (pull)	Fair
Sequist et al., 2005 ⁶⁶	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology Preventive	Sync	No response	Integrated, Paper	System (push)	Poor
Shojania et al., 1998 ¹²²	USA	Academic	Inpatient	7 mo	Local	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Simon et al., 2006 ¹²³	USA	Community	Outpatient	18 mo	Local	Pharmacology	Sync	Mandatory	Integrated	System (push)	Fair
Smith et al., 2008 ¹²⁴	USA	Community	Outpatient	30 mo	Local	Pharmacology	Sync	Mandatory	Online	System (push)	Good
Subramanian et al., 2004 ²⁴	USA	VA	Outpatient	1 year	Local	Chronic disease management	Sync	No response	Paper	System (push)	Fair
Strom et al., 2010 ¹²⁵	USA	Academic	Inpatient	6 mo	Local	Pharmacology	Sync	Mandatory	Integrated	System (push)	Fair
Strom et al., 2010 ¹²⁶	USA	Academic	Inpatient	15 mo	Com	Pharmacology	Sync	Mandatory	Integrated	System (push)	Fair
Tamblyn et al., 2003 ¹²⁷	Canada	Academic	Outpatient	13 mo	Local	Pharmacology	Sync	NR ,unclear	Integrated	System (push)	Good
Tamblyn et al., 2008 ¹²⁸	Canada	NR	Outpatient	6 mo	Local	Pharmacology	Sync	Justification	Integrated	System (push)	Fair
Tamblyn et al., 2009 ¹²⁹	Canada	NR	Outpatient	6 mo	Local	Pharmacology	Sync	NR unclear	Integrated	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Terrell et al., 2009 ¹³⁰	USA	Academic	ED	2.5 years	Local	Pharmacology preventive	Sync	Mandatory	Integrated	System (push)	Good
Terrell et al., 2010 ¹³¹	USA	Academic	ED	2 years	Local	Pharmacology	Sync	Mandatory	Integrated	System (push)	Fair
Tierney et al., 2003 ²⁵	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	Noncommittal Acknowledgement	Integrated, Paper	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor
Vadher et al., 1997 ¹³²	Europe	Community	Outpatient	NR	Local	Pharmacology	Sync	NR, unclear	Standalone	System (push)	Fair
Vadher et al., 1997 ¹³³	Europe	Community	Outpatient	1 mo	Local	Pharmacology	Sync	NR, unclear	Standalone	System (push)	Fair
Vanwyk et al., 2008 ⁷⁰	Europe	Community	Outpatient	NR	Com	Diagnosis Preventive Screening and treatment of dyslipidemia	Sync	NR, assume no response	Integrated	System (push)	Good
Visser et al., 1995 ¹³⁴ and Visser et al., 1996 ¹³⁵	Europe	Academic	ED	7 mo	NR, not clearly described	Diagnosis General reference	Sync and async	Mandatory	Paper	User (pull)	Good
Weir et al., 2003 ¹³⁶	NR	Academic and community	Both-Academic and community	6 mo	NR, not clearly described	Pharmacology	Async	NR, assume no response	Paper	System (push)	Good
White et al., 1984 ¹³⁷	USA	Community	Inpatient	3 mo	Local	Pharmacology	Async	No response	Paper	System (push)	Good
Zanetti et al., 2003 ²⁷	USA	Academic	Inpatient	3 mo	Local	Pharmacology	Sync	Mandatory	Integrated,	System (push)	Good

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-9. Outcome measure: user knowledge

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Alper et al, 2005 ¹³⁸	USA Israel Lebanon Pakistan	NR	NR	3 mo	Com	Answering specific clinical questions	Sync and async	Mandatory	Online	User (pull)	Fair
Del Fiol et al., 2008 ¹³⁹	USA	Community	Outpatient	6 mo	Local	Other	Sync	No response	Integrated	User (pull)	Fair
Emery et al., 2007 ⁷⁴	Europe	Community	Outpatient	12 mo	Com	Referral for genetic counseling	Sync	NR, assume no response	NR, unclear	NR	Fair
Hobbs et al., 1996 ⁵¹	Europe	NR	Outpatient	6 mo	Local	Diagnosis Lab test ordering Preventive	Sync	NR, unclear	Standalone	User (pull)	Poor
Holbrook et al., 2009 ⁵²	Canada	Community	Outpatient	NR	NR, not clearly described	Chronic disease management Initiating discussion	Sync	NR, assume no response	Online	NR	Fair

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-10. Outcome measure: efficiency

Study	Location	General Setting	Specific Setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Alper et al., 2005 ¹³⁸	USA Israel Lebanon Pakistan	NR	NR	3 mo	Com	Answering specific clinical questions	Sync and async	Mandatory	Online	User (pull)	Fair
Del Fiol et al., 2008 ¹³⁹	USA	Community	Outpatient	6 mo	Local	Other	Sync	No response	Integrated	User (pull)	Fair
Etchells et al., 2010 ¹⁴⁰	Canada	Academic	Inpatient	4 mo	Com	Lab test ordering	Async	NR, assume no response	Other: pager	System (push)	Fair
Graumlich et al., 2009 ¹² and Graumlich et al., 2009 ¹⁴¹	USA	Academic	Inpatient	26 mo	Local	Discharge planning	Sync	NR, unclear	Standalone	NR	Good
McGregor et al., 2006 ⁴	USA	Academic	Inpatient	12 wk	Com	Pharmacology	Sync	NR unclear	Integrated	System (push)	Good
Smith et al., 2008 ¹²⁴	USA	Community	Outpatient	30 mo	Local	Pharmacology	Sync	Mandatory	Online	System (push)	Good
Tierney et al., 1987 ⁹¹	USA	Academic	Outpatient	16 weeks	Local	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Fair

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, mo = month/months, NR = not reported, sync = synchronous, wk = week/weeks

Table I-11. Outcome measure: patient satisfaction

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Apkon et al., 2005 ³²	USA	Community	Outpatient	NR	Com	Diagnosis Chronic disease management Preventive	Sync	No response	Integrated	System (push)	Good
Feldstein et al., 2006 ¹⁰⁰	NR	NR	Outpatient	14 wk	Local	Lab test ordering	Sync	No response	Integrated	System (push)	Good
Graumlich et al., 2009 ¹⁴¹	USA	Academic	Inpatient	26 mo	Local	Discharge planning	Sync	NR, unclear	Standalone	NR	Good
Holbrook et al., 2009 ⁵²	Canada	Community	Outpatient	NR	NR, not clearly described	Chronic disease management Initiating discussion	Sync	NR, assume no response	Online	NR	Fair
Kline et al., 2009 ³	USA	Academic	ED	2 years	Local	Diagnosis	Sync	No response	Paper	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Chronic	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor

Abbreviations: com = commercial, mo = month/months, NR = not reported, sync = synchronous, wk = week/weeks

Table I-12. Outcome measure: cost

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Apkon et al., 2005 ³²	USA	Community	Outpatient	NR	Com	Diagnosis Chronic disease management Preventive	Sync	No response	Integrated	System (push)	Good
Bates et al., 1999 ⁷¹	USA	Academic	Inpatient	4 mo	Local	Lab test ordering	Sync	Justification	Integrated	System (push)	Fair
Bird et al., 1990 ¹⁴²	USA	Academic	Outpatient	9 mo	Local	Preventive	Sync	No response	Paper	System (push)	Poor
Cleveringa et al., 2008 ¹⁴³	Europe	Community	Outpatient	1 year	Com	Chronic disease management	Sync	Mandatory	Standalone	User (pull)	Good
Cobos et al., 2005 ⁹⁸	Europe	Community	Outpatient	1 year	Local	Chronic disease management	Sync	Justification	Standalone	System (push)	Fair
Fitzmaurice et al., 2000 ¹⁰³	Europe	Community	Outpatient	12 mo	Com	Chronic disease management	Sync	NR unclear	NR unclear	NR	Poor
Frame et al., 1994 ¹⁴⁴	USA	Community	Outpatient	2 year	Local	Initiating discussion Preventive	Async	NR, assume no response	Paper	System (push)	Fair
Fretheim et al., 2006 ⁴⁸ and Fretheim et al., 2006 ⁴⁹	Europe	Community	Outpatient	1 year	Com	Pharmacology Preventive	Sync	No response	Integrated	System (push)	Fair
Harpole et al., 1997 ⁷⁷	USA Canada	Academic	Inpatient	19 wk	Local	Diagnosis Radiograph ordering	Sync	Mandatory	Integrated	User (pull)	Fair
Hobbs et al., 1996 ⁵¹	Europe	NR	Outpatient	6 mo	NR	Diagnosis Lab test ordering Preventive	Sync	NR, unclear	Standalone	User (pull)	Poor
Khan et al., 2010 ¹ and Maclean et al., 2009 ²	USA	Community	Outpatient	NR	Local	Chronic disease management	Async	NR, assume no response	Paper	System (push)	Good
McGregor et al., 2006 ⁴	USA	Academic	Inpatient	12 wk	Com	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Murray et al., 2004 ²¹	USA	Academic	Outpatient	1 year	Local	Chronic disease management	Sync	Noncommittal ack	Integrated	System (push)	Good
Overhage et al., 1997 ⁵	USA	Academic	Inpatient	30 wk	Local	Pharmacology Lab test ordering	Sync	Noncommittal ack	Integrated	System (push)	Good
Paul et al., 2006 ⁶	Germany Israel Italy	Academic	Inpatient	7 mo	Local	Diagnosis Pharmacology	Sync	No response	Standalone	System (push)	Good
Smith et al., 2008 ¹²⁴	USA	Community	Outpatient	30 mo	Local	Pharmacology	Sync	Mandatory	Online	System (push)	Good
Smith et al., 2009 ¹⁴⁵	NR	Community	Outpatient	25 days	Local	Lab test ordering	Sync	No response	Integrated	System (push)	Good
Tierney et al., 1987 ⁹¹	USA	Academic	Outpatient	16 weeks	Local	Lab test ordering	Sync	Mandatory	Integrated	System (push)	Fair
Tierney et al., 1988 ¹⁴⁶	USA	Academic	Outpatient	6 mo	Local	Diagnosis Lab test ordering	Sync	Mandatory	Integrated	System (push)	Fair
Tierney et al., 2003 ²⁵	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	Noncommittal ack	Integrated, Paper	System (push)	Good
Tierney et al., 2005 ²⁶	USA	Academic	Outpatient	28 mo	Local	Chronic disease management	Sync	NR, unclear	Integrated	System (push)	Poor
Wilson et al., 2006 ⁹⁴	Europe	Community	Outpatient	8 mo	Local	Initiating discussion Providing information to GP	Sync	NR, unclear	NR, not clearly described	User (pull)	Poor

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-13. Outcome measure: cost-effectiveness

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Cleveringa et al., 2008 ¹⁴³	Europe	Community	Outpatient	1 year	Com	Chronic disease management	Sync	Mandatory	Standalone	User (pull)	Good
Fretheim et al., 2006 ⁴⁸ and Fretheim et al., 2006 ⁴⁹	Europe	Community	Outpatient	1 year	Com	Pharmacology Preventive	Sync	No response	Integrated	System (push)	Fair
McDowell et al., 1986 ⁵⁶	Canada	Academic	Outpatient	10 wk	NR, not clearly described	Immunization Preventive	Sync	NR unclear	Paper	System (push)	Fair
McDowell et al., 1989 ⁵⁷	Canada	Academic	Outpatient	1 year	Local	Preventive	Sync	No response	Paper	System (push)	Fair
McDowell et al., 1989 ⁸²	Canada	Academic	Outpatient	15 mo	Local	Diagnosis	Sync	No response	Paper	System (push)	Fair
Rosser et al., 1992 ⁶⁵	Canada	Academic	Outpatient	12 mo	Local	Immunization	Sync	No response	Paper	System (push)	Fair

Abbreviations: com = commercial, mo = month/months, NR = not reported, sync = synchronous, wk = week/weeks

Table I-14. Outcome measure: health care provider acceptance

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Bird et al., 1990 ¹⁴²	USA	Academic	Outpatient	9 mo	Local	Preventive	Sync	No response	Paper	System (push)	Poor
Cobos et al., 2005 ⁹⁸	Europe	Community	Outpatient	1 year	Local	Chronic disease management	Sync	Justification	Standalone	System (push)	Fair
Dykes et al., 2010 ⁴³	USA	Academic and Community	Inpatient	6 mo	Local	Diagnosis Preventive	Sync	NR, assume no response	Online, Paper	User (pull)	Fair
Fihn et al., 1994 ³⁰	USA	Academic	Outpatient	NR	Local	Scheduling next clinic visit	Sync	NR unclear	Not clearly described	System (push)	Poor
Fortuna et al., 2009 ¹⁰⁴	USA	Academic and Community	Outpatient	12 mo	Com	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Frame et al., 1994 ¹⁴⁴	USA	Community	Outpatient	2 years	Local	Initiating discussion Preventive	Async	NR, assume no response	Paper	System (push)	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Goudet et al., 2009 ¹⁰⁵	Europe	Academic and Community	Outpatient	NR	Local	Chronic disease management Preventive	Sync and async	Justification	Integrated, Paper	User (pull)	Good
Harpole et al., 1997 ⁷⁷	USA, Canada	Academic	Inpatient	19 wk	Local	Diagnosis Radiograph ordering	Sync	Mandatory	Integrated	User (pull)	Fair
Hetlevik et al., 1998 ¹⁴⁷ and Hetlevik et al., 1999 ¹⁴⁸	Europe	Community	Outpatient	18 mo	Local	Chronic disease management	Sync	NR, assume no response	Integrated	User (pull)	Fair
Hetlevik et al., 2000 ¹⁴⁹	Europe	Community	Outpatient	18 mo	Local	Chronic disease management	Sync	NR, assume no response	Integrated	User (pull)	Fair
Judge et al., 2006 ¹⁵⁰	USA	Academic	Long-term care setting	12 mo	Local	Pharmacology	Sync	No response	Integrated	System (push)	Fair
Litzelman et al., 1993 ⁵⁴	USA	Academic	Outpatient	6 mo	Local	Lab test ordering Preventive	Sync	Mandatory, Justification required	Paper	System (push)	Fair
Maviglia et al., 2006 ¹⁵¹	USA	Academic	Outpatient	12 mo	Local	Pharmacology	Sync	No response	Integrated	User (pull)	Good
McDonald et al., 1984 ¹⁹	USA	Academic	Outpatient	2 years	Local	Immunization Pharmacology Lab test ordering Chronic disease management Preventive	Sync	Noncommittal ack	Paper	System (push)	Good
McLaughlin et al., 2010 ¹⁵²	USA	NR	Outpatient	NR	Local	Preventive	Sync	NR, assume no response	Standalone	System (push)	Poor
Ornstein et al., 1991 ⁵⁹	USA	Academic	Outpatient	1 year	NR, not clearly described	Lab test ordering preventive	Sync	Justification	Paper	System (push)	Fair
Rollman et al., 2001 ¹⁵³	USA	Academic	Outpatient	20 mo	Com	Diagnosis	Async	Mandatory	Integrated Other: email	System (push)	Poor
Rossi et al., 1997 ¹¹⁹	USA	VA	Outpatient	6 mo	Local	Pharmacology	Sync	Justification	Paper	System (push)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Rothschild et al., 2007 ¹²⁰	USA	Academic	Inpatient	4 mo	Local	Transfusion ordering	Sync	Justification	Integrated	System (push)	Good
Sundaram et al., 2009	USA	VA	Outpatient	9 mo	Local	Lab test ordering	Sync	Justification	Integrated	System (push)	Good
Tamblyn et al., 2008 ¹²⁸	Canada	NR	Outpatient	6 mo	Local	Pharmacology	Sync	Justification	Integrated	System (push)	Fair
Tamblyn et al., 2009 ¹²⁹	Canada	NR	Outpatient	6 mo	Local	Pharmacology	Sync	NR unclear	Integrated	System (push)	Good
Terrellet al., 2009 ¹³⁰	USA	Academic	ED	2.5 years	Local	Pharmacology Preventive	Sync	Mandatory	Integrated	System (push)	Good
Vadher et al., 1997 ¹³³	Europe	Community	Outpatient	1 mo	Local	Pharmacology	Sync	NR unclear	Standalone	System (push)	Fair

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-15. Outcome measure: health care provider satisfaction

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Alper et al., 2005 ¹³⁸	USA Israel Lebanon Pakistan	NR	NR	3 mo	Com	Answering specific clinical questions	Sync and async	Mandatory	Online	User (pull)	Fair
Apkon et al., 2005 ³²	USA	Community	Outpatient	NR	Com	Diagnosis Chronic disease management Preventive	Sync	No response	Integrated	System (push)	Good
Bird et al., 1990 ¹⁴²	USA	Academic	Outpatient	9 mo	Local	Preventive	Sync	No response	Paper	System (push)	Poor
Co et al., 2010 ⁹⁷	USA	Community	Outpatient	6 mo	Local	Diagnosis Chronic disease management	Sync	Justification	Integrated	System (push)	Fair
Del Fiol et al., 2008 ¹³⁹	USA	Community	Outpatient	6 mo	Local	Other	Sync	No response	Integrated	User (pull)	Fair
Emery et al., 2007 ⁷⁴	Europe	Community	Outpatient	12 mo	Com	Referral for genetic counseling	Sync	NR, assume no response	NR/Unclear	NR	Fair

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Fortuna et al., 2009 ¹⁰⁴	USA	Academic and Community	Outpatient	12 mo	Com	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Graumlich et al., 2009	USA	Academic	Inpatient	26 mo	Local	Discharge planning	Sync	NR, unclear	Standalone	NR	Good
Heidenreich et al., 2007 ¹⁴	USA	VA	Academic and community	4.5 years	Local	Pharmacology	Sync	NR, assume no response	Paper	System (push)	Good
Martens et al., 2006 ¹¹¹ and Martens et al., 2007 ¹¹²	Europe	Academic and Community	Outpatient	NR	Local	Pharmacology	Sync	NR unclear	Integrated	System (push)	Fair
Maviglia et al., 2006 ¹⁵¹	USA	Academic	Outpatient	12 mo	Local	Pharmacology	Sync	No response	Integrated	User (pull)	Good
McCowan et al., 2001 ¹⁸	Europe	Community	Outpatient	NR	Local	Chronic disease management	Sync	NR, assume non response	Standalone	User (pull)	Fair
Sequist et al., 2005 ⁶⁶	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology Preventive	Sync	No response	Integrated, Paper	System (push)	Poor
Sequist et al., 2009 ²³	USA	Community	Outpatient	15 mo	Com	Lab test ordering Preventive	Sync	Mandatory	Integrated	System (push)	Fair
Smith et al., 2008 ¹²⁴	USA	Community	Outpatient	30 mo	Local	Pharmacology	Sync	Mandatory	Online	System (push)	Good
Sundaram et al., 2009 ¹⁵⁴	USA	VA	Outpatient	9 mo	Local	Lab test ordering	Sync	Justification	Integrated	System (push)	Good
Visser et al., 1995 ¹³⁴ and Visser et al., 1996 ¹³⁵	Europe	Academic	ED	7 mo	NR, not clearly described	Diagnosis General reference	Sync and async	Mandatory	Paper	User (pull)	Good
Weir et al., 2003 ¹³⁶	NR	Academic and community	Academic and community	6 mo	NR, not clearly described	Pharmacology	Async	NR, assume no response	Paper	System (push)	Good
Wilson et al., 2006 ⁹⁴	Europe	Community	Outpatient	8 mo	Local	Initiating discussion Providing information to GP	Sync	NR unclear	NR, not clearly described	User (pull)	Poor

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-16. Outcome measure: health care provider use

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Bosworth et al., 2009 ¹⁵⁵	USA	VA	Outpatient	2 years	Local	Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Good
Bourgeois et al., 2010 ⁹⁵	USA	Community	Outpatient	6 mo	Local	Pharmacology Lab test ordering Acute and chronic disease management	Sync	NR, unclear	Integrated	User (pull)	Fair
Del Fiol et al., 2008 ¹³⁹	USA	Community	Outpatient	6 mo	Local	Other	Sync	No response	Integrated	User (pull)	Fair
Eccles et al., 2002 ⁴⁴	Europe	Community	Outpatient	12 mo	Com	Chronic disease management	Sync	NR, assume no response	Integrated	System (push)	Fair
Emery et al., 2007 ⁷⁴	Europe	Community	Outpatient	12 mo	Com	Referral for genetic counseling	Sync	NR, assume no response	NR/Not clear	NR	Fair
Fillippi et al., 2003 ¹⁰²	Europe	Community	Outpatient	6 mo	NR	Pharmacology	Sync	NR, unclear	Integrated	System (push)	Fair
Fortuna et al., 2009 ¹⁰⁴	USA	Academic and Community	Outpatient	12 mo	Com	Pharmacology	Sync	Mandatory	Integrated	System (push)	Good
Hetlevik et al., 1998 ¹⁴⁷ and Hetlevik et al., 1999 ¹⁴⁸	Europe	Community	Outpatient	18 mo	Local	Chronic disease management	Sync	NR, assume no response	Integrated	User (pull)	Fair
Hetlevik et al., 2000 ¹⁴⁹	Europe	Community	Outpatient	18 mo	Local	Chronic disease management	Sync	NR, assume no response	Integrated	User (pull)	Fair
Hobbs et al., 1996 ⁵¹	Europe	NR	Outpatient	6 mo	Local	Diagnosis Lab test ordering Preventive	Sync	NR, unclear	Standalone	User (pull)	Poor
Linder et al., 2009 ¹⁰⁸	USA	Academic and Community	Outpatient	9 mo	Local	Diagnosis Pharmacology Chronic disease management	Sync	NR, assume no response	Integrated	System (push) and user (pull)	Good

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Maviglia et al., 2006 ¹⁵¹	USA	Academic	Outpatient	12 mo	Local	Pharmacology	Sync	No response	Integrated	User (pull)	Good
Samore et al., 2005 ¹²¹	USA	Community	Outpatient	2 years	Local	Diagnosis Pharmacology	Sync	NR, assume no response	Standalone	User (pull)	Fair
Sequist et al., 2005 ⁶⁶	USA	Academic and Community	Outpatient	6 mo	Local	Pharmacology Preventive	Sync	No response	Integrated, Paper	System (push)	Poor
Strom et al., 2010 ¹²⁵	USA	Academic	Inpatient	6 mo	Local	Pharmacology	Sync	Mandatory	Integrated	System (push)	Fair
Tamblyn et al., 2008 ¹²⁸	Canada	NR	Outpatient	6 mo	Local	Pharmacology	Sync	Justification	Integrated	System (push)	Fair
van Wijk et al., 2001 ⁹²	Europe	Community	Outpatient	12 mo	Local	Lab test ordering	Sync	No response	Integrated	User (pull)	Good

Abbreviations: ack = acknowledgment, async = asynchronous, com = commercial, ED = emergency department, GP = general practitioner, mo = month/months, NR = not reported, sync = synchronous, VA = Veterans Administration, wk = week/weeks

Table I-17. Outcome measure: implementation of CDSS/KMS

Study	Location	General setting	Specific setting	Duration	Source	Objective	Relation	Response	Format	Mode	Quality
Co et al., 2010 ⁹⁷	USA	Community	Outpatient	6 mo	Local	Diagnosis Chronic disease management	Sync	Justification	Integrated	System (push)	Fair
Flanagan et al., 1999 ⁴⁶	USA	Academic	Outpatient	10 mo	Local	Immunization	Sync	Noncommittal ack	Online	User (pull)	Poor
Greiver et al., 2005 ⁷⁶	Canada	Academic and Community	Outpatient	7 mo	Local	Diagnosis Lab test ordering	Sync	NR, unclear	Standalone	User (pull)	Poor
Hamilton et al., 2004 ¹³	USA Canada	Academic	Inpatient, Long-term care facility	25 mo	Local	Diagnosis	Sync	No response	Standalone	User (pull)	Fair
Tierney et al., 1988 ¹⁴⁶	USA	Academic	Outpatient	6 mo	Local	Diagnosis Lab test ordering	Sync	Mandatory	Integrated	System (push)	Fair

Abbreviations: ack = acknowledgment, mo = month/months, NR = not reported

References Cited in Appendix I

1. Khan S, Maclean CD, Littenberg B. The effect of the Vermont Diabetes Information System on inpatient and emergency room use: results from a randomized trial. *Health Outcomes Res Med* 2010;1(1):e61-e66.
2. Maclean CD, Gagnon M, Callas P, et al. The vermont diabetes information system: a cluster randomized trial of a population based decision support system. *J Gen Intern Med* 2009;24(12):1303-10.
3. Kline JA, Zeitouni RA, Hernandez-Nino J, et al. Randomized trial of computerized quantitative pretest probability in low-risk chest pain patients: effect on safety and resource use. *Ann Emerg Med* 2009;53(6):727-35 e1.
4. McGregor JC, Weekes E, Forrest GN, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(4):378-84.
5. Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4(5):364-75.
6. Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58(6):1238-45.
7. Roukema J, Steyerberg EW, van der Lei J, et al. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. *J Am Med Inform Assoc* 2008;15(1):107-13.
8. Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107(22):2799-804.
9. Brier ME, Gaweda AE, Dailey A, et al. Randomized trial of model predictive control for improved anemia management. *Clin J Am Soc Nephrol* 2010;5(5):814-20.
10. Cavalcanti AB, Silva E, Pereira AJ, et al. A randomized controlled trial comparing a computer-assisted insulin infusion protocol with a strict and a conventional protocol for glucose control in critically ill patients. *J Crit Care* 2009;24(3):371-8.
11. Gilutz H, Novack L, Shvartzman P, et al. Computerized community cholesterol control (4C): meeting the challenge of secondary prevention. *Isr Med Assoc J* 2009;11(1):23-9.
12. Graumlich JF, Novotny NL, Nace GS, et al. Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial. *J Hosp Med* 2009;4(7):E11-9.
13. Hamilton E, Platt R, Gauthier R, et al. The effect of computer-assisted evaluation of labor on cesarean rates. *J Healthc Qual* 2004;26(1):37-44.
14. Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115(22):2829-34.
15. Holt TA, Thorogood M, Griffiths F, et al. Protocol for the 'e-Nudge trial': a randomised controlled trial of electronic feedback to reduce the cardiovascular risk of individuals in general practice [ISRCTN64828380]. *Trials* 2006;7:11.
16. Holt TA, Thorogood M, Griffiths F, et al. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60(573):e137-43.
17. Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352(10):969-77.

18. McCowan C, Neville RG, Ricketts IW, et al. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26(3):191-201.
19. McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Ann Intern Med* 1984;100(1):130-8.
20. McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Comput* 1992;9(5):304-12.
21. Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24(3):324-37.
22. Roumie CL, Elasy TA, Greevy R, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. *Ann Intern Med* 2006;145(3):165-75.
23. Sequist TD, Zaslavsky AM, Marshall R, et al. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169(4):364-71.
24. Subramanian U, Fihn SD, Weinberger M, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. *Am J Med* 2004;116(6):375-84.
25. Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18(12):967-76.
26. Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40(2):477-97.
27. Zanetti G, Flanagan HL, Jr., Cohn LH, et al. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24(1):13-6.
28. Kuperman GJ, Teich JM, Tanasijevic MJ, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6(6):512-22.
29. Thomas HV, Lewis G, Watson M, et al. Computerised patient-specific guidelines for management of common mental disorders in primary care: a randomised controlled trial. *Br J Gen Pract* 2004;54(508):832-7.
30. Fihn SD, McDonnell MB, Vermes D, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. *J Gen Intern Med* 1994;9(3):131-9.
31. Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56(12):2225-33.
32. Apkon M, Mattera JA, Lin Z, et al. A randomized outpatient trial of a decision-support information technology tool. *Arch Intern Med* 2005;165(20):2388-94.
33. Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med* 2009;169(7):678-86.
34. Burack RC, Gimotty PA, George J, et al. Promoting screening mammography in inner-city settings: a randomized controlled trial of computerized reminders as a component of a program to facilitate mammography. *Med Care* 1994;32(6):609-24.
35. Burack RC, Gimotty PA. Promoting screening mammography in inner-city settings. The sustained effectiveness of computerized reminders in a randomized controlled trial. *Med Care* 1997;35(9):921-31.

36. Burack RC, Gimotty PA, George J, et al. How reminders given to patients and physicians affected pap smear use in a health maintenance organization: results of a randomized controlled trial. *Cancer* 1998;82(12):2391-400.
37. Burack RC, Gimotty PA, Simon M, et al. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. *Prev Med* 2003;36(5):547-54.
38. Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. *J Am Med Inform Assoc* 2000;7(2):196-203.
39. Chambers CV, Balaban DJ, Carlson BL, et al. Microcomputer-generated reminders. Improving the compliance of primary care physicians with mammography screening guidelines. *J Fam Pract* 1989;29(3):273-80.
40. Demakis JG, Beauchamp C, Cull WL, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. *JAMA* 2000;284(11):1411-6.
41. Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345(13):965-70.
42. Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA* 2004;292(19):2366-71.
43. Dykes PC, Carroll DL, Hurley A, et al. Fall Prevention in Acute Care Hospitals A Randomized Trial. *Jama-Journal of the American Medical Association* 2010;304(17):1912-1918.
44. Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002;325(7370):941.
45. Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124(1):159-69.
46. Flanagan JR, Doebbeling BN, Dawson J, et al. Randomized study of online vaccine reminders in adult primary care. *Proc Amia Symp* 1999:755-9.
47. Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33(1-2):87-90.
48. Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. *PLoS Med* 2006;3(6):e216.
49. Fretheim A, Oxman AD, Havelsrud K, et al. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. *PLoS Med* 2006;3(6):e134.
50. Gill JM, Chen YX, Glutting JJ, et al. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12(5):221-6.
51. Hobbs FD, Delaney BC, Carson A, et al. A prospective controlled trial of computerized decision support for lipid management in primary care. *Fam Pract* 1996;13(2):133-7.
52. Holbrook A, Thabane L, Keshavjee K, et al. Individualized electronic decision support and reminders to improve diabetes care in the community: COMPETE II randomized trial. *CMAJ* 2009;181(1-2):37-44.
53. Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20(10):916-21.
54. Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med* 1993;8(6):311-7.
55. Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. *Proc Annu Symp Comput Appl Med Care* 1994:787-91.

56. McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. *CMAJ* 1986;135(9):991-7.
57. McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *J Fam Pract* 1989;28(4):420-4.
58. McPhee SJ, Bird JA, Jenkins CN, et al. Promoting cancer screening. A randomized, controlled trial of three interventions. *Arch Intern Med* 1989;149(8):1866-72.
59. Ornstein SM, Garr DR, Jenkins RG, et al. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. *J Fam Pract* 1991;32(1):82-90.
60. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156(14):1551-6.
61. Peterson KA, Radosevich DM, O'Connor PJ, et al. Improving Diabetes Care in Practice: findings from the TRANSLATE trial. *Diabetes Care* 2008;31(12):2238-43.
62. Price M. Can hand-held computers improve adherence to guidelines? A (Palm) Pilot study of family doctors in British Columbia. *Can Fam Physician* 2005;51:1506-7.
63. Reeve JF, Tenni PC, Peterson GM. An electronic prompt in dispensing software to promote clinical interventions by community pharmacists: a randomized controlled trial. *Br J Clin Pharmacol* 2008;65(3):377-85.
64. Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. *CMAJ* 1991;145(7):807-14.
65. Rosser WW, Hutchison BG, McDowell I, et al. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992;146(6):911-7.
66. Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12(4):431-7.
67. Taylor V, Thompson B, Lessler D, et al. A clinic-based mammography intervention targeting inner-city women. *J Gen Intern Med* 1999;14(2):104-11.
68. Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care* 1986;24(8):659-66.
69. Unrod M, Smith M, Spring B, et al. Randomized controlled trial of a computer-based, tailored intervention to increase smoking cessation counseling by primary care physicians. *J Gen Intern Med* 2007;22(4):478-84.
70. van Wyk JT, van Wijk MA, Sturkenboom MC, et al. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117(3):371-8.
71. Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106(2):144-50.
72. Bell LM, Grundmeier R, Localio R, et al. Electronic Health Record-Based Decision Support to Improve Asthma Care: A Cluster-Randomized Trial. *Pediatrics* 2010;125(4):E770-E777.
73. Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332(7543):692-6.
74. Emery J, Morris H, Goodchild R, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. *Br J Cancer* 2007;97(4):486-93.
75. Flottorp S, Oxman AD, Havelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325(7360):367.

76. Greiver M, Drummond N, White D, et al. Angina on the Palm: randomized controlled pilot trial of Palm PDA software for referrals for cardiac testing. *Can Fam Physician* 2005;51:382-3.
77. Harpole LH, Khorasani R, Fiskio J, et al. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4(6):511-21.
78. Lee NJ, Chen ES, Currie LM, et al. The effect of a mobile clinical decision support system on the diagnosis of obesity and overweight in acute and primary care encounters. *ANS Adv Nurs Sci* 2009;32(3):211-21.
79. Lo HG, Matheny ME, Seger DL, et al. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16(1):66-71.
80. Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15(4):424-9.
81. McDonald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med* 1976;84(2):162-7.
82. McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. *Med Care* 1989;27(3):297-305.
83. Palen TE, Raebel M, Lyons E, et al. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. *Am J Manag Care* 2006;12(7):389-95.
84. Palen TE, Price DW, Snyder AJ, et al. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16(11):e267-75.
85. Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18(4):223-9.
86. Raebel MA, Lyons EE, Chester EA, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. *Arch Intern Med* 2005;165(20):2395-401.
87. Raebel MA, Chester EA, Newsom EE, et al. Randomized trial to improve laboratory safety monitoring of ongoing drug therapy in ambulatory patients. *Pharmacotherapy* 2006;26(5):619-26.
88. Roy PM, Durieux P, Gillaizeau F, et al. A computerized handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151(10):677-86.
89. Schriefer SP, Landis SE, Turbow DJ, et al. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41(7):502-7.
90. Stiell IG, Clement CM, Grimshaw J, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.
91. Tierney WM, McDonald CJ, Martin DK, et al. Computerized display of past test results. Effect on outpatient testing. *Ann Intern Med* 1987;107(4):569-74.
92. van Wijk MA, van der Lei J, Mosseveld M, et al. Assessment of decision support for blood test ordering in primary care. a randomized trial. *Ann Intern Med* 2001;134(4):274-81.
93. Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37(7):445-50.
94. Wilson BJ, Torrance N, Mollison J, et al. Cluster randomized trial of a multifaceted primary care decision-support intervention for inherited breast cancer risk. *Fam Pract* 2006;23(5):537-44.
95. Bourgeois FC, Linder J, Johnson SA, et al. Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clin Pediatr (Phila)* 2010;49(10):976-83.

96. Christakis DA, Zimmerman FJ, Wright JA, et al. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics* 2001;107(2):E15.
97. Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126(2):239-46.
98. Cobos A, Vilaseca J, Asenjo C, et al. Cost effectiveness of a clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Disease Management & Health Outcomes* 2005;13(6):421-432.
99. Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2(5):e25.
100. Feldstein AC, Smith DH, Perrin N, et al. Improved therapeutic monitoring with several interventions: a randomized trial. *Arch Intern Med* 2006;166(17):1848-54.
101. Field TS, Rochon P, Lee M, et al. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16(4):480-5.
102. Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26(5):1497-500.
103. Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *Arch Intern Med* 2000;160(15):2343-8.
104. Fortuna RJ, Zhang F, Ross-Degnan D, et al. Reducing the prescribing of heavily marketed medications: a randomized controlled trial. *J Gen Intern Med* 2009;24(8):897-903.
105. Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.
106. Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23(4):429-41.
107. Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107(Pt 1):135-9.
108. Linder JA, Rigotti NA, Schneider LI, et al. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169(8):781-7.
109. Locatelli F, Covic A, Macdougall IC, et al. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22(5):662-74.
110. Manotti C, Moia M, Palareti G, et al. Effect of computer-aided management on the quality of treatment in anticoagulated patients: a prospective, randomized, multicenter trial of APROAT (Automated PRogram for Oral Anticoagulant Treatment). *Haematologica* 2001;86(10):1060-70.
111. Martens JD, van der Aa A, Panis B, et al. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. *Stud Health Technol Inform* 2006;124:617-23.
112. Martens JD, van der Weijden T, Severens JL, et al. The effect of computer reminders on GPs' prescribing behaviour: a cluster-randomised trial. *Int J Med Inform* 2007;76 Suppl 3:S403-16.
113. Montgomery AA, Fahey T, Peters TJ, et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000;320(7236):686-90.

114. Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129(Pt 2):1037-40.
115. Phillips LS, Ziemer DC, Doyle JP, et al. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. *Diabetes Care* 2005;28(10):2352-60.
116. Ziemer DC, Doyle JP, Barnes CS, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting: Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. *Arch Intern Med* 2006;166(5):507-13.
117. Raebel MA, Charles J, Dugan J, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. *J Am Geriatr Soc* 2007;55(7):977-85.
118. Rood E, Bosman RJ, van der Spoel JI, et al. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. *J Am Med Inform Assoc* 2005;12(2):172-80.
119. Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. *J Gen Intern Med* 1997;12(11):672-8.
120. Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion (Paris)* 2007;47(2):228-39.
121. Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA* 2005;294(18):2305-14.
122. Shojania KG, Yokoe D, Platt R, et al. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5(6):554-62.
123. Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-968.
124. Smith SA, Shah ND, Bryant SC, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83(7):747-57.
125. Strom BL, Schinnar R, Abera F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med* 2010;170(17):1578-83.
126. Strom BL, Schinnar R, Bilker W, et al. Randomized clinical trial of a customized electronic alert requiring an affirmative response compared to a control group receiving a commercial passive CPOE alert: NSAID--warfarin co-prescribing as a test case. *J Am Med Inform Assoc* 2010;17(4):411-5.
127. Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169(6):549-56.
128. Tamblyn R, Huang A, Taylor L, et al. A randomized trial of the effectiveness of on-demand versus computer-triggered drug decision support in primary care. *J Am Med Inform Assoc* 2008;15(4):430-8.
129. Tamblyn R, Reidel K, Huang A, et al. Increasing the Detection and Response to Adherence Problems with Cardiovascular Medication in Primary Care through Computerized Drug Management Systems: A Randomized Controlled Trial. *Med Decis Making* 2009.
130. Terrell KM, Perkins AJ, Dexter PR, et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57(8):1388-94.

131. Terrell KM, Perkins AJ, Hui SL, et al. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56(6):623-9.
132. Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997;314(7089):1252-6.
133. Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. *Clin Lab Haematol* 1997;19(3):203-7.
134. Vissers MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. *Comput Methods Programs Biomed* 1995;48(1-2):53-8.
135. Vissers MC, Biert J, van der Linden CJ, et al. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. *Comput Methods Programs Biomed* 1996;49(2):177-84.
136. Weir CJ, Lees KR, MacWalter RS, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM* 2003;96(2):143-53.
137. White KS, Lindsay A, Pryor TA, et al. Application of a computerized medical decision-making process to the problem of digoxin intoxication. *J Am Coll Cardiol* 1984;4(3):571-6.
138. Alper BS, White DS, Ge B. Physicians answer more clinical questions and change clinical decisions more often with synthesized evidence: a randomized trial in primary care. *Ann Fam Med* 2005;3(6):507-13.
139. Del Fiol G, Haug PJ, Cimino JJ, et al. Effectiveness of topic-specific infobuttons: a randomized controlled trial. *J Am Med Inform Assoc* 2008;15(6):752-9.
140. Etchells E, Adhikari NK, Cheung C, et al. Real-time clinical alerting: effect of an automated paging system on response time to critical laboratory values--a randomised controlled trial. *Qual Saf Health Care* 2010;19(2):99-102.
141. Graumlich JF, Novotny NL, Nace GS, et al. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2009;4(6):356-63.
142. Bird JA, McPhee SJ, Jenkins C, et al. Three strategies to promote cancer screening. How feasible is wide-scale implementation? *Med Care* 1990;28(11):1005-12.
143. Cleveringa FG, Gorter KJ, van den Donk M, et al. Combined task delegation, computerized decision support, and feedback improve cardiovascular risk for type 2 diabetic patients: a cluster randomized trial in primary care. *Diabetes Care* 2008;31(12):2273-5.
144. Frame PS, Zimmer JG, Werth PL, et al. Computer-based vs manual health maintenance tracking. A controlled trial. *Arch Fam Med* 1994;3(7):581-8.
145. Smith DH, Feldstein AC, Perrin NA, et al. Improving laboratory monitoring of medications: an economic analysis alongside a clinical trial. *Am J Manag Care* 2009;15(5):281-9.
146. Tierney WM, McDonald CJ, Hui SL, et al. Computer predictions of abnormal test results. Effects on outpatient testing. *JAMA* 1988;259(8):1194-8.
147. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of hypertension in general practice. *Blood Press* 1998;7(5-6):270-6.
148. Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. *Scand J Prim Health Care* 1999;17(1):35-40.

149. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. *Int J Technol Assess Health Care* 2000;16(1):210-27.
150. Judge J, Field TS, DeFlorio M, et al. Prescribers' responses to alerts during medication ordering in the long term care setting. *J Am Med Inform Assoc* 2006;13(4):385-90.
151. Maviglia SM, Yoon CS, Bates DW, et al. KnowledgeLink: impact of context-sensitive information retrieval on clinicians' information needs. *J Am Med Inform Assoc* 2006;13(1):67-73.
152. McLaughlin D, Hayes JR, Kelleher K. Office-Based Interventions for Recognizing Abnormal Pediatric Blood Pressures. *Clin Pediatr (Phila)* 2010;49(4):355-362.
153. Rollman BL, Hanusa BH, Gilbert T, et al. The electronic medical record. A randomized trial of its impact on primary care physicians' initial management of major depression [corrected]. *Arch Intern Med* 2001;161(2):189-97.
154. Sundaram V, Lazzeroni LC, Douglass LR, et al. A randomized trial of computer-based reminders and audit and feedback to improve HIV screening in a primary care setting. *Int J STD AIDS* 2009;20(8):527-33.
155. Bosworth HB, Olsen MK, Dudley T, et al. Patient education and provider decision support to control blood pressure in primary care: a cluster randomized trial. *Am Heart J* 2009;157(3):450-6.

Appendix J: Analyses of Potential Publication Bias

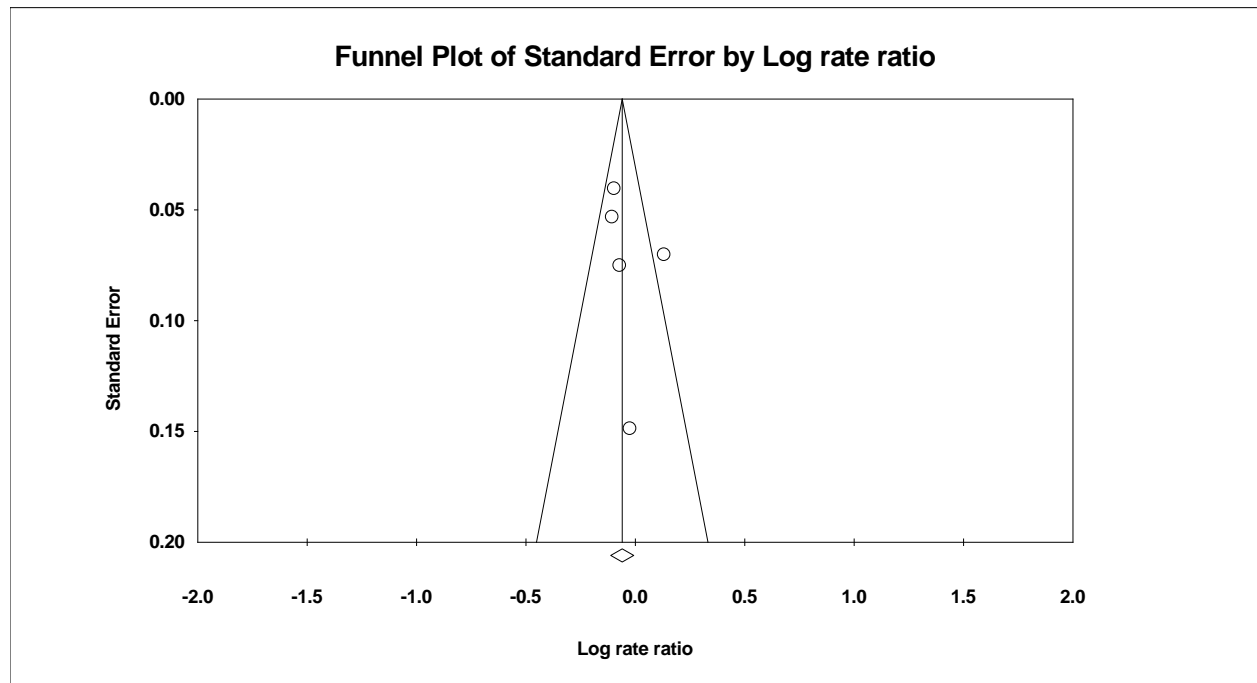
Testing for publication bias is difficult at best. In effect, one is testing for the number of studies that have not been reported based on the results of those that have been reported. To look for bias, we used three tools: (1) the funnel plot, which looks for an uneven number of studies falling to the left or right of the funnel, (2) Begg and Mazumdar's test based on the rank correlation between the observed effect sizes and observed standard errors, and (3) Egger's regression intercept, which is similar to Begg and Mazumdar's but uses actual values instead of ranks.

We used Comprehensive Meta-Analysis Version 2 (Borenstein M, Hedges L, Higgins J, Rothstein H. Comprehensive Meta-analysis Version 2, Biostat, Englewood NJ [2005]) to test for potential publication bias for the outcomes described below.

Length of Stay Outcomes

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of length of stay outcomes. The resulting funnel plot is shown in Figure J-1.

Figure J-1. Funnel plot for studies of length of stay outcomes

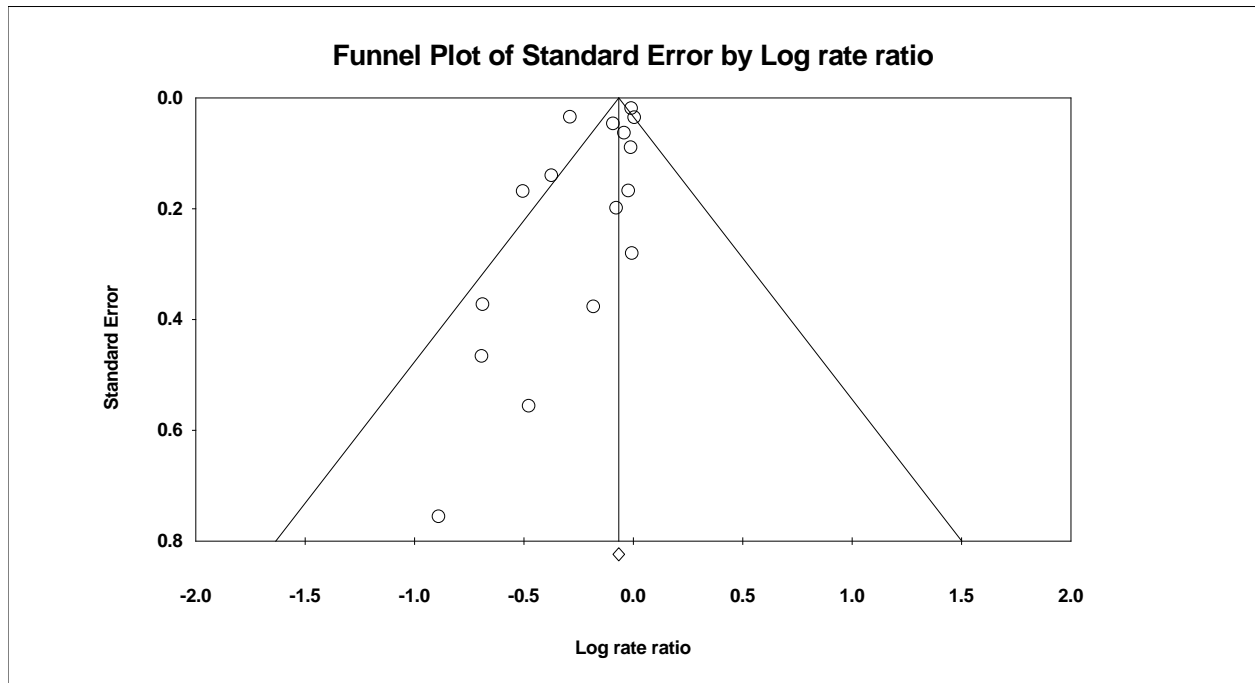


Note that only one of the studies lies outside of the funnel. Begg and Mazumdar's correlation was 0.50 (two-tailed p-value = 0.221). Egger's regression intercept was 1.637 (two-tailed p-value = 0.463). Thus, there was no evidence of publication bias in this meta-analysis.

Morbidity Outcomes

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of morbidity outcomes. The resulting funnel plot is shown in Figure J-2.

Figure J-2. Funnel plot for studies of morbidity outcomes

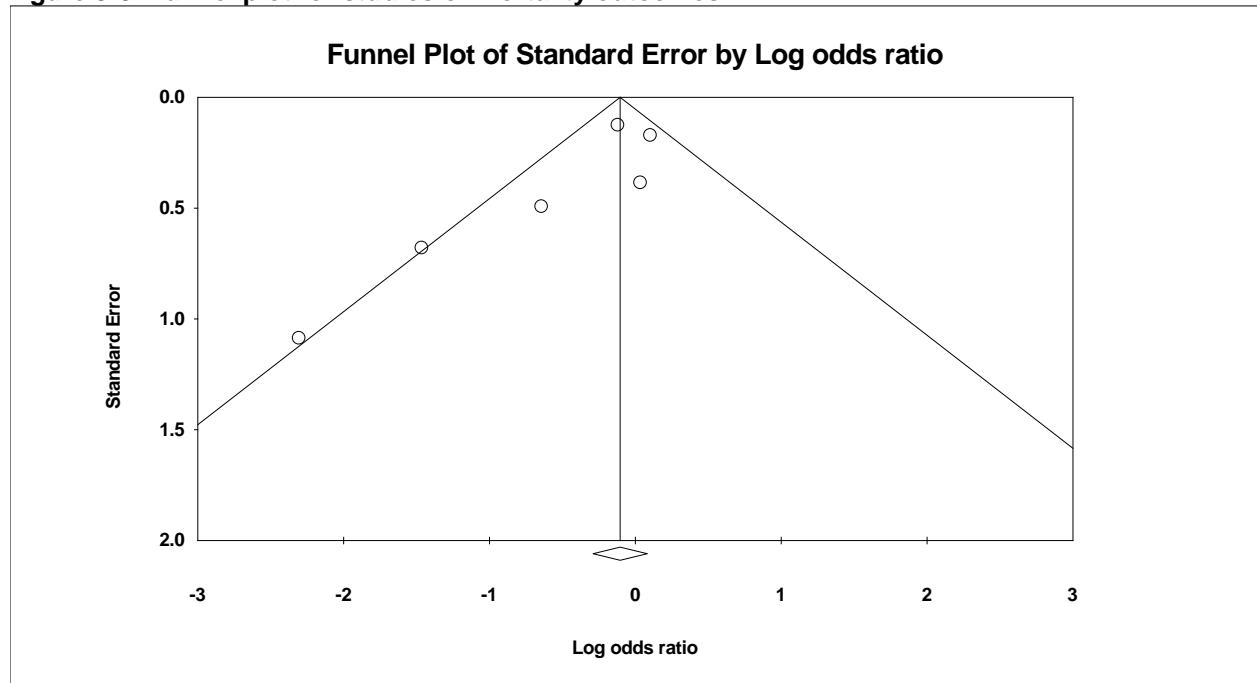


Note that re three studies lie to the left of the funnel, and two studies lie to the right. Begg and Mazumdar's correlation was -0.275 (two-tailed p-value = 0.137). Egger's regression intercept was -1.145 (two-tailed p-value = 0.126). Thus, there was no strong evidence of publication bias in this meta-analysis.

Mortality Outcomes

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of mortality outcomes. The resulting funnel plot is shown in Figure J-3.

Figure J-3. Funnel plot for studies of mortality outcomes

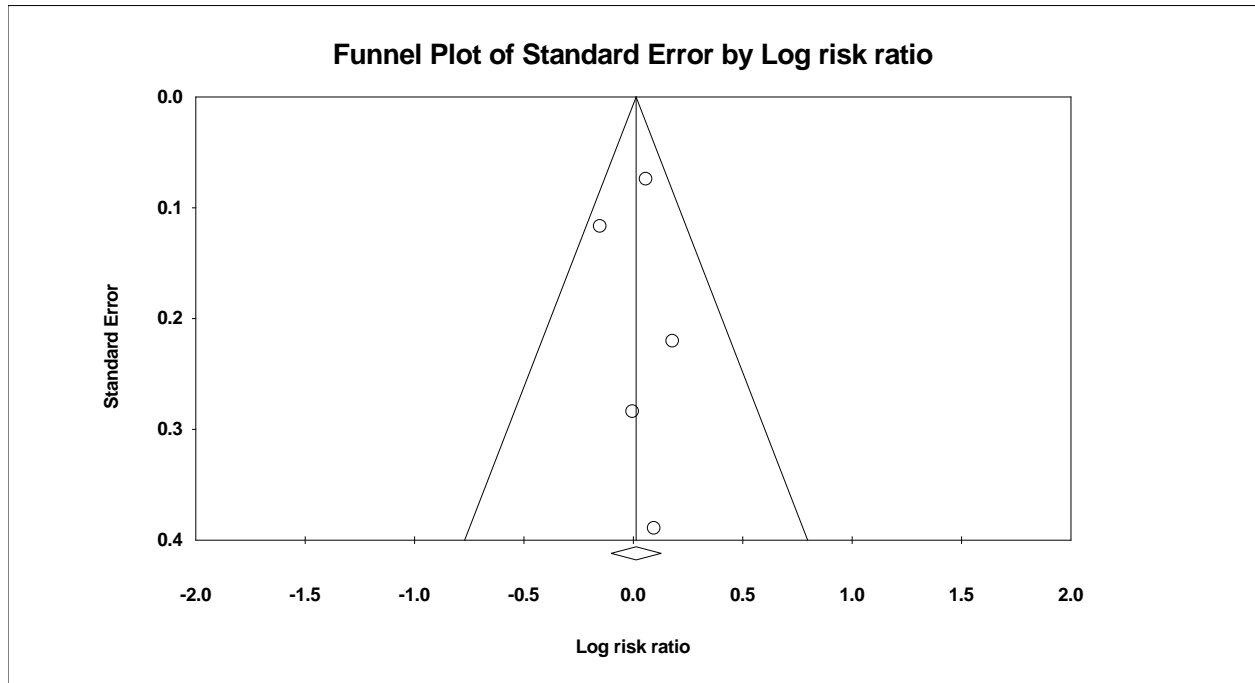


Note that two studies lie to the left of the funnel, and no studies lie to the right. Begg and Mazumdar's correlation was -0.667 (two-tailed p-value = 0.060). Egger's regression intercept was -1.737 (two-tailed p-value = 0.077). Thus, there was some evidence of bias based on the two correlation tests, but the small numbers of events in the correlation studies make it difficult to reach any conclusion.

Adverse Events

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of adverse events. The resulting funnel plot is shown in Figure J-4.

Figure J-4. Funnel plot for studies of adverse events

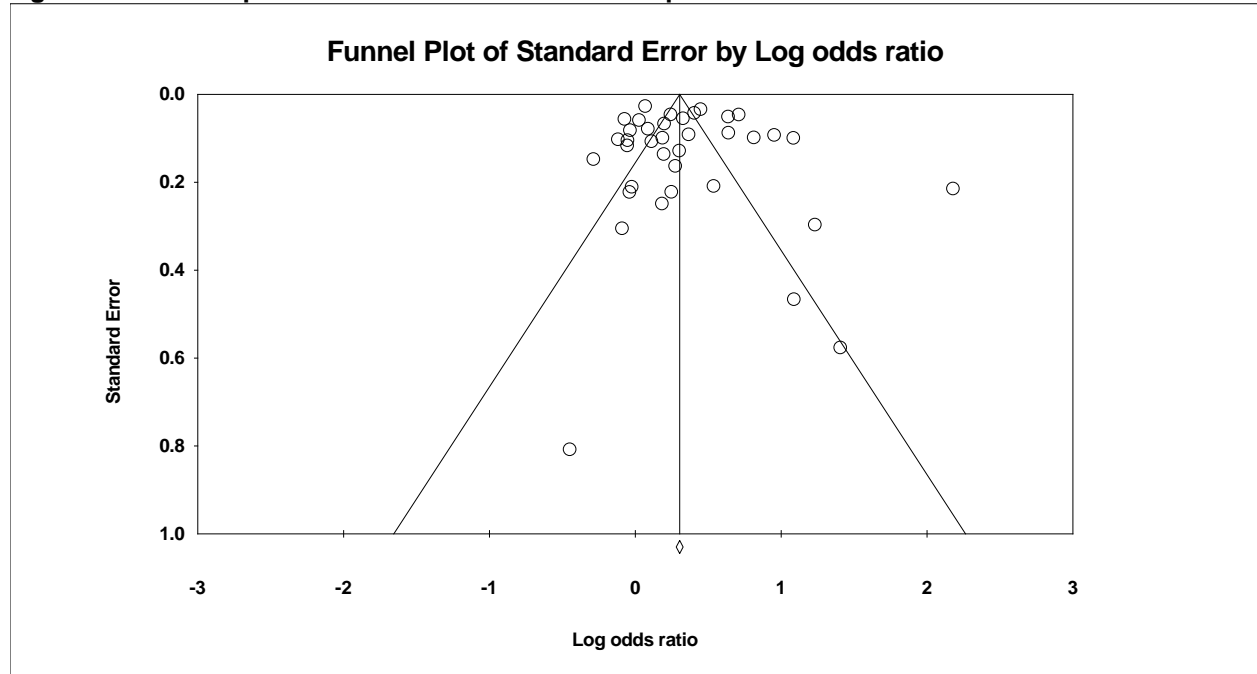


None of the studies lie outside the funnel. Begg and Mazumdar's correlation was -0.1000 (two-tailed p-value = 0.807). Egger's regression intercept was 0.086 (two-tailed p-value = 0.926). Thus, there was no evidence of publication bias in this meta-analysis.

Recommended Preventive Care Service Ordered

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of recommended preventive care service ordered. The resulting funnel plot is shown in Figure J-5.

Figure J-5. Funnel plot for studies of recommended preventive care service ordered

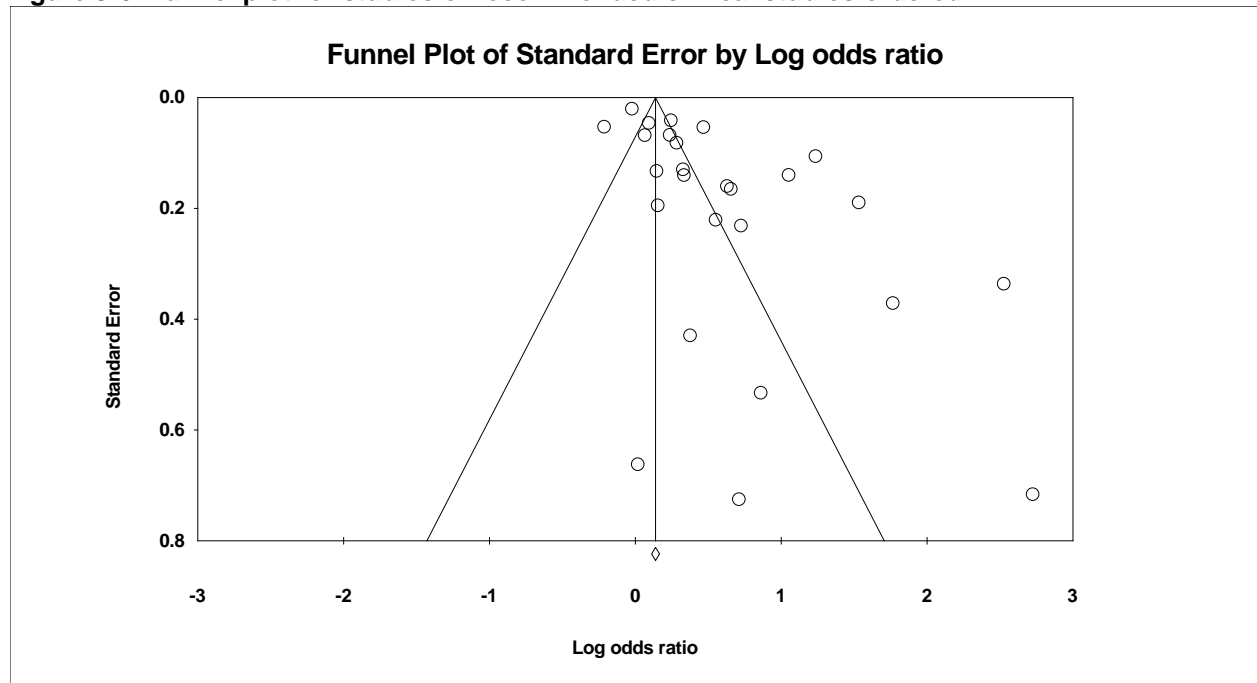


Note that eight studies lie to the left of the funnel, and nine studies lie to the right. Begg and Mazumdar's correlation was 0.071 (two-tailed p-value = 0.539). Egger's regression intercept was 0.789 (two-tailed p-value = 0.512). Thus, there was no evidence of publication bias in this meta-analysis.

Recommended Clinical Studies Ordered

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of recommended clinical studies ordered. The resulting funnel plot is shown in Figure J-6.

Figure J-6. Funnel plot for studies of recommended clinical studies ordered

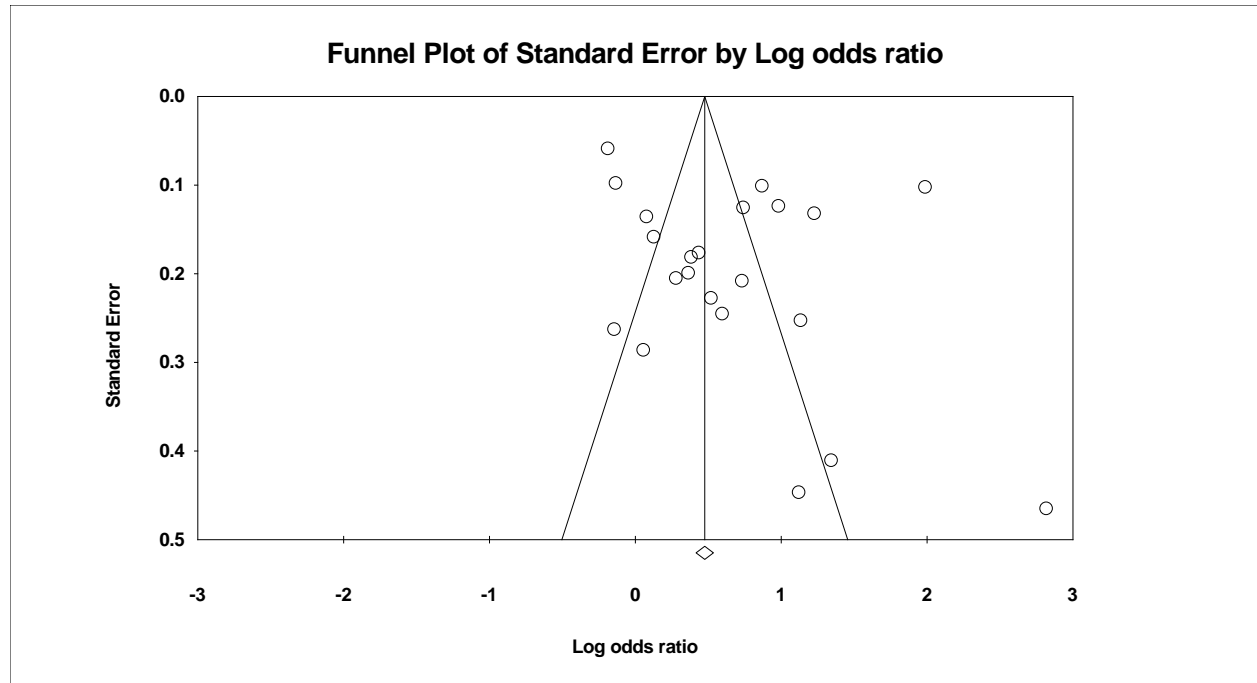


Note that two studies lie to the left of the funnel, and eleven studies lie to the right. Begg and Mazumdar's correlation test was 0.129 (two-tailed p-value = 0.354). Egger's regression intercept was 3.911 (two-tailed p-value = 0.0003). There was evidence of potential publication bias in this meta-analysis based on the funnel plot and on Egger's test, and therefore these findings should be viewed with caution.

Recommended Treatment Studies Ordered

We used Comprehensive Meta-Analysis to examine any potential publication bias in the studies of recommended treatment studies ordered. The resulting funnel plot is shown in Figure J-7.

Figure J-7. Funnel plot for studies of recommended treatment studies ordered



Note that five studies lie to the left of the funnel, and seven studies lie to the right. Begg and Mazumdar's correlation was 0.105 (two-tailed p-value = 0.296). Egger's regression intercept was 1.309 (two-tailed p-value = 0.194). Thus, there was no evidence of publication bias in this meta-analysis.

Appendix K: Summary Tables for Key Question 4

Table K-1. Types of generalized knowledge: length of stay

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Paul et al., 2006 ¹	0.9082 (0.8392 to 0.9828)							✓				✓
Overhage et al., 1997 ²	0.9307 (0.8032 to 1.078)							✓			✓	
McGregor et al., 2006 ³	0.9760 (0.7292 to 1.306)									✓		✓
Khan et al., 2010 ⁴ and Maclean et al., 2009 ⁵	0.9000 (0.811 to 0.999)							✓				✓
Roukema et al., 2008 ⁶	1.141 (0.9944 to 1.309)								✓			✓
Kline et al., 2009 ⁷	NA							✓				✓

Abbreviations: CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table K-2. Types of generalized knowledge: morbidity

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
McCowan et al., 2001 ⁸	0.4114 (0.09349 to 1.810)						✓					✓
Cavalcanti et al., 2009 ⁹	0.5006 (0.2006 to 1.249)							✓				✓
Kline et al., 2009 ⁷	0.5029 (0.2421 to 1.045)							✓				✓
Kucher et al., 2005 ¹⁰	0.6043 (0.4341 to 0.8412)							✓				✓
Zanetti et al., 2003 ¹¹	0.6211 (0.2087 to 1.848)							✓				✓
McDonald et al., 1984 ¹²	0.6889 (0.5233 to 0.9069)							✓			✓	
Khan et al., 2010 ⁴ and Maclean et al., 2009 ⁵	0.750 (0.700 to 0.803)							✓				✓
Roumie et al., 2006 ¹³	0.8343 (0.3984 to 1.747)					✓						✓
Paul et al., 2006 ¹	0.9020 (0.7293 to 1.116)							✓				✓
Ansari et al., 2003 ¹⁴	0.9262 (0.6272 to 1.368)						✓					✓
Holt et al., 2006 ¹⁵ and Holt et al., 2010 ¹⁶	0.9600 (0.848 to 1.087)						✓					✓
Graumlich et al., 2009 ¹⁷ and Graumlich et al., 2009 ¹⁸	0.9788 (0.7043 to 1.360)								✓			✓
Heidenreich et al., 2007 ¹⁹	0.9900 (0.8303 to 1.180)						✓					✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Tierney et al., 2005 ²⁰	0.9924 (0.9560 to 1.030)						✓					✓
Tierney et al., 2003 ²¹	0.9949 (0.5739 to 1.725)							✓				✓
Gilutz et al., 2009 ²²	1.006 (0.9387 to 1.079)						✓					✓
Brier et al., 2010 ²³	NA						✓					✓
Hamilton et al., 2004 ²⁴	NA								✓			✓
McDonald et al., 1992 ²⁵	NA									✓		✓
Murray et al., 2004 ²⁶	NA						✓					✓
Sequist et al., 2009 ²⁷	NA					✓						✓
Subramanian et al., 2004 ²⁸	NA							✓				✓

Abbreviations: CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table K-3. Types of generalized knowledge: mortality

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Ansari et al., 2003 ¹⁴	0.1182 (0.01598 to 0.8744)						✓					✓
Roumie et al., 2006 ¹³	0.2356 (0.06311 to 0.8794)					✓						✓
Kuperman et al., 1999 ²⁹	0.5616 (0.2344 to 1.346)								✓		✓	
Paul et al., 2006 ¹	0.9020 (0.7293 to 1.116)							✓				✓
Kucher et al., 2005 ¹⁰	1.025 (0.5710 to 1.838)							✓				✓
McGregor et al., 2006 ³	1.106 (0.7977 to 1.532)									✓		✓
Brier et al., 2010 ²³	NA						✓					✓

Abbreviations: CI = confidence interval, RR = relative risk

Table K-4. Types of generalized knowledge: adverse events

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
McGregor et al., 2006 ³	0.8592 (0.6833 to 1.080)									✓		
Graumlich et al., 2009 ¹⁷ and Graumlich et al., 2009 ¹⁸	0.9968 (0.5714 to 1.739)								✓			✓
Gurwitz et al., 2008 ³⁰	1.060 (0.9168 to 1.226)							✓			✓	
Fihn et al., 1994 ³¹	1.100 (0.5129 to 2.359)								✓			✓
Kuperman et al., 1999 ²⁹	1.197 (0.7770 to 1.843)								✓		✓	

Abbreviations: CI = confidence interval, RR = relative risk

Table K-5. Types of generalized knowledge: preventive care adherence

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
McDowell et al., 1986 ³²	8.856 (5.809 to 13.50)					✓						✓
Cannon et al., 2000 ³³	4.090 (1.320 to 12.67)						✓					✓
Taylor et al., 1999 ³⁴	3.435 (1.918 to 6.151)						✓					✓
Price et al., 2005 ³⁵	2.975 (1.191 to 7.430)						✓				✓	
Kucher et al., 2005 ¹⁰	2.965 (2.437 to 3.607)							✓				✓
McDonald et al., 1992 ²⁵	2.590 (2.157 to 3.109)									✓		✓
Dexter et al., 2001 ³⁶	2.038 (1.859 to 2.234) 1.502 (1.380 to 1.634)							✓			✓	
Frank et al., 2004 ³⁷	1.920 (1.617 to 2.279) 0.8904 (0.7277 to 1.090)								✓		✓	
Demakis et al., 2000 ³⁸	1.569 (1.466 to 1.679)							✓			✓	
Burack et al., 2003 ³⁹	1.445 (1.207 to 1.730) 0.9670 (0.8228 to 1.136)							✓				✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Litzelman et al., 1993 ⁴⁰	1.390 (1.247 to 1.549)							✓				✓
Chambers et al., 1989 ⁴¹	1.356 (1.053 to 1.745)					✓						✓
Dykes et al., 2010 ⁴²	1.318 (0.956 to 1.817)								✓			✓
Gilutz et al., 2009 ²²	1.277 (1.166 to 1.399)						✓					✓
Apkon et al., 2005 ⁴³	1.222 (1.071 to 1.394)									✓	✓	
Fretheim et al., 2006 ⁴⁴ and Fretheim et al., 2006 ⁴⁵	1.218 (0.9317 to 1.592)						✓					✓
Burack et al., 1998 ⁴⁶	1.208 (0.9940 to 1.469)							✓				✓
McDowell et al., 1989 ⁴⁷	1.204 (0.7387 to 1.963)					✓						✓
Sequist et al., 2009 ²⁷	1.073 (1.016 to 1.132)					✓						✓
Eccles et al., 2002 ⁴⁸	0.9637 (0.6225, 1.492)						✓					✓
Overhage et al., 1996 ⁴⁹	0.9486 (0.7540 to 1.193)							✓			✓	
Bertoni et al., 2009 ⁵⁰	0.9311 (0.8332 to 1.041)						✓					✓
Tierney et al., 2005 ²⁰	0.9157 (0.5030, 1.6667)						✓					✓
Dexter et al., 2004 ⁵¹	0.7524 (0.5627, 1.006)							✓				✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Unrod et al., 2007 ⁵²	0.6395 (0.1311, 3.120)						✓					✓
Burack et al., 1997 ⁵³ and Burack et al., 1994 ⁵⁴	NA							✓				✓
Fiks et al., 2009 ⁵⁵	NA					✓						✓
Flanagan et al., 1999 ⁵⁶	NA							✓				✓
Fordham et al., 1990 ⁵⁷ and McPhee et al., 1989 ⁵⁸	NA					✓					✓	
Gill et al., 2009 ⁵⁹	NA						✓					✓
Hobbs et al., 1996 ⁶⁰	NA							✓				✓
Holbrook et al., 2009 ⁶¹	NA							✓				✓
Kenealy et al., 2005 ⁶²	NA							✓				✓
Lobach et al., 1994 ⁶³	NA							✓				✓
McDonald et al., 1984 ¹²	NA							✓			✓	
Ornstein et al., 1991 ⁶⁴	NA	✓									✓	
Peterson et al., 2008 ⁶⁵	NA							✓				✓
Reeve et al., 2008 ⁶⁶	NA						✓					✓
Rosser et al., 1991 ⁶⁷	NA						✓					✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Rosser et al., 1992 ⁶⁸	NA						✓				✓	
Sequist et al., 2005 ⁶⁹	NA							✓				✓
Tierney et al., 1986 ⁷⁰	NA							✓			✓	
van Wyk et al., 2008 ⁷¹	NA						✓					✓

Abbreviations: CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table K-6. Types of generalized knowledge: clinical study adherence

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Bell et al., 2010 ⁷²	15.29 (3.75 to 62.26) 1.16 (0.89 to 1.50)						✓					✓
Lee et al., 2009 ⁷³	12.54 (6.48 to 24.26)									✓		✓
Roukema et al., 2008 ⁶	5.86 (2.83 to 12.15)								✓			✓
Mc Donald, 1976 ⁷⁴	4.64 (3.20 to 6.74)							✓			✓	
Roy et al., 2009 ⁷⁵	3.45 (2.80 to 4.25)								✓			✓
Bates et al., 1999 ⁷⁶	2.87 (2.18 to 3.78)							✓				✓
Greiver et al., 2005 ⁷⁷	2.37 (0.83 to 6.72) 2.04 (0.49 to 8.43)						✓					✓
Schriefer et al., 2009 ⁷⁸	2.07 (1.31 to 3.25)					✓						✓
McDowell et al., 1989 ⁷⁹	1.93 (1.39 to 2.66)					✓						✓
Sundaram et al., 2009 ⁸⁰	1.88 (1.37 to 2.57)					✓						✓
Raebel et al., 2005 ⁸¹	1.60 (1.44 to 1.78)							✓			✓	
Wilson et al., 2006 ⁸²	1.46 (0.63 to 3.40)							✓				✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Player et al., 2010 ⁸³	1.330 (1.13 to 1.56)						✓					✓
Raebel et al., 2006 ⁸⁴	1.28 (1.18 to 1.39)							✓				✓
Walker et al., 2010 ⁸⁵	1.270 (1.11 to 1.45)						✓					✓
Khan et al., 2010 ⁴ and Maclean et al., 2009 ⁵	1.17 (0.80 to 1.72)							✓				✓
Flottorp et al., 2002 ⁸⁶	1.10 (1.00 to 1.20) 0.81 (0.73 to 0.90)						✓					✓
Lo et al., 2009 ⁸⁷	1.07 (0.94 to 1.23)							✓			✓	
Tierney et al., 2005 ²⁰	1.02 (0.28 to 3.76)						✓					✓
Palen et al., 2006 ⁸⁸	0.98 (0.94 to 1.02)							✓			✓	
Downs et al., 2006 ⁸⁹	NA							✓				✓
Emery et al., 2007 ⁹⁰	NA						✓					✓
Feldstein et al., 2006 ⁹¹	NA							✓			✓	
Harpole et al., 1997 ⁹²	NA							✓				✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Matheny et al., 2008 ⁹³	NA							✓			✓	
Palen et al., 2010 ⁹⁴	NA						✓					✓
Stiell et al., 2009 ⁹⁵	NA	✓										✓
Tierney et al., 1987 ⁹⁶	NA								✓		✓	
van Wijk et al., 2001 ⁹⁷	NA							✓				✓

Abbreviations: CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table K-7. Types of generalized knowledge: treatment adherence

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Rossi et al., 1997 ⁹⁸	45.570 (6.635, 312.900)						✓					✓
Feldstein et al., 2006 ⁹⁹	16.78 (6.743 to 41.77)								✓			✓
Strom et al., 2010 ¹⁰⁰	8.559 (4.936 to 14.842)	✓										✓
van Wyk et al., 2008 ⁷¹	7.309 (5.979 to 8.936)						✓					✓
Vissers et al., 1996 ¹⁰¹ and Vissers et al., 1995 ¹⁰²	4.247 (1.398 to 12.90)							✓			✓	
Terrell et al., 2010 ¹⁰³	3.839 (1.716 to 8.589)							✓				✓
Krall et al., 2004 ¹⁰⁴	3.417 (2.637 to 4.428)								✓		✓	
Zanetti et al., 2003 ¹¹	3.113 (1.896 to 5.111)							✓				✓
Overhage et al., 1997 ²	3.074 (1.280, 7.380)							✓			✓	
Bell et al., 2010 ⁷²	2.675 (2.098 to 3.410) 0.8762 (0.7227 to 1.062)						✓					✓
McGregor et al., 2006 ³	2.389 (1.959 to 2.913)									✓		✓
Cobos et al., 2005 ¹⁰⁵	2.100 (1.641 to 2.686)					✓						✓
Co et al., 2010 ¹⁰⁶	2.083						✓					✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
	(1.384 to 3.133)											
Rood et al., 2005 ¹⁰⁷	1.904 (1.679 to 2.159)							✓				✓
Linder et al., 2009 ¹⁰⁸	1.864 (1.208 to 2.874)						✓					✓
McCowan et al., 2001 ⁸	1.684 (1.078 to 2.632)						✓					✓
Fretheim et al., 2006 ⁴⁴ and Fretheim et al., 2006 ⁴⁵	1.680 (1.405 to 2.010)						✓					✓
Field et al., 2009 ¹⁰⁹	1.548 (1.095 to 2.188)							✓			✓	
Paul et al., 2006 ¹	1.470 (1.030 to 2.098)							✓				✓
Tamblyn et al., 2009 ¹¹⁰	1.461 (1.162 to 1.836)									✓	✓	
Heidenreich et al., 2007 ¹⁹	1.457 (1.145 to 1.855)						✓					✓
Bourgeois et al., 2010 ¹¹¹	1.430 (1.161 to 1.761)						✓					✓
Hicks et al., 2008 ¹¹²	1.441 (0.9748 to 2.130)							✓				✓
Gill et al., 2009 ⁵⁹	1.386 (1.002 to 1.918)						✓					✓
Filippi et al., 2003 ¹¹³	1.356 (1.207 to 1.523)					✓						✓
Montgomery et al., 2000 ¹¹⁴	1.324 (0.8852 to 1.979)							✓				✓
Smith et al., 2008 ¹¹⁵	1.277							✓			✓	

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
	(0.6964 to 2.342)											
Gilutz et al., 2009 ²²	1.246 (1.137, 1.366)						✓					✓
Tamblyn et al., 2003 ¹¹⁶	1.202 (1.089 to 1.327)							✓				✓
Subramanian et al., 2004 ²⁸	1.137 (0.8335 to 1.552)							✓				✓
Strom et al., 2010 ¹¹⁷	1.160 (0.877 to 1.535)	✓										✓
Player et al., 2010 ⁸³	1.110 (0.861 to 1.431)						✓					✓
Davis et al., 2007 ¹¹⁸	1.086 (0.464, 2.541)									✓	✓	
Tierney et al., 2005 ²⁰	1.082 (0.8290 to 1.412)						✓					✓
Tierney et al., 2003 ²¹	1.059 (0.604, 1.856)							✓				✓
Bertoni et al., 2009 ⁵⁰	1.041 (0.6554 to 1.653)						✓					✓
Weir et al., 2003 ¹¹⁹	0.9843 (0.5118 to 1.893)									✓		✓
Brier et al., 2010 ²³	0.977 (0.552 to 1.729)						✓					✓
Murray et al., 2004 ²⁶	0.867 (0.518, 1.452)						✓					✓
Roumie et al., 2006 ¹³	0.844 (0.626, 1.137)					✓						✓
Raebel et al., 2007 ¹²⁰	0.8299 (0.7395 to 0.9314)							✓			✓	

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Apkon et al., 2005 ⁴³	0.7899 (0.5539 to 1.126)									✓	✓	
Locatelli et al., 2009 ¹²¹	0.7227 (0.5114 to 1.021)						✓					✓
Terrell et al., 2009 ¹²²	0.6296 (0.4672 to 0.8486)							✓			✓	
Mc Donald, 1976 ⁷⁴	0.4258 (0.2211 to 0.8203)							✓			✓	
Christakis et al., 2001 ¹²³	NA		✓									✓
Fihn et al., 1994 ³¹	NA								✓			✓
Fitzmaurice et al., 2000 ¹²⁴	NA						✓					✓
Flottorp et al., 2002 ⁸⁶	NA						✓					✓
Fortuna et al., 2009 ¹²⁵	NA							✓				✓
Goud et al., 2009 ¹²⁶	NA						✓					✓
Kuperman et al., 1999 ²⁹	NA								✓		✓	
Manotti et al., 2001 ¹²⁷	NA							✓				✓
Marco et al., 2003 ¹²⁸	NA							✓				✓
Martens et al., 2006 ¹²⁹ and Martens et al., 2007 ¹³⁰	NA							✓			✓	
Peterson et al., 2007 ¹³¹	NA							✓			✓	
Phillips et al., 2005 ¹³² and Ziemer et al., 2006 ¹³³	NA						✓				✓	

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Rothschild et al., 2007 ¹³⁴	NA							✓				✓
Samore et al., 2005 ¹³⁵	NA							✓				✓
Sequist et al., 2005 ⁶⁹	NA							✓				✓
Shojania et al., 1998 ¹³⁶	NA					✓						✓
Simon et al., 2006 ¹³⁷	NA							✓				✓
Tamblyn et al., 2008 ¹³⁸	NA				✓						✓	
Vadher et al., 1997 ¹³⁹	NA								✓			✓
Vadher et al., 1997 ¹⁴⁰	NA								✓			✓
White et al., 1984 ¹⁴¹	NA							✓				✓

Abbreviations: CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

Table K-8. Types of generalized knowledge: HCP use

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
Tambllyn et al., 2008 ¹³⁸	1.194 (1.150 to 1.241)				✓						✓	
Strom et al., 2010 ¹⁰⁰	0.12 (0.045 to 0.33)	✓										✓
Bosworth et al., 2009 ¹⁴² and Bosworth et al., 2005 ¹⁴³	NA						✓					✓
Bourgeois et al., 2010 ¹¹¹	NA						✓					✓
Del Fiol et al., 2008 ¹⁴⁴	NA									✓	✓	
Eccles et al., 2002 ⁴⁸	NA						✓					✓
Emery et al., 2007 ⁹⁰	NA						✓					✓
Filippi et al., 2003 ¹¹³	NA					✓						✓
Fortuna et al., 2009 ¹²⁵	NA							✓				✓
Hetlevik et al., 1999 ¹⁴⁵ and Hetlevik et al., 1998 ¹⁴⁶	NA						✓					✓
Hetlevik et al.,	NA						✓					✓

Study	RR (95% CI)	Primary Research	Systematic Reviews	Research Evidence Summaries	Domain Knowledge Databases	Policy Statements and Recommendations	Clinical Practice Guidelines	Structured Care Protocols	Locally Developed Knowledge	Multiple types	Broad	Targeted
2000 ¹⁴⁷												
Hobbs et al., 1996 ⁶⁰	NA							✓				✓
Linder et al., 2009 ¹⁰⁸	NA						✓					✓
Maviglia et al., 2006 ¹⁴⁸	NA									✓	✓	
Samore et al., 2005 ¹³⁵	NA							✓				✓
Sequist et al., 2005 ⁶⁹	NA					✓						✓
van Wijk et al., 2001 ⁹⁷	NA							✓				✓

Abbreviations: CI = confidence interval, NA= not available (study did not provide sufficient data to calculate common endpoint), RR = relative risk

References Cited in Appendix K

1. Paul M, Andreassen S, Tacconelli E, et al. Improving empirical antibiotic treatment using TREAT, a computerized decision support system: cluster randomized trial. *J Antimicrob Chemother* 2006;58(6):1238-45.
2. Overhage JM, Tierney WM, Zhou XH, et al. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc* 1997;4(5):364-75.
3. McGregor JC, Weekes E, Forrest GN, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. *J Am Med Inform Assoc* 2006;13(4):378-84.
4. Khan S, Maclean CD, Littenberg B. The effect of the Vermont Diabetes Information System on inpatient and emergency room use: results from a randomized trial. *Health Outcomes Res Med* 2010;1(1):e61-e66.
5. Maclean CD, Gagnon M, Callas P, et al. The vermont diabetes information system: a cluster randomized trial of a population based decision support system. *J Gen Intern Med* 2009;24(12):1303-10.
6. Roukema J, Steyerberg EW, van der Lei J, et al. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. *J Am Med Inform Assoc* 2008;15(1):107-13.
7. Kline JA, Zeitouni RA, Hernandez-Nino J, et al. Randomized trial of computerized quantitative pretest probability in low-risk chest pain patients: effect on safety and resource use. *Ann Emerg Med* 2009;53(6):727-35 e1.
8. McCowan C, Neville RG, Ricketts IW, et al. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. *Med Inform Internet Med* 2001;26(3):191-201.
9. Cavalcanti AB, Silva E, Pereira AJ, et al. A randomized controlled trial comparing a computer-assisted insulin infusion protocol with a strict and a conventional protocol for glucose control in critically ill patients. *J Crit Care* 2009;24(3):371-8.
10. Kucher N, Koo S, Quiroz R, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. *N Engl J Med* 2005;352(10):969-77.
11. Zanetti G, Flanagan HL, Jr., Cohn LH, et al. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. *Infect Control Hosp Epidemiol* 2003;24(1):13-6.
12. McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. *Ann Intern Med* 1984;100(1):130-8.
13. Roumie CL, Elasy TA, Greevy R, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. *Ann Intern Med* 2006;145(3):165-75.
14. Ansari M, Shlipak MG, Heidenreich PA, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. *Circulation* 2003;107(22):2799-804.
15. Holt TA, Thorogood M, Griffiths F, et al. Protocol for the 'e-Nudge trial': a randomised controlled trial of electronic feedback to reduce the cardiovascular risk of individuals in general practice [ISRCTN64828380]. *Trials* 2006;7:11.
16. Holt TA, Thorogood M, Griffiths F, et al. Automated electronic reminders to facilitate primary cardiovascular disease prevention: randomised controlled trial. *Br J Gen Pract* 2010;60(573):e137-43.

17. Graumlich JF, Novotny NL, Nace GS, et al. Patient and physician perceptions after software-assisted hospital discharge: cluster randomized trial. *J Hosp Med* 2009;4(6):356-63.
18. Graumlich JF, Novotny NL, Nace GS, et al. Patient readmissions, emergency visits, and adverse events after software-assisted discharge from hospital: cluster randomized trial. *J Hosp Med* 2009;4(7):E11-9.
19. Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115(22):2829-34.
20. Tierney WM, Overhage JM, Murray MD, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. *Health Serv Res* 2005;40(2):477-97.
21. Tierney WM, Overhage JM, Murray MD, et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med* 2003;18(12):967-76.
22. Gilutz H, Novack L, Shvartzman P, et al. Computerized community cholesterol control (4C): meeting the challenge of secondary prevention. *Isr Med Assoc J* 2009;11(1):23-9.
23. Brier ME, Gaweda AE, Dailey A, et al. Randomized trial of model predictive control for improved anemia management. *Clin J Am Soc Nephrol* 2010;5(5):814-20.
24. Hamilton E, Platt R, Gauthier R, et al. The effect of computer-assisted evaluation of labor on cesarean rates. *J Healthc Qual* 2004;26(1):37-44.
25. McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. *MD Comput* 1992;9(5):304-12.
26. Murray MD, Harris LE, Overhage JM, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. *Pharmacotherapy* 2004;24(3):324-37.
27. Sequist TD, Zaslavsky AM, Marshall R, et al. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Arch Intern Med* 2009;169(4):364-71.
28. Subramanian U, Fihn SD, Weinberger M, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. *Am J Med* 2004;116(6):375-84.
29. Kuperman GJ, Teich JM, Tanasijevic MJ, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. *J Am Med Inform Assoc* 1999;6(6):512-22.
30. Gurwitz JH, Field TS, Rochon P, et al. Effect of computerized provider order entry with clinical decision support on adverse drug events in the long-term care setting. *J Am Geriatr Soc* 2008;56(12):2225-33.
31. Fihn SD, McDonnell MB, Vermes D, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. *J Gen Intern Med* 1994;9(3):131-9.
32. McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. *CMAJ* 1986;135(9):991-7.
33. Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. *J Am Med Inform Assoc* 2000;7(2):196-203.
34. Taylor V, Thompson B, Lessler D, et al. A clinic-based mammography intervention targeting inner-city women. *J Gen Intern Med* 1999;14(2):104-11.
35. Price M. Can hand-held computers improve adherence to guidelines? A (Palm) Pilot study of family doctors in British Columbia. *Can Fam Physician* 2005;51:1506-7.
36. Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med* 2001;345(13):965-70.

37. Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. *Aust Fam Physician* 2004;33(1-2):87-90.
38. Demakis JG, Beauchamp C, Cull WL, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. *JAMA* 2000;284(11):1411-6.
39. Burack RC, Gimotty PA, Simon M, et al. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. *Prev Med* 2003;36(5):547-54.
40. Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med* 1993;8(6):311-7.
41. Chambers CV, Balaban DJ, Carlson BL, et al. Microcomputer-generated reminders. Improving the compliance of primary care physicians with mammography screening guidelines. *J Fam Pract* 1989;29(3):273-80.
42. Dykes PC, Carroll DL, Hurley A, et al. Fall Prevention in Acute Care Hospitals A Randomized Trial. *Jama-Journal of the American Medical Association* 2010;304(17):1912-1918.
43. Apkon M, Mattera JA, Lin Z, et al. A randomized outpatient trial of a decision-support information technology tool. *Arch Intern Med* 2005;165(20):2388-94.
44. Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. *PLoS Med* 2006;3(6):e216.
45. Fretheim A, Oxman AD, Havelsrud K, et al. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. *PLoS Med* 2006;3(6):e134.
46. Burack RC, Gimotty PA, George J, et al. How reminders given to patients and physicians affected pap smear use in a health maintenance organization: results of a randomized controlled trial. *Cancer* 1998;82(12):2391-400.
47. McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. *J Fam Pract* 1989;28(4):420-4.
48. Eccles M, McColl E, Steen N, et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ* 2002;325(7370):941.
49. Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. *Arch Intern Med* 1996;156(14):1551-6.
50. Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med* 2009;169(7):678-86.
51. Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA* 2004;292(19):2366-71.
52. Unrod M, Smith M, Spring B, et al. Randomized controlled trial of a computer-based, tailored intervention to increase smoking cessation counseling by primary care physicians. *J Gen Intern Med* 2007;22(4):478-84.
53. Burack RC, Gimotty PA. Promoting screening mammography in inner-city settings. The sustained effectiveness of computerized reminders in a randomized controlled trial. *Med Care* 1997;35(9):921-31.
54. Burack RC, Gimotty PA, George J, et al. Promoting screening mammography in inner-city settings: a randomized controlled trial of computerized reminders as a component of a program to facilitate mammography. *Med Care* 1994;32(6):609-24.
55. Fiks AG, Hunter KF, Localio AR, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009;124(1):159-69.

56. Flanagan JR, Doebbeling BN, Dawson J, et al. Randomized study of online vaccine reminders in adult primary care. *Proc Amia Symp* 1999;755-9.
57. Fordham D, McPhee SJ, Bird JA, et al. The Cancer Prevention Reminder System. *MD Comput* 1990;7(5):289-95.
58. McPhee SJ, Bird JA, Jenkins CN, et al. Promoting cancer screening. A randomized, controlled trial of three interventions. *Arch Intern Med* 1989;149(8):1866-72.
59. Gill JM, Chen YX, Glutting JJ, et al. Impact of decision support in electronic medical records on lipid management in primary care. *Popul Health Manag* 2009;12(5):221-6.
60. Hobbs FD, Delaney BC, Carson A, et al. A prospective controlled trial of computerized decision support for lipid management in primary care. *Fam Pract* 1996;13(2):133-7.
61. Holbrook A, Thabane L, Keshavjee K, et al. Individualized electronic decision support and reminders to improve diabetes care in the community: COMPETE II randomized trial. *CMAJ* 2009;181(1-2):37-44.
62. Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. *J Gen Intern Med* 2005;20(10):916-21.
63. Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. *Proc Annu Symp Comput Appl Med Care* 1994:787-91.
64. Ornstein SM, Garr DR, Jenkins RG, et al. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. *J Fam Pract* 1991;32(1):82-90.
65. Peterson KA, Radosevich DM, O'Connor PJ, et al. Improving Diabetes Care in Practice: findings from the TRANSLATE trial. *Diabetes Care* 2008;31(12):2238-43.
66. Reeve JF, Tenni PC, Peterson GM. An electronic prompt in dispensing software to promote clinical interventions by community pharmacists: a randomized controlled trial. *Br J Clin Pharmacol* 2008;65(3):377-85.
67. Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. *CMAJ* 1991;145(7):807-14.
68. Rosser WW, Hutchison BG, McDowell I, et al. Use of reminders to increase compliance with tetanus booster vaccination. *CMAJ* 1992;146(6):911-7.
69. Sequist TD, Gandhi TK, Karson AS, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. *J Am Med Inform Assoc* 2005;12(4):431-7.
70. Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care* 1986;24(8):659-66.
71. van Wyk JT, van Wijk MA, Sturkenboom MC, et al. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation* 2008;117(3):371-8.
72. Bell LM, Grundmeier R, Localio R, et al. Electronic Health Record-Based Decision Support to Improve Asthma Care: A Cluster-Randomized Trial. *Pediatrics* 2010;125(4):E770-E777.
73. Lee NJ, Chen ES, Currie LM, et al. The effect of a mobile clinical decision support system on the diagnosis of obesity and overweight in acute and primary care encounters. *ANS Adv Nurs Sci* 2009;32(3):211-21.
74. Mc Donald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med* 1976;84(2):162-7.
75. Roy PM, Durieux P, Gillaizeau F, et al. A computerized handheld decision-support system to improve pulmonary embolism diagnosis: a randomized trial. *Ann Intern Med* 2009;151(10):677-86.
76. Bates DW, Kuperman GJ, Rittenberg E, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. *Am J Med* 1999;106(2):144-50.

77. Greiver M, Drummond N, White D, et al. Angina on the Palm: randomized controlled pilot trial of Palm PDA software for referrals for cardiac testing. *Can Fam Physician* 2005;51:382-3.
78. Schriefer SP, Landis SE, Turbow DJ, et al. Effect of a computerized body mass index prompt on diagnosis and treatment of adult obesity. *Fam Med* 2009;41(7):502-7.
79. McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. *Med Care* 1989;27(3):297-305.
80. Sundaram V, Lazzaroni LC, Douglass LR, et al. A randomized trial of computer-based reminders and audit and feedback to improve HIV screening in a primary care setting. *Int J STD AIDS* 2009;20(8):527-33.
81. Raebel MA, Lyons EE, Chester EA, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. *Arch Intern Med* 2005;165(20):2395-401.
82. Wilson BJ, Torrance N, Mollison J, et al. Cluster randomized trial of a multifaceted primary care decision-support intervention for inherited breast cancer risk. *Fam Pract* 2006;23(5):537-44.
83. Player MS, Gill JM, Mainous AG, 3rd, et al. An electronic medical record-based intervention to improve quality of care for gastro-esophageal reflux disease (GERD) and atypical presentations of GERD. *Qual Prim Care* 2010;18(4):223-9.
84. Raebel MA, Chester EA, Newsom EE, et al. Randomized trial to improve laboratory safety monitoring of ongoing drug therapy in ambulatory patients. *Pharmacotherapy* 2006;26(5):619-26.
85. Walker J, Fairley CK, Walker SM, et al. Computer reminders for Chlamydia screening in general practice: a randomized controlled trial. *Sex Transm Dis* 2010;37(7):445-50.
86. Flottorp S, Oxman AD, Havelsrud K, et al. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. *BMJ* 2002;325(7360):367.
87. Lo HG, Matheny ME, Seger DL, et al. Impact of non-interruptive medication laboratory monitoring alerts in ambulatory care. *J Am Med Inform Assoc* 2009;16(1):66-71.
88. Palen TE, Raebel M, Lyons E, et al. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. *Am J Manag Care* 2006;12(7):389-95.
89. Downs M, Turner S, Bryans M, et al. Effectiveness of educational interventions in improving detection and management of dementia in primary care: cluster randomised controlled study. *BMJ* 2006;332(7543):692-6.
90. Emery J, Morris H, Goodchild R, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. *Br J Cancer* 2007;97(4):486-93.
91. Feldstein AC, Smith DH, Perrin N, et al. Improved therapeutic monitoring with several interventions: a randomized trial. *Arch Intern Med* 2006;166(17):1848-54.
92. Harpole LH, Khorasani R, Fiskio J, et al. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. *J Am Med Inform Assoc* 1997;4(6):511-21.
93. Matheny ME, Sequist TD, Seger AC, et al. A randomized trial of electronic clinical reminders to improve medication laboratory monitoring. *J Am Med Inform Assoc* 2008;15(4):424-9.
94. Palen TE, Price DW, Snyder AJ, et al. Computerized alert reduced D-dimer testing in the elderly. *Am J Manag Care* 2010;16(11):e267-75.
95. Stiell IG, Clement CM, Grimshaw J, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *BMJ* 2009;339:b4146.
96. Tierney WM, McDonald CJ, Martin DK, et al. Computerized display of past test results. Effect on outpatient testing. *Ann Intern Med* 1987;107(4):569-74.

97. van Wijk MA, van der Lei J, Mosseveld M, et al. Assessment of decision support for blood test ordering in primary care. a randomized trial. *Ann Intern Med* 2001;134(4):274-81.
98. Rossi RA, Every NR. A computerized intervention to decrease the use of calcium channel blockers in hypertension. *J Gen Intern Med* 1997;12(11):672-8.
99. Feldstein A, Elmer PJ, Smith DH, et al. Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. *J Am Geriatr Soc* 2006;54(3):450-7.
100. Strom BL, Schinnar R, Abera F, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med* 2010;170(17):1578-83.
101. Vissers MC, Biert J, van der Linden CJ, et al. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. *Comput Methods Programs Biomed* 1996;49(2):177-84.
102. Vissers MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. *Comput Methods Programs Biomed* 1995;48(1-2):53-8.
103. Terrell KM, Perkins AJ, Hui SL, et al. Computerized decision support for medication dosing in renal insufficiency: a randomized, controlled trial. *Ann Emerg Med* 2010;56(6):623-9.
104. Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. *Stud Health Technol Inform* 2004;107(Pt 1):135-9.
105. Cobos A, Vilaseca J, Asenjo C, et al. Cost effectiveness of a clinical decision support system based on the recommendations of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Disease Management & Health Outcomes* 2005;13(6):421-432.
106. Co JP, Johnson SA, Poon EG, et al. Electronic health record decision support and quality of care for children with ADHD. *Pediatrics* 2010;126(2):239-46.
107. Rood E, Bosman RJ, van der Spoel JJ, et al. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. *J Am Med Inform Assoc* 2005;12(2):172-80.
108. Linder JA, Rigotti NA, Schneider LI, et al. An electronic health record-based intervention to improve tobacco treatment in primary care: a cluster-randomized controlled trial. *Arch Intern Med* 2009;169(8):781-7.
109. Field TS, Rochon P, Lee M, et al. Computerized clinical decision support during medication ordering for long-term care residents with renal insufficiency. *J Am Med Inform Assoc* 2009;16(4):480-5.
110. Tamblyn R, Reidel K, Huang A, et al. Increasing the Detection and Response to Adherence Problems with Cardiovascular Medication in Primary Care through Computerized Drug Management Systems: A Randomized Controlled Trial. *Med Decis Making* 2009.
111. Bourgeois FC, Linder J, Johnson SA, et al. Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clin Pediatr (Phila)* 2010;49(10):976-83.
112. Hicks LS, Sequist TD, Ayanian JZ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. *J Gen Intern Med* 2008;23(4):429-41.
113. Filippi A, Sabatini A, Badioli L, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. *Diabetes Care* 2003;26(5):1497-500.
114. Montgomery AA, Fahey T, Peters TJ, et al. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. *BMJ* 2000;320(7236):686-90.

115. Smith SA, Shah ND, Bryant SC, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83(7):747-57.
116. Tamblyn R, Huang A, Perreault R, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. *CMAJ* 2003;169(6):549-56.
117. Strom BL, Schinnar R, Bilker W, et al. Randomized clinical trial of a customized electronic alert requiring an affirmative response compared to a control group receiving a commercial passive CPOE alert: NSAID--warfarin co-prescribing as a test case. *J Am Med Inform Assoc* 2010;17(4):411-5.
118. Davis RL, Wright J, Chalmers F, et al. A cluster randomized clinical trial to improve prescribing patterns in ambulatory pediatrics. *PLoS Clin Trials* 2007;2(5):e25.
119. Weir CJ, Lees KR, MacWalter RS, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. *QJM* 2003;96(2):143-53.
120. Raebel MA, Charles J, Dugan J, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. *J Am Geriatr Soc* 2007;55(7):977-85.
121. Locatelli F, Covic A, Macdougall IC, et al. Effect of computer-assisted European Best Practice Guideline implementation on adherence and target attainment: ORAMA results. *J Nephrol* 2009;22(5):662-74.
122. Terrell KM, Perkins AJ, Dexter PR, et al. Computerized decision support to reduce potentially inappropriate prescribing to older emergency department patients: a randomized, controlled trial. *J Am Geriatr Soc* 2009;57(8):1388-94.
123. Christakis DA, Zimmerman FJ, Wright JA, et al. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics* 2001;107(2):E15.
124. Fitzmaurice DA, Hobbs FD, Murray ET, et al. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. *Arch Intern Med* 2000;160(15):2343-8.
125. Fortuna RJ, Zhang F, Ross-Degnan D, et al. Reducing the prescribing of heavily marketed medications: a randomized controlled trial. *J Gen Intern Med* 2009;24(8):897-903.
126. Goud R, de Keizer NF, ter Riet G, et al. Effect of guideline based computerised decision support on decision making of multidisciplinary teams: cluster randomised trial in cardiac rehabilitation. *BMJ* 2009;338:b1440.
127. Manotti C, Moia M, Palareti G, et al. Effect of computer-aided management on the quality of treatment in anticoagulated patients: a prospective, randomized, multicenter trial of APROAT (Automated PProgram for Oral Anticoagulant Treatment). *Haematologica* 2001;86(10):1060-70.
128. Marco F, Sedano C, Bermudez A, et al. A prospective controlled study of a computer-assisted acenocoumarol dosage program. *Pathophysiol Haemost Thromb* 2003;33(2):59-63.
129. Martens JD, van der Aa A, Panis B, et al. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. *Stud Health Technol Inform* 2006;124:617-23.
130. Martens JD, van der Weijden T, Severens JL, et al. The effect of computer reminders on GPs' prescribing behaviour: a cluster-randomised trial. *Int J Med Inform* 2007;76 Suppl 3:S403-16.
131. Peterson JF, Rosenbaum BP, Waitman LR, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. *Stud Health Technol Inform* 2007;129(Pt 2):1037-40.

132. Phillips LS, Ziemer DC, Doyle JP, et al. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. *Diabetes Care* 2005;28(10):2352-60.
133. Ziemer DC, Doyle JP, Barnes CS, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting: Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. *Arch Intern Med* 2006;166(5):507-13.
134. Rothschild JM, McGurk S, Honour M, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. *Transfusion (Paris)* 2007;47(2):228-39.
135. Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA* 2005;294(18):2305-14.
136. Shojania KG, Yokoe D, Platt R, et al. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial. *J Am Med Inform Assoc* 1998;5(6):554-62.
137. Simon SR, Smith DH, Feldstein AC, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. *J Am Geriatr Soc* 2006;54(6):963-968.
138. Tamblyn R, Huang A, Taylor L, et al. A randomized trial of the effectiveness of on-demand versus computer-triggered drug decision support in primary care. *J Am Med Inform Assoc* 2008;15(4):430-8.
139. Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. *Clin Lab Haematol* 1997;19(3):203-7.
140. Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. *BMJ* 1997;314(7089):1252-6.
141. White KS, Lindsay A, Pryor TA, et al. Application of a computerized medical decision-making process to the problem of digoxin intoxication. *J Am Coll Cardiol* 1984;4(3):571-6.
142. Bosworth HB, Olsen MK, Dudley T, et al. Patient education and provider decision support to control blood pressure in primary care: a cluster randomized trial. *Am Heart J* 2009;157(3):450-6.
143. Bosworth HB, Olsen MK, Goldstein MK, et al. The veterans' study to improve the control of hypertension (V-STITCH): design and methodology. *Contemp Clin Trials* 2005;26(2):155-68.
144. Del Fiol G, Haug PJ, Cimino JJ, et al. Effectiveness of topic-specific infobuttons: a randomized controlled trial. *J Am Med Inform Assoc* 2008;15(6):752-9.
145. Hetlevik I, Holmen J, Kruger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. *Scand J Prim Health Care* 1999;17(1):35-40.
146. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of hypertension in general practice. *Blood Press* 1998;7(5-6):270-6.
147. Hetlevik I, Holmen J, Kruger O, et al. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. *Int J Technol Assess Health Care* 2000;16(1):210-27.
148. Maviglia SM, Yoon CS, Bates DW, et al. KnowledgeLink: impact of context-sensitive information retrieval on clinicians' information needs. *J Am Med Inform Assoc* 2006;13(1):67-73.