Evidence Report/Technology Assessment
Number 203

Enabling Health Care Decisionmaking Through Clinical Decision Support and Knowledge Management

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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. Osheroff, 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 of 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.

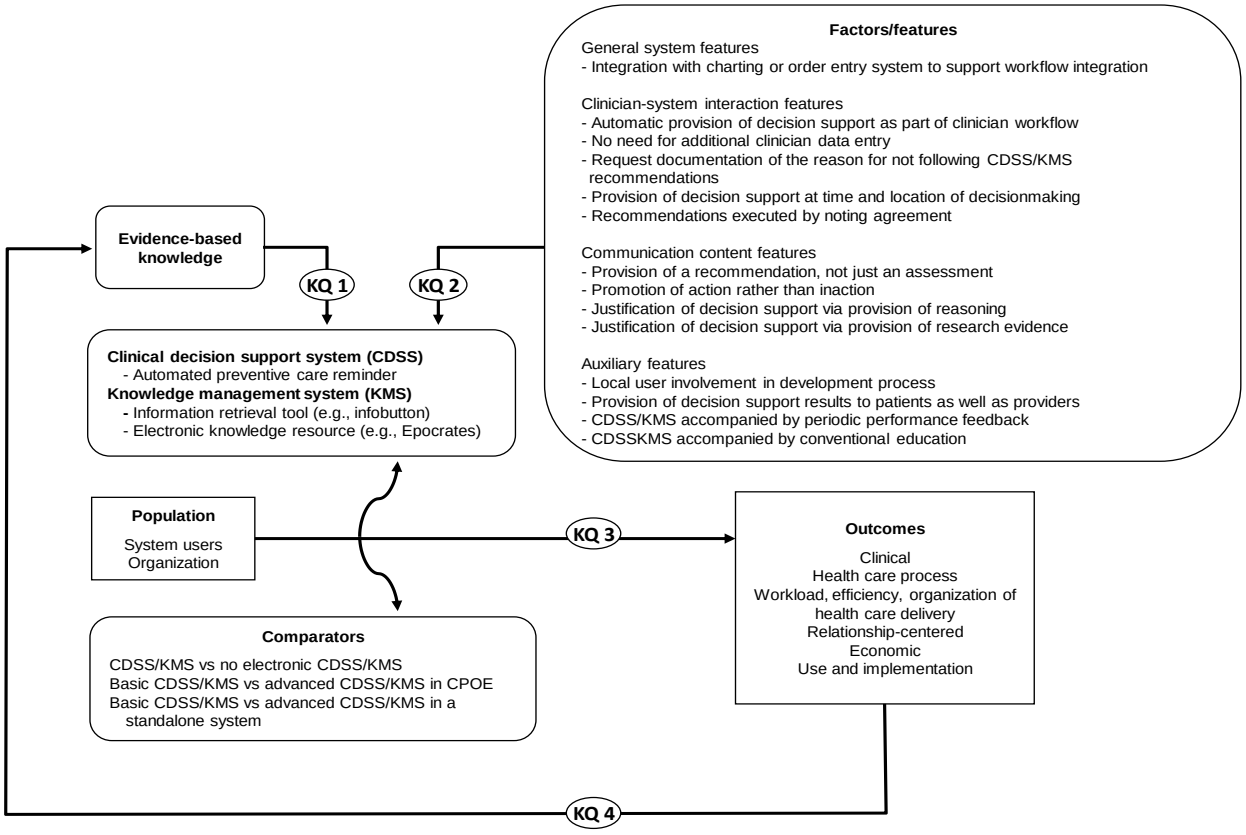
The goals of this report were to summarize the available evidence related to CDSSs and KMSs, highlight the limitations of the evidence, and identify areas for future research. The key questions (KQs) considered in this systematic review were:

- **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.

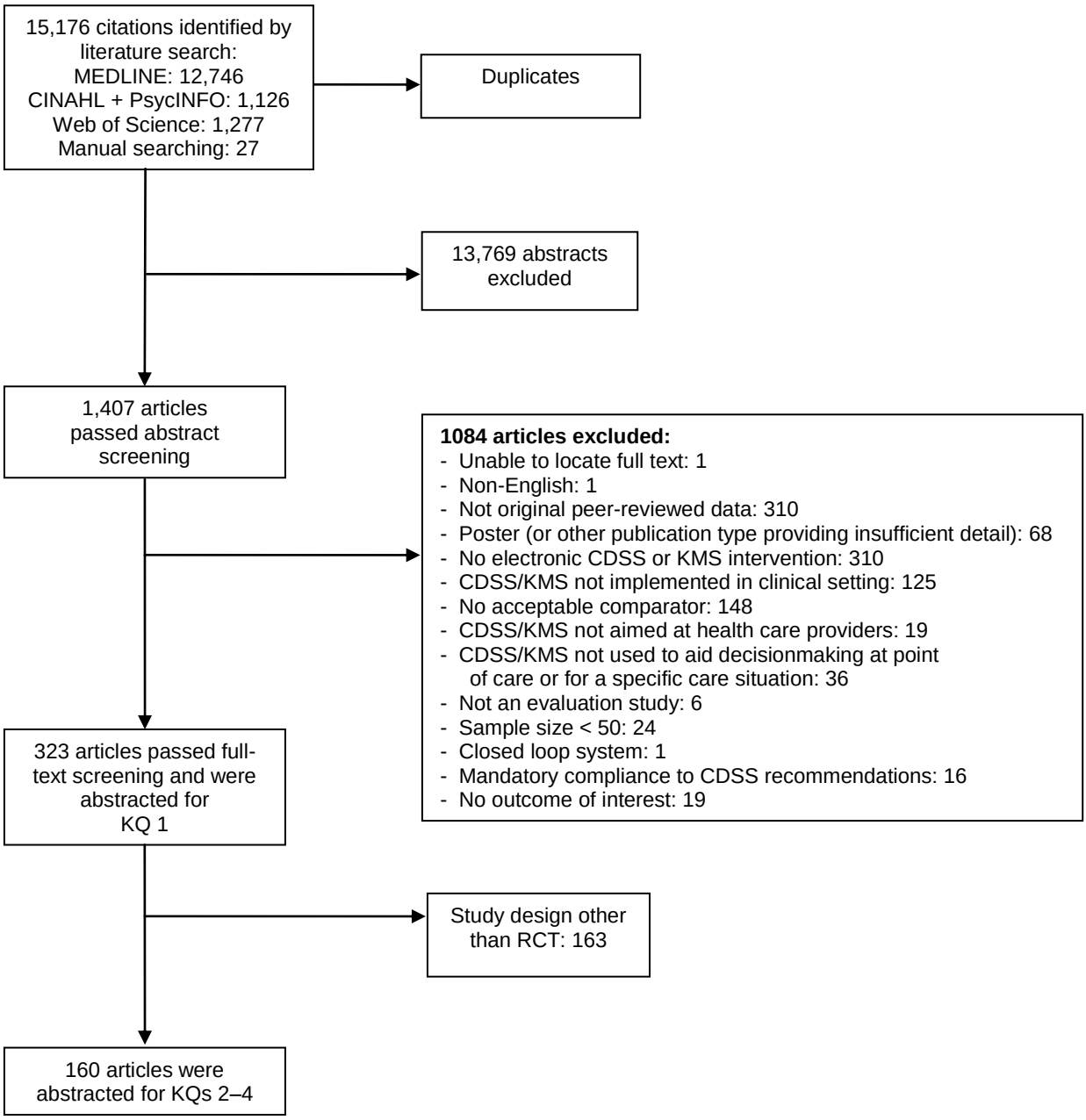
The included studies were assessed on the basis of the quality of their reporting of relevant data. We evaluated the quality of individual studies using the approach described in AHRQ's *Methods Guide for Effectiveness and Comparative Effectiveness Reviews*. To assess methodological quality, we employed 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	• 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:
		  ○ 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	• 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: o *Automatic provision of decision support as part of clinician workflow* (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. o *Provision of decision support at time and location of decisionmaking* (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. o *Provision of a recommendation, not just an assessment* (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)		• The meta-analysis also identified 6 additional factors/features that were correlated with the success of CDSSs: ○ *Integration with charting or order entry system to support workflow integration* (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. ○ *No need for additional clinician data entry* (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. ○ *Promotion of action rather than inaction* (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. ○ *Justification of decision support via provision of research evidence* (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. ○ *Local user involvement in development process* (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. ○ *Provision of decision support results to patients as well as providers* (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
		• 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	• 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	• Of the eligible studies, none examined the impact of CDSSs/KMSs on the number of patients seen/unit time.
Clinician workload	Insufficient	• Of the eligible studies, none examined the impact of CDSSs/KMSs on clinician workload.
Efficiency	Low	• 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		
Health care process measures		
Recommended preventive care service ordered/completed	High	• 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
		• 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	• 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	• 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	• 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.
Clinical outcomes		
Length of stay	Low	• 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	• 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	• 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	• 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	• 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.
Economic outcomes		
Cost	Moderate	• 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	• 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.
Use and implementation outcomes		
Health care provider acceptance	Low	• 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	• 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	• 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	• 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	• 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.
		• There is insufficient evidence for how CDSSs/KMSs impacted implementation in practice, and no high-quality studies specifically examined this outcome.
Relationship-centered outcomes		
Patient satisfaction	Insufficient	• 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	• 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. This set of studies included 56 good-quality, 33 fair-quality, and 15 poor-quality studies.
4b. How a clinician's expertise/proficiency/informatics competency using the electronic knowledge management and	Not applicable	• 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	• 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)		• 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 care[6] 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 of for a specific care situation. An example of an information retrieval tool is an infobutton 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.

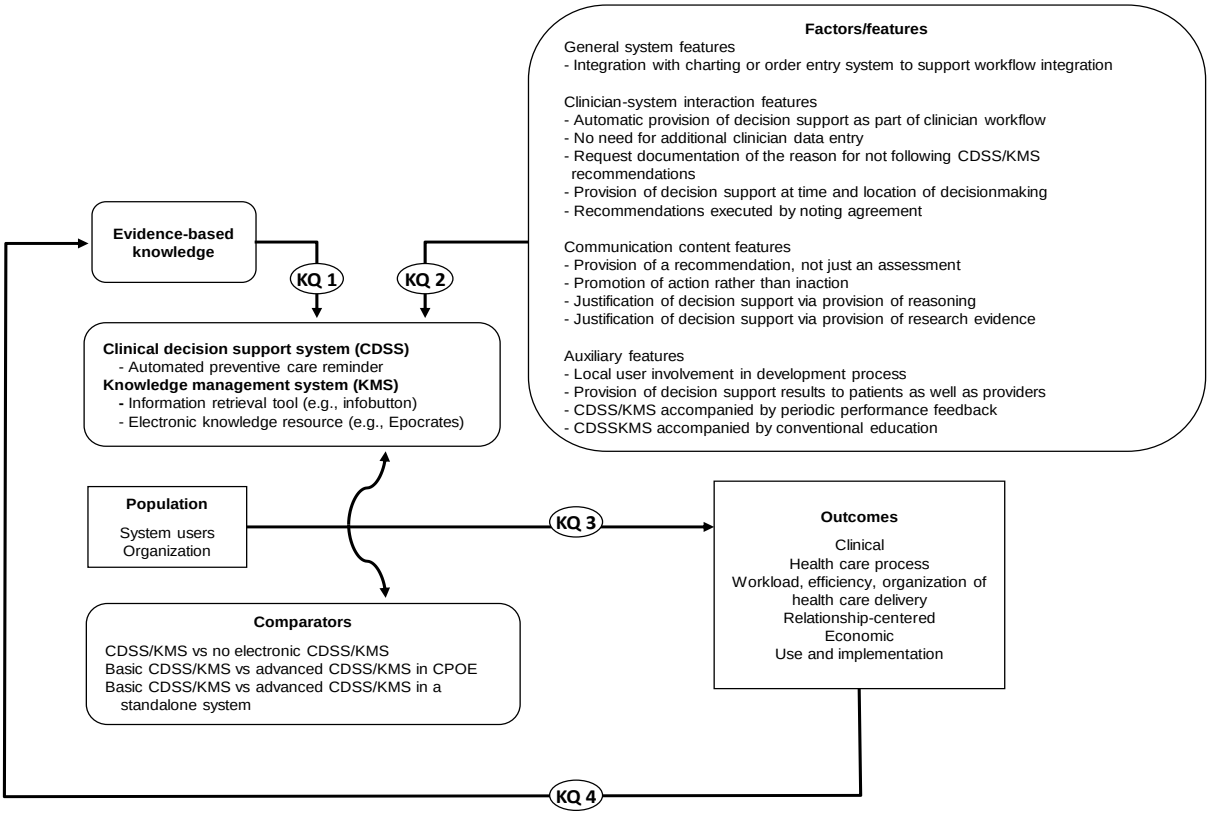
A **knowledge resource** is defined as an electronic resource comprising distilled primary literature that allows selection of content that is germane to a specific patient in order to facilitate decisionmaking at the point of care or for a specific care situation. Examples of knowledge resources include 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)	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

Table 3. Factors and features of CDSS/KMS interventions

Source/origin of system
- Locally developed
- Commercially available

Content
- Objective of the intervention:
  - Diagnosis
  - Immunization
  - Pharmacotherapy
  - Lab test ordering
  - Chronic disease management
  - Initiating discussion with patient
  - Preventive care
- Relationship to point of care:
  - Synchronous
  - Asynchronous

Decision support
- Response requirement:
  - 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:
  - Online access
  - Integrated with CPOE or EHR system
  - Standalone system
  - Paper-based
- Delivery mode:
  - System-initiated (“push”)
  - User-initiated (“pull”)

Contextual factors/features influencing the use and implementation of CDSSs/KMSs
- General system features:
  - Integration with charting or order entry system to support workflow integration
- 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 decisionmaking
  - Recommendations executed by noting agreement
- Communication content features:
  - 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
- 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

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

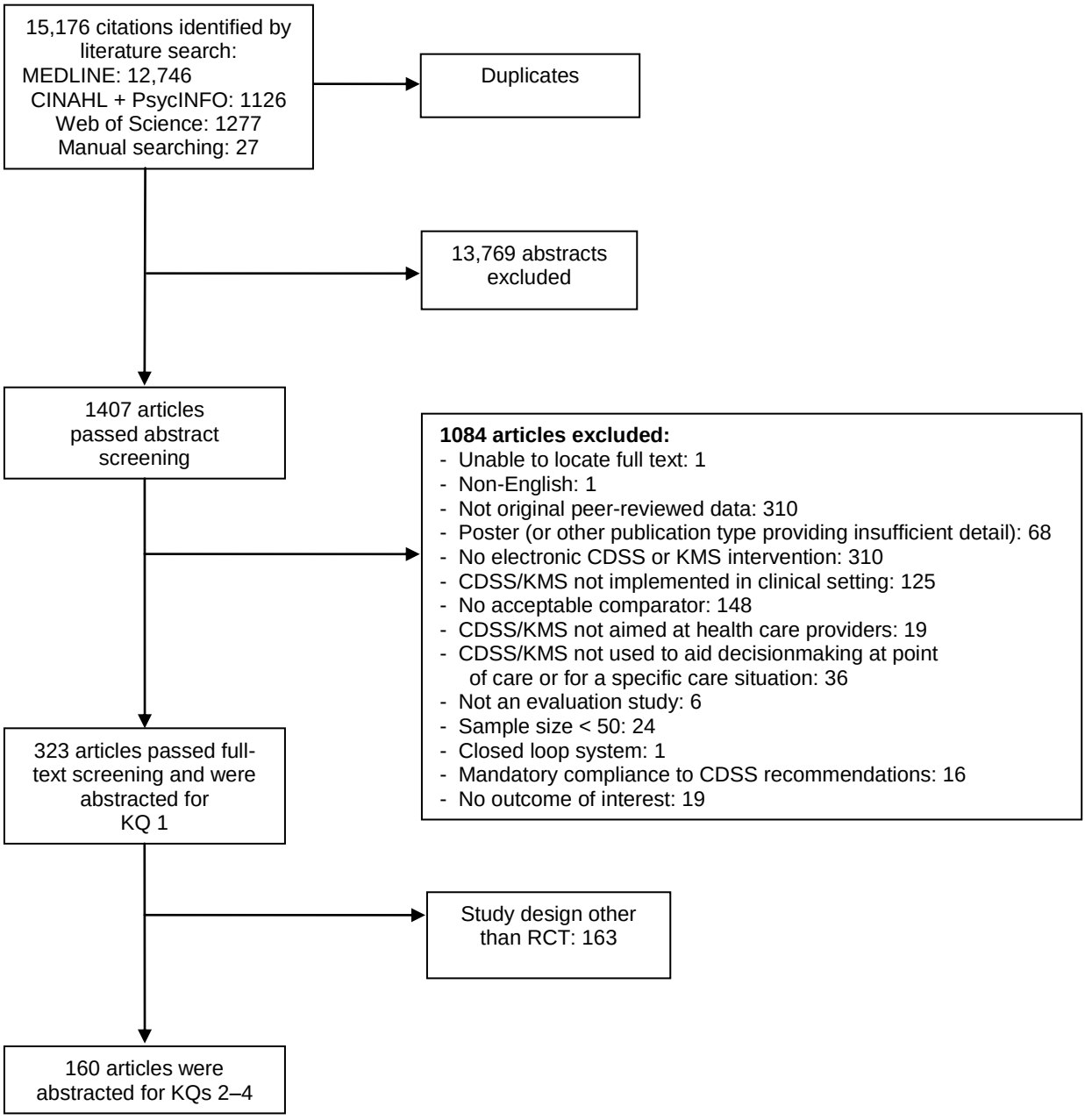
Our principal external quality-monitoring device was the peer review process. Nominations for peer reviewers were solicited from several sources, including the TEP and interested Federal agencies. The list of nominees was forwarded to AHRQ for vetting and approval. A list of peer reviewers submitting 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 review[9] 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 workflow[20-24]
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 system[21]
- One included no need for additional data entry[21]
- One included promotion of action rather than inaction[21]
- 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 decisionmaking[20]
- 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 inaction[20]
- One included justification of decision support via provision of research evidence[24]
- One included a CDSS accompanied by conventional education[20]

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 2005[9] 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 recommendations[60]
- 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 providers[84]
- 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 recommendations[48]
- 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

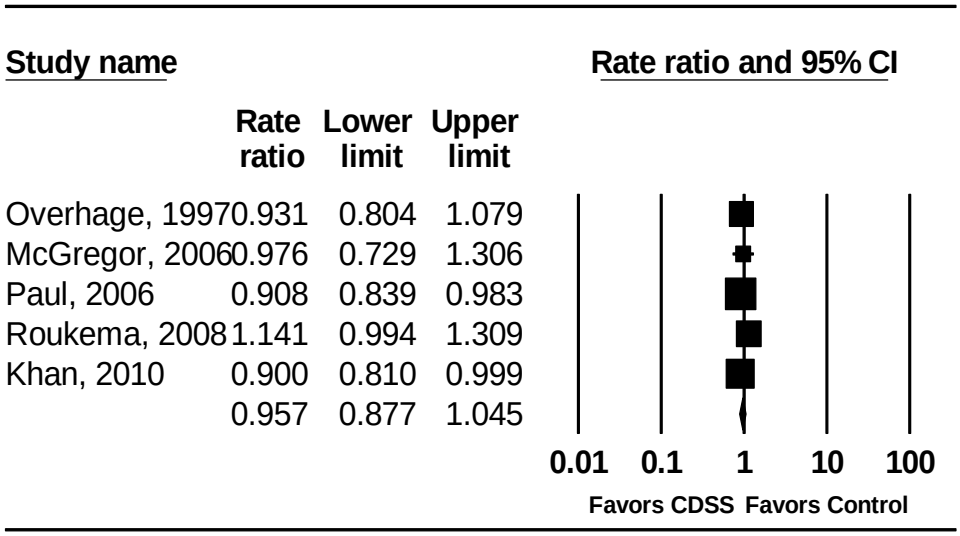
Length of stay. We identified 6 of the 148 eligible studies (4.1%) that specifically examined the impact of CDSSs/KMSs on length of stay. These studies are summarized in Table I-1 of Appendix I.

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 weeks[30] 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 study[34] 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 (25^{th} to 75^{th} 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.

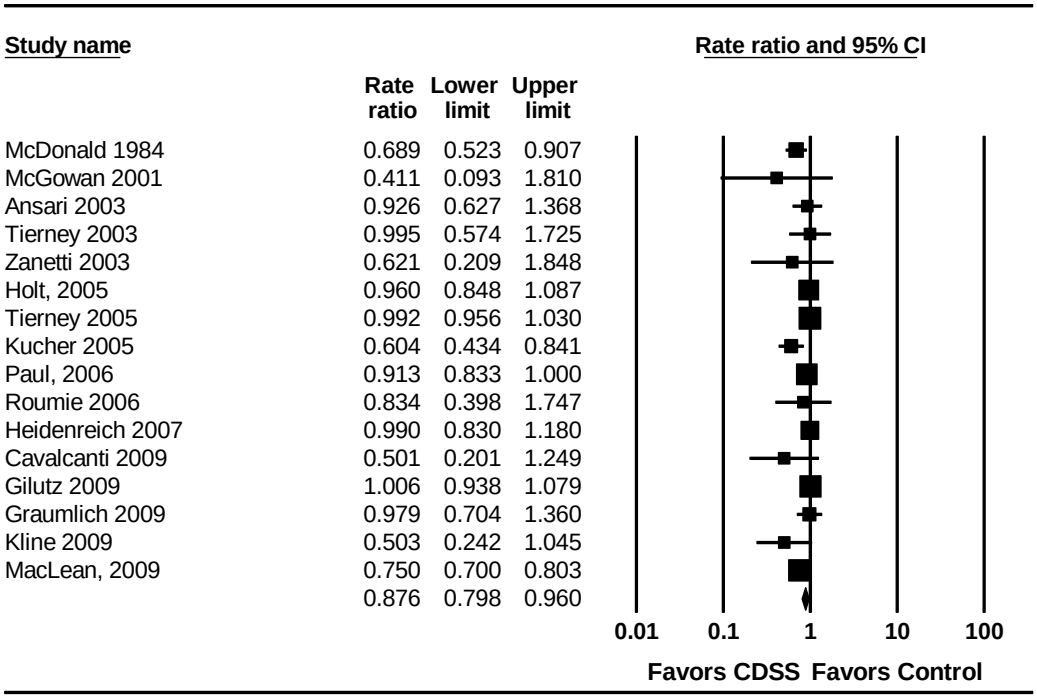
Morbidity. We identified 22 of the 148 eligible studies (14.9%) that specifically examined the impact of CDSSs/KMSs on morbidity. These studies are summarized in Table I-2 of Appendix I.

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 months[35] 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 diagnosis[34] 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.

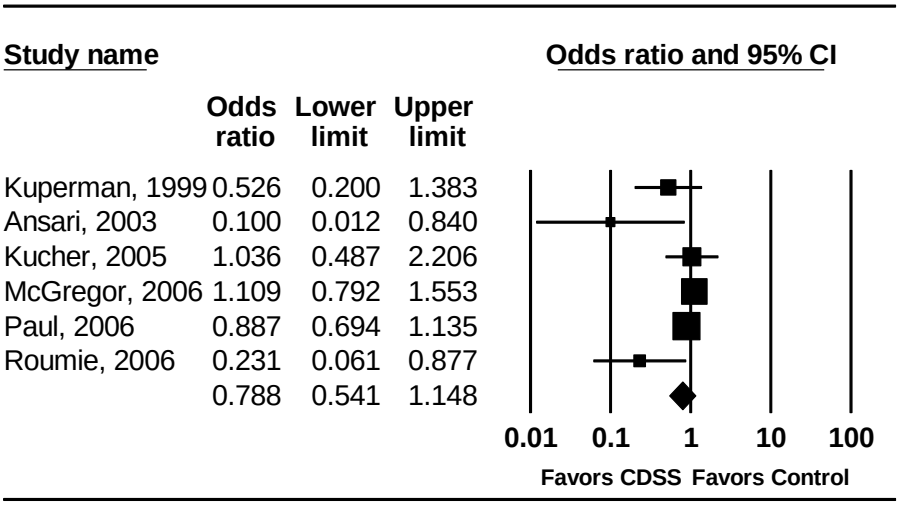
Mortality. We identified 7 of the 148 eligible studies (4.7%) that specifically examined the impact of CDSSs/KMSs on mortality. These studies are summarized in Table I-3 of Appendix I.

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 weeks[30] 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 months[132] 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.

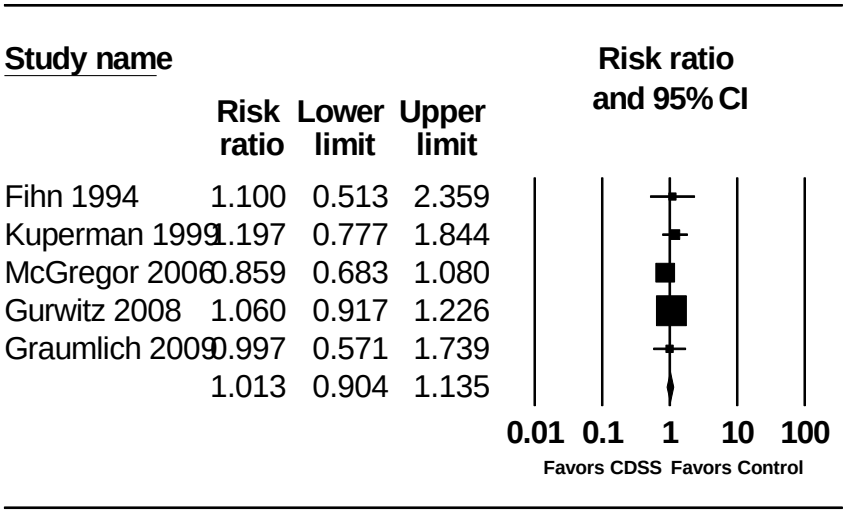
Examples of these outcomes included bleeding risks and thromboembolic complications;[45] diarrhea as a side effect of antimicrobial use as indicated by testing for *Clostridium difficile;*[30] adverse drug events from medication errors or from adverse drug reactions;[46] postdischarge adverse events 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 weeks[30] 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

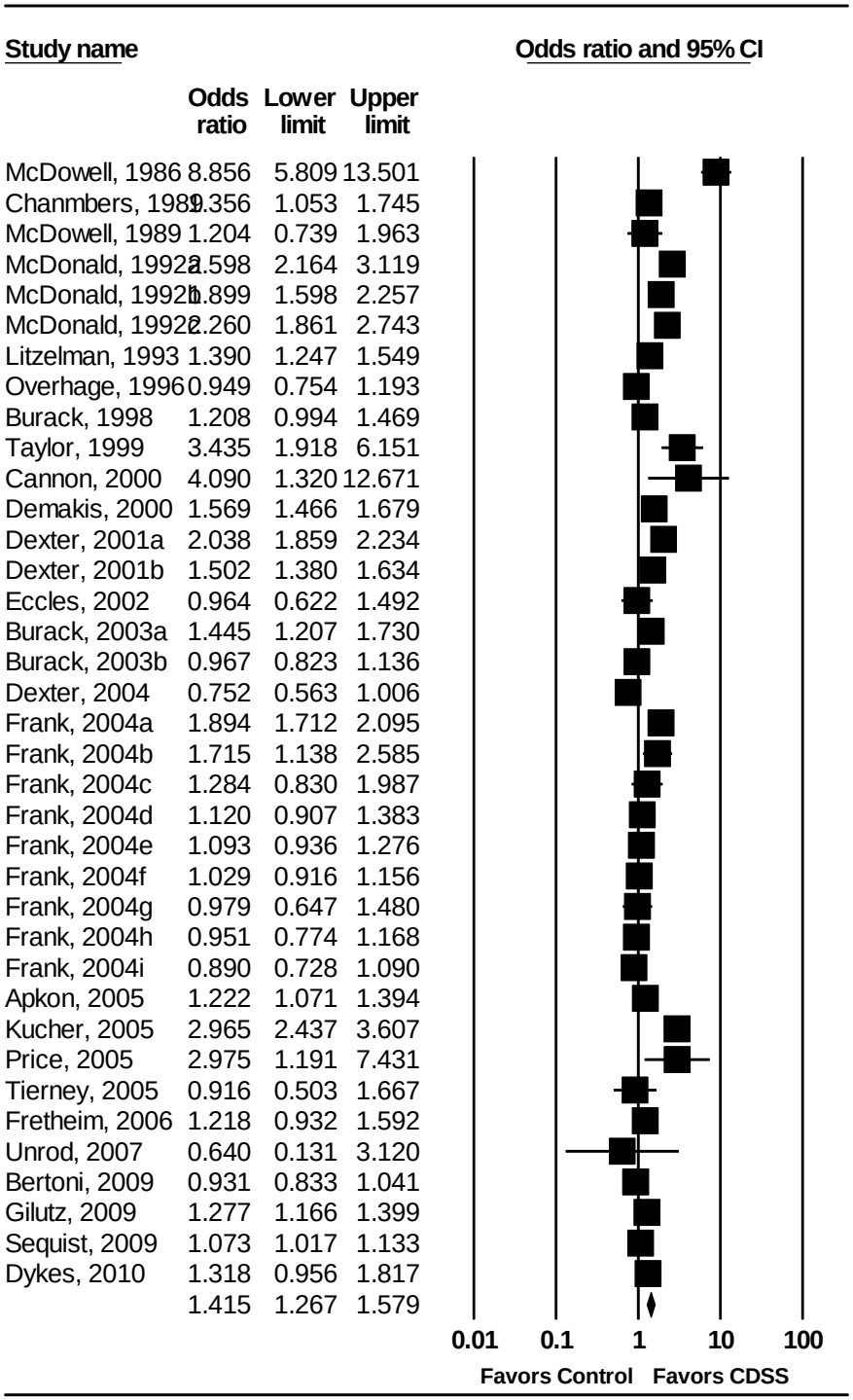
Recommendations to order/complete a preventive care service. We identified 43 of the 148 eligible studies (29.1%) that specifically examined the impact of CDSSs/KMSs on the rates of ordering or completing recommended preventive care services. These studies are summarized in Table I-6 of Appendix I.

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 weeks[146] 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 paper[92] 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]

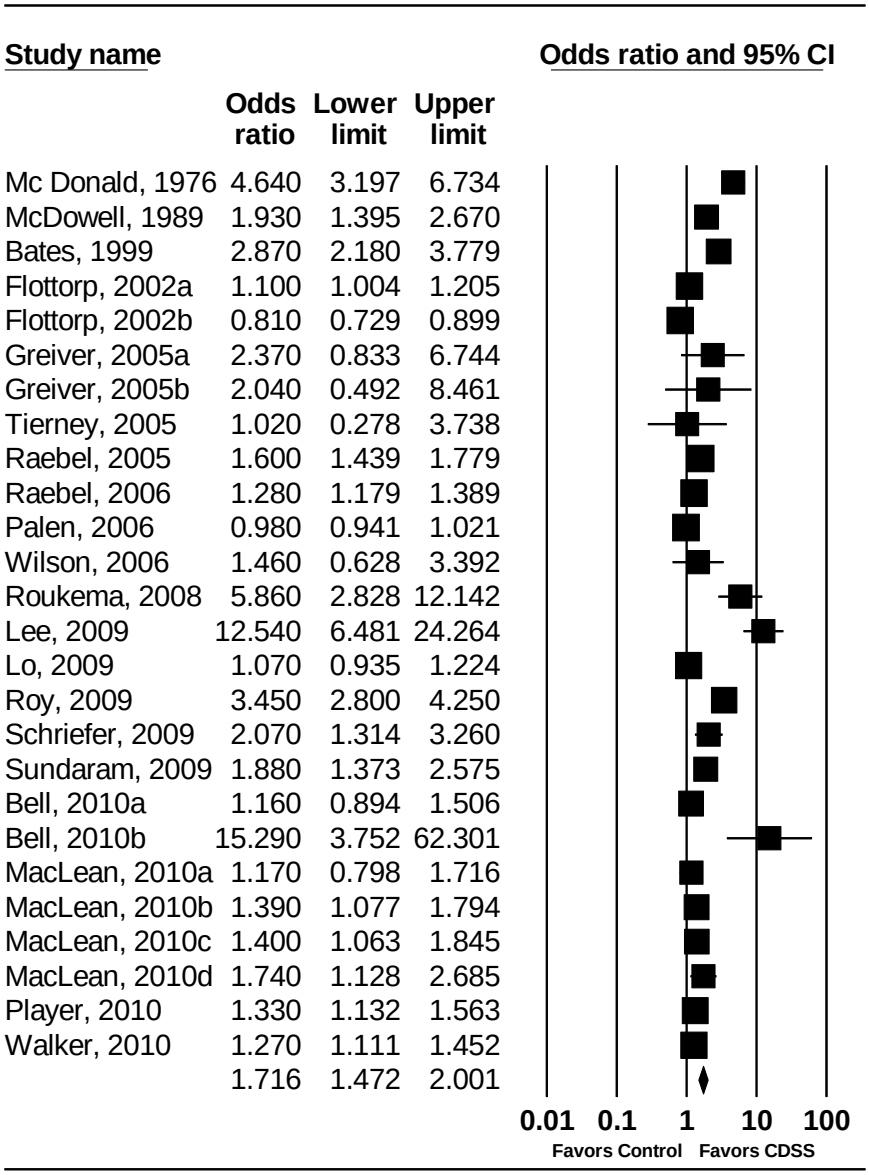
Recommendations to order/complete a clinical study. We identified 29 of the 148 eligible studies (19.6%) that specifically examined the impact of CDSSs/KMSs on the ordering and completion of recommended clinical studies. Examples of these interventions included reminders to order blood tests when ordering 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 weeks[154] 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 year[95] 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]

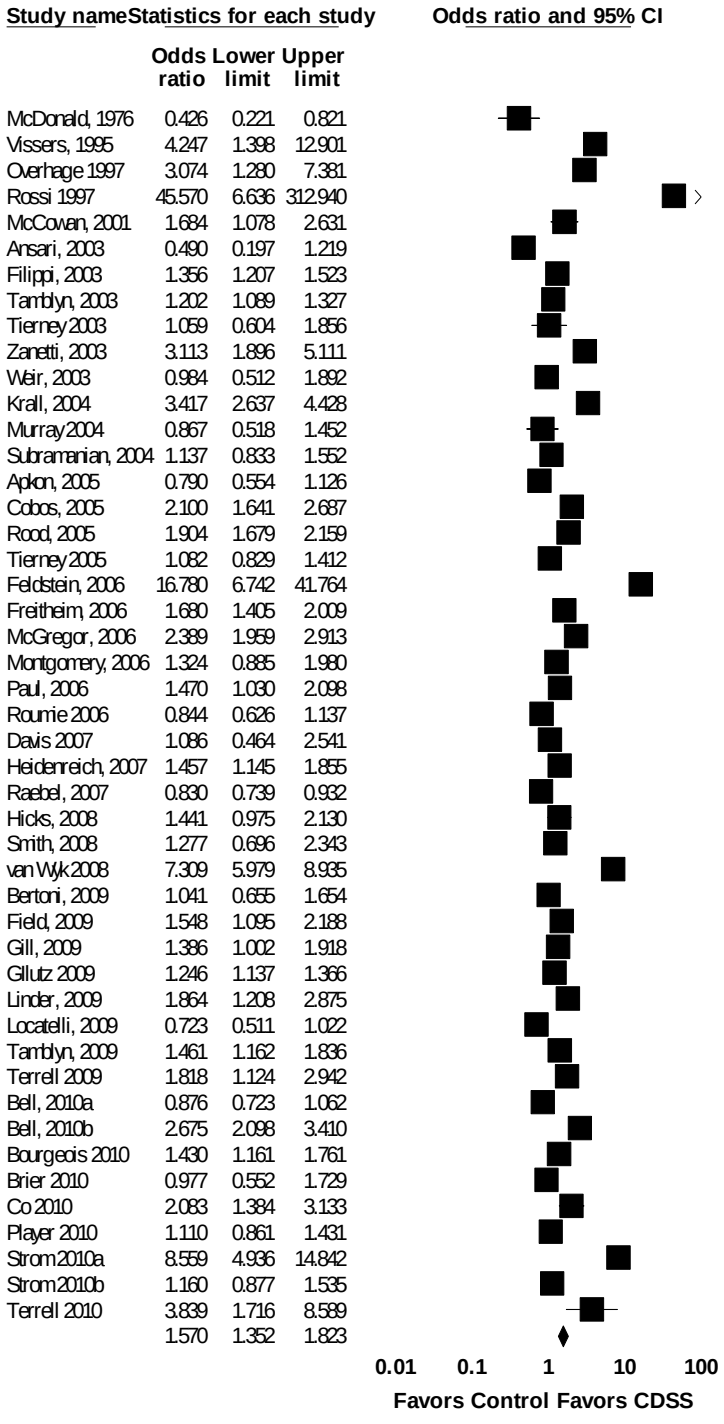
Recommendations to order/prescribe treatment. We identified 67 of the 148 eligible studies (45.3%) that specifically examined the impact of CDSSs/KMSs on the ordering and prescribing of therapy. These studies are summarized in Table I-8 of Appendix I.

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 weeks[64] 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 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 months[171] 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.[117,118,171 117,118,123,126] 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 Fiol 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 article[30] 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 patients[30] 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 Canada[143], 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 weeks[154] 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 days [176] 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 = 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 2008[110] 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 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 weeks [63] 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 month[170] 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 months[171] 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 providers[119] 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] [100,136] 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 be 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.

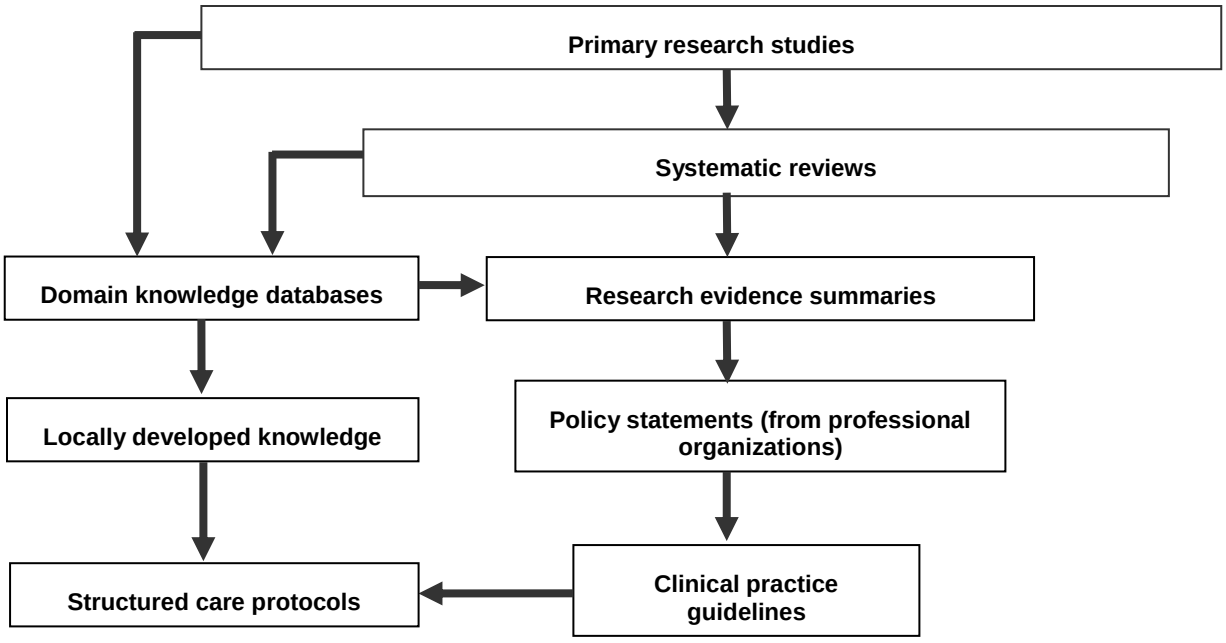
Detailed Analysis

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]	Compliance with 11 health maintenance protocols identified in the literature
		Ornstein et al., 1991[140]	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]	Locally developed protocol for maintaining blood glucose level between 100 and 130 mg/dL
		Hamilton et al., 2004[131]	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/inventions.

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.

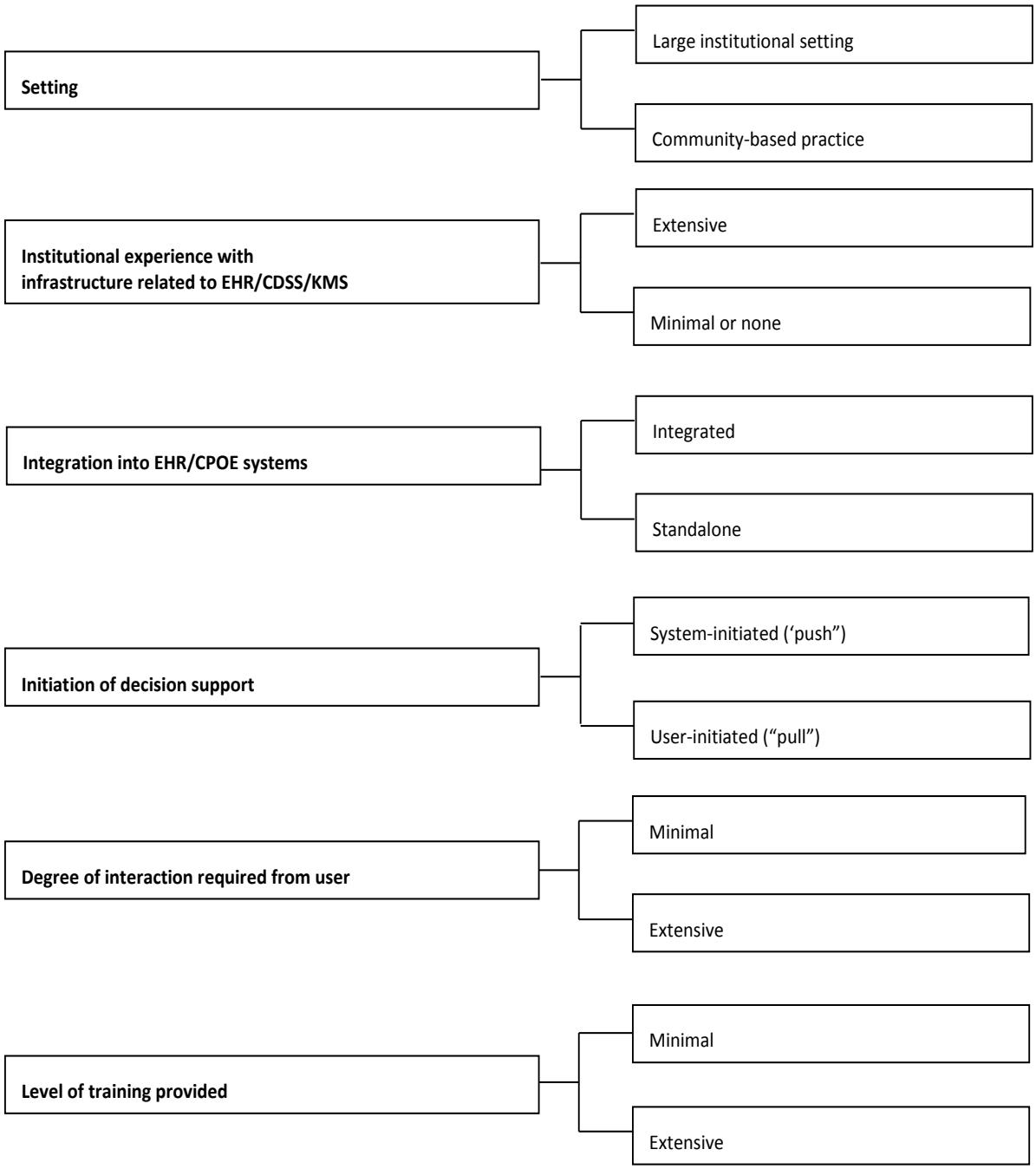
The degree of training provided on CDSSs/KMSs varied across studies, ranging from a 1-hour tutorial and assistance during the first month of use[136] to a half-day training session and site visits by study authors.[163] In addition, some studies required the use of a particular electronic medical record 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 implementations[9] 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 guidelines[1] 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	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: 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 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	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: *Automatic provision of decision support as part of clinician workflow* (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. *Provision of decision support at time and location of decisionmaking* (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. *Provision of a recommendation, not just an assessment* (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 12. Summary of key findings (continued)

Key question	Strength of evidence	Conclusions
KQ 2 (continued)		• The meta-analysis also identified 6 additional factors/features that were correlated with the success of CDSSs: ○ *Integration with charting or order entry system to support workflow integration* (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. ○ *No need for additional clinician data entry* (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. ○ *Promotion of action rather than inaction* (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. ○ *Justification of decision support via provision of research evidence* (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. ○ *Local user involvement in development process* (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. ○ *Provision of decision support results to patients as well as providers* (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.
		• 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	• 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	• Of the eligible studies, none examined the impact of CDSSs/KMSs on the number of patients seen/unit time.
Clinician workload	Insufficient	• Of the eligible studies, none examined the impact of CDSSs/KMSs on clinician workload.
Efficiency	Low	• 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		
Health care process measures		
Recommended preventive care service ordered/completed	High	• 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	• 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	• 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	• 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
Clinical outcomes		
Length of stay	Low	• 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	• 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	• 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	• 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	• 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.
Economic outcomes		
Cost	Moderate	• 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	• 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.
Use and implementation outcomes		
Health care provider acceptance	Low	• 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	• 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	• 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	• 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
Relationship-centered outcomes		
Patient satisfaction	Insufficient	• 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	• 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. This set of studies included 56 good-quality, 33 fair-quality, and 15 poor-quality studies.
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	• 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.

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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.

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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 "inforetriever") OR (AB "inforetriever") 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("inforetriever")) OR (AB ("inforetriever")) 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)

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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:** *a) Objective(s):* - Diagnosis - Immunization - Pharmacotherapy - Lab test ordering - Chronic disease management - Initiating discussion with patient - Preventive care - Other [describe] *b) Relationship to point of care:* - Synchronous - Asynchronous **Decision support:** *Response requirement:* - Noncommittal acknowledgement - Justification for not complying - No response requirement - Mandatory response - NR (assume no response requirement) - NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* - Online access - Integrated with CPOE/EHR - Standalone system - Paper-based - Other [specify] *b) Delivery mode:*	**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
	- Patients - Clinics/practices/ hospitals - Individual HCPs: > Training MDs > MDs [note specialty, if any] > PAs/NPs > Nurses > Care managers > Pharmacists > Other [specify] - Events - Other [specify] **User level of expertise/ proficiency:**	- System-initiated ("push") - User-initiated ("pull") **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/N/Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 *e) Other* [specify]		- 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

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 *or* 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 of 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:** - 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:** 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; - 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:** - 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. 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 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	**Geographical location:** U.S., Israel, Lebanon, Pakistan **Study dates:** January 20, 2004–June 23, 2004 **General setting:** NR **Specific setting:** NR **Study design:** RCT, crossover **Unit of randomization:** System query **Duration of intervention:** 3 months **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	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Other; answering specific clinician questions *b) Relationship to point of care:* - Synchronous - Asynchronous **Decision support:** *Response requirement:* Mandatory response	**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: 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) 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) 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)	**General comments:** Participants could still use their usual information sources **Quality assessment:** Overall rating: Fair Comments: Baseline issues—participants recruited, not compelled to participate **Applicability/ generalizability:** Participants recruited voluntarily Intervention was not locally developed The study 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
	User level of expertise/ proficiency: NR	**Information delivery:** *a) Delivery format:* Online access *b) Delivery mode:* User-initiated ("pull") **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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		**3) Impact on workload, efficiency, and organization of health care delivery:** - 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 Median time to find answers (n = 510 questions), minutes— With DynaMed: 4.78 Without DynaMed: 4.89 Median time for unsuccessful searches (n = 185 questions), minutes— With DynaMed: 5.23 Without DynaMed: 5.1 **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: Answered more questions (n = 46 [%])— With DynaMed: 23 (50) Without DynaMed: 13 (28.3) Difference: 10 (21.7), P = 0.05 Found more answers that changed clinical decisionmaking (n = 46 [%])— With DynaMed: 25 (54.3)	

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 *d) Auxiliary features:* - 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		Without DynaMed: 13 (28.3) Difference: 8 (17.4), P = 0.01 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
	Specific setting: Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 1 year **Sample type(s) (with N randomized for each):** Patients: 169 **User level of expertise/ proficiency:** System users were physicians using the CDSS for the first time during this intervention phase	stable outpatients with CHF compared with an aggressive provider education program alone. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Pharmacotherapy - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **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	2) Nurse facilitator 3) Provider and patient notification via CDSS	Hospitalizations for CHF: Control (n = 51): 5(10%) Nurse Facilitator (n = 54): 5 (9%) CDSS Notification (n = 64): 9(14%) P = 0.66 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 - 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) - 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: 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) Patients at target beta blocker doses at end of study (# [%]) P < 0.001—	**generalizability:** Setting was VA hospital 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
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		Control (n = 51): 5 (10) Nurse Facilitator (n = 54): 23 (43) CDSS Notification (n = 64): 1 (2) - 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
Apkon, Mattera, Lin, et al., 2005 #3126	**Geographical location:** Fort Knox, KY Mayport, FL **Study dates:** Patient screening: 4/22/2004–12/31/2002 **General setting:** Community; 2 military treatment facilities dealing with ambulatory practice **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: 1902 (936 intervention [I], 966 control [C]) **User level of expertise/ proficiency:** NR	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* - Diagnosis - Chronic disease management - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation**	**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: 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 **3) Impact on workload, efficiency, and organization of health care delivery:** NR **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=NA Overall visit assessment – I:4.27	**General comments:** Providers cared for both intervention and control patients; a historical control and a concurrent control clinic were also used for comparison **Quality assessment:** Overall rating: Good **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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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: 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support results to patients as well as		C: 4.30 P= 0.74 **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 **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	

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:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **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	**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
		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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		laboratory budget) - Cost-effectiveness: NR **6) Impact on HCP use and implementation:** NR	**Applicability/ generalizability:** Conducted in an academic tertiary care institution Designed to evaluated only a limited number of tests

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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **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	**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
	Sample type(s) (with N randomized for each): Clinics/practices/hospitals: 12 **User level of expertise/ proficiency:** Practicing primary care physicians trained in the use of the CDSS	*b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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) Auxiliary features:* - 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		- 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	

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) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:**	**Comparator(s):** Another CDSS/KMS In the control CDSS, recommendations 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	*Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Standalone system (PDA-based) *b) Delivery mode:* User-initiated ("pull") (response to user-entered data) **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than		[baseline 4.2% (n = 650)] Net change -4.9%; P = 0.01 - 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	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
		inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y *d) Auxiliary features:* - 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			
Bird, McPhee, Jenkins, et al., 1990 #7221 **Comparison 1 of 3**	**Geographical location:** San Francisco, CA **Study dates:** 1984−1987 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group, 2 x 3 factorial design **Unit of randomization:** Clinician	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement (no	**Comparator(s):** <u>Cancer screening reminders</u> 2 x 3 factorial design: Patient education (present or absent) by: - Cancer screening reminders versus - Audit with feedback versus - No physician intervention	**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: 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	**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. Patient education intervention only

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: 9 months **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) **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.	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) -**Information delivery:** *a) Delivery format:* Paper-based *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: N *b) Clinician-system interaction features:* - 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 *c) Communication content*	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: Cancer screening with and without patient education Audit with feedback with and without patient education No physician intervention, by inference, with only the patient education group	No tests of significance reported - Cost-effectiveness: Implementation cost— Cost per additional test: $18.19 # of tests promoted per $1000 expenditure: 55 **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%). - HCP satisfaction: Most of the residents were also enthusiastic; 14 of 21 residents found the reminders very useful/helpful - HCP use: NR - Implementation of CDSS/KMS: NR	addressed screening for breast cancer among women, while intervention arms had screening strategies with broader focus (including other cancers and male patients) **Quality assessment:** Overall rating: Poor Comments: Methods used for randomization and allocation concealment not adequately described Small sample size (~10 per cell in 2 x 3 factorial design) Inadequate reporting of methods and results Potential for multiple confounders **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
		features: - 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 *d) Auxiliary features:* - 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			Technical features of the intervention may be outdated by the standards of current information technology Assessed among residents in an academic teaching hospital Units of costs in 1984–1987 dollars
Bird, McPhee, Jenkins, et al., 1990 #7221 **Comparison 2 of 3**	**Geographical location:** San Francisco, CA **Study dates:** 1984−1987 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group, 2 x 3 factorial design	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:*	**Comparator(s):** Audit with feedback 2 x 3 factorial design: Patient education (present or absent) by: - Cancer screening reminders versus - Audit with feedback	**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: Total cost of implementation—Audit with feedback: $4488 Per patient: $9.63	**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.

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: Clinician **Duration of intervention:** 9 months **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) **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.	Synchronous **Decision support:** *Response requirement:* 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) -**Information delivery:** *a) Delivery format:* Paper-based *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: N *b) Clinician-system interaction features:* - 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	versus - No physician intervention 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: Cancer screening with and without patient education Audit with feedback with and without patient education No physician intervention, by inference, with only the patient education group	Labor cost: Audit with feedback (by inference, n = 20)— Total cost: $8976 Prorated cost: $4488 - Cost-effectiveness: Implementation cost— Cost per additional test: $50.40 # of tests promoted per $1000 expenditure: 20 **6) Impact on HCP use and implementation:** NR	Arch Intern Med 1989; 149:1866. 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) **Quality assessment:** Overall rating: Poor Comments: Methods used for randomization and allocation concealment not adequately described Small sample size (~10 per cell in 2 x 3 factorial design) Inadequate reporting of methods and results Potential for

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		making: Y - Recommendations executed by noting agreement: N *c) Communication content features:* - 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 *d) Auxiliary features:* - 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			multiple confounders **Applicability/ generalizability:** Technical features of the intervention may be outdated by the standards of current information technology Assessed among residents in an academic teaching hospital Units of costs in 1984–1987 dollars
Bird, McPhee, Jenkins, et al., 1990 #7221 **Comparison 3 of 3**	**Geographical location:** San Francisco, CA **Study dates:** 1984−1987 **General setting:** Academic **Specific setting:**	**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. **Source/origin of system:** Locally developed	**Comparator(s):** Patient education 2 x 3 factorial design: Patient education (present or absent) by: - Cancer	**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	**General comments:** This was a secondary (feasibility) analysis of a previously published study: McPhee SJ, Bird JA, Jenkins C, Fordham D.

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Outpatient **Study design:** RCT, parallel group, 2 x 3 factorial design **Unit of randomization:** Clinician **Duration of intervention:** 9 months **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) **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	**Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* 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) **Information delivery:** *a) Delivery format:* Paper-based *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: N *b) Clinician-system interaction features:* - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: Y	screening reminders versus - Audit with feedback versus - No physician intervention 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: Cancer screening with and without patient education Audit with feedback with and without patient education No physician intervention, by inference, with only the patient	**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 No tests of significance reported - Cost-effectiveness: Implementation cost— Cost per additional test: $51.20 # of tests promoted per $1000 expenditure: 20 **6) Impact on HCP use and implementation:** NR	Promoting cancer screening: a randomized, controlled trial of three interventions. Arch Intern Med 1989; 149:1866. 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) **Quality assessment:** Overall rating: Poor Comments: Methods used for randomization and allocation concealment not adequately described Small sample size (~10 per cell in 2 x 3 factorial design) Inadequate

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.	- 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		reporting of methods and results Potential for multiple confounders **Applicability/ generalizability:** Technical features of the intervention may be outdated by the standards of current information technology Assessed among residents in an academic teaching hospital Units of costs in 1984–1987 dollars
Bosworth, Olsen, Dudley, et al., 2009 #560	**Geographical location:** Durham, NC **Study dates:** March 2002–April 2005	**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 2-level cluster RCT:	**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

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	**General setting:** VA **Specific setting:** - Outpatient - Chronic **Study design:** 2-level (PCP and patient) RCT, cluster randomization **Unit of randomization:** Clinician **Duration of intervention:** 2 years **Sample type(s) (with N randomized for each):** Individual HCPs: >Training MDs > MDs: 23 general internists - PAs/NPs: 7 **User level of expertise/ proficiency:** NR	recommendations about hypertension decision support delivered at the point of care during each patient visit. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **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	1) PCPs receiving intervention (n = 17) 2) PCPs not receiving intervention (n = 15) 3) Patients receiving usual care 4) Patients receiving bimonthly tailored nurse-delivered behavioral telephone intervention to improve hypertension treatment	**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: 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	pressure control over 24-month intervention period **Quality assessment:** Overall rating: Good **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)

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: Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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) Auxiliary features:* - 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	October 2006–April 2007 **General setting:** Community **Specific setting:** - Outpatient - Chronic and acute **Study design:** RCT, cluster randomization **Unit of randomization:** - Clinic or team **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Clinics/practices/ hospitals: 12 - Individual HCPs: 146 **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	antibiotic prescribing for acute respiratory illness (ARI). **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Pharmacotherapy - Lab test ordering - Disease management (chronic and acute) *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated (“pull”) **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		- Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Antimicrobial prescriptions (percentage of total visits)— I = 5929/14934 (39.7%) C = 2303/5007 (46%) P = 0.844 Macrolide prescriptions (percentage of total visits)— I = 1408/14934 (9.4%) C = 290/5007 (5.8%) P < 0.0001 Antimicrobial prescriptions for viral illnesses (%)— I = 1526/14934 (17.9%) C = 408/5007 (15.7%) P = 0.129 Macrolide prescription for viral illnesses (%)— I = 336/14934 (4%) C = 93/5007 (3.6%) P = 0.484 - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR **4) Impact on relationship-centered outcomes:** NR	**assessment:** Overall rating: Fair Comments: Valid outcome measures No details on randomization, concealment, or blinding provided More clinics, clinicians, and patients included in the intervention group **Applicability/ generalizability:** Locally developed system by Partners Healthcare Low adoption rate among clinicians prevent accurate assessment for generalizability

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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) Auxiliary features:* - 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		**5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** - 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 of112 (29%) intervention clinic clinicians. - Implementation of CDSS/KMS: NR - 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. 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.	

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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* Not clearly described **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: N *b) Clinician-system interaction features:* - 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
		support as part of clinician workflow: N - 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 *c) Communication content features:* - 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) Auxiliary features:* - 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		AUC— Control = 3.38 ± 2.69 Intervention = 2.86 ± 1.46 P = 0.025 (difference in variance) Number of dose changes— Control = 3.9 ± 1.6 Intervention = 4.8 ± 2.2 Total EPO dose (1000U)— Control = 97.6 ± 66.1 Intervention = 129.3 ± 170.8 P = 0.005 (difference in variance) Total Iron dose (mg)— Control = 1133 ± 1212 Intervention = 1496 ± 1573 P = 0.261 (difference in variance) - 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	

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., 1994 #6957 **AND** **Burack and Gimotty, 1997** #6473	**Geographical location:** Detroit, MI **Study dates:** May 1, 1989–Sep 1, 1991 **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: Year 1: 2725 Year 2: 1225 **User level of expertise/ proficiency:** NA; paper-based reminders	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **Information delivery:** *a) Delivery format:* Paper-based *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	**Comparator(s):** No CDSS or KMS	**1) Impact on clinical outcomes:** NR **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) - 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:** 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 **Quality assessment:** Overall rating: Good Comments: Study population, baseline characteristics well-described **Applicability/ generalizability:** Intervention implemented in the community setting in three health care organizations serving urban, predominantly Medicaid-eligible population

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		integration: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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			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

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	**Geographical location:** Detroit, MI, **Study dates:** March 1993–April 1994 **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):** Patients: 5801 **User level of expertise/ proficiency:** NA; paper-based reminders	**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. 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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based	**Comparator(s):** No CDSS or KMS	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - Recommended preventive care ordered/completed: NR 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) - 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:** 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 Additional organizational resources to scan records and generate recommendations

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* 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
	Patients: 2471 **User level of expertise/ proficiency:** NA; paper- based reminders	*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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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		**outcomes:** NR **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	Additional organizational resources to scan records and generate recommendations

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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
Cannon and Allen, 2000 #5781	**Geographical location:** Salt Lake City, UT **Study dates:** Jan 5, 1998–Oct 7, 1998 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 9 months **Sample type(s) (with N randomized for each):** Patients: 78 **User level of expertise/ proficiency:** NR	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* 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.] *b) Delivery mode:* System-initiated ("push")	**Comparator(s):** No CDSS or KMS; manual reminder 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.	**1) Impact on clinical outcomes:** NR **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 **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: Fair Comments: Small team of health care providers (clinical psychologist, registered nurse, social worker and addiction therapist) evaluated subjects in both arms of the study Potential for contamination across study arms as 4 HCPs administered care to all the subjects in the study. **Applicability/ generalizability:** Small sample of highly select group of patients attending an outpatient clinic at a VA Health

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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			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
		d) Auxiliary features: - 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			
Cavalcanti, Silva, Pereira, et al., 2009 #216 **Comparison 1 of 2**	**Geographical location:** Brazil; multicenter trial in 5 ICUs at 5 different Brazilian institutions **Study dates:** May 4, 2005–Dec 4, 2006 **General setting:** - Academic - Community (3 ICUs associated with teaching hospitals and 2 associated with nonteaching hospitals) **Specific setting:** Inpatient – ICU **Study design:** RCT, parallel group **Unit of randomization:** Patient	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy, insulin therapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR **Information delivery:** *a) Delivery format:*	**Comparator(s):** Usual care/no CDSS or KMS <u>Comparator 1:</u> Leuven protocol with continuous insulin infusion maintaining BG between 80 and 110 mg/dL	**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 **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	**General comments:** None **Quality assessment:** Overall rating: Fair 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

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: 18 months **Sample type(s) (with N randomized for each):** Patients: 168 (56 CAIP, 58 Leuven protocol, 54 conventional) **User level of expertise/ proficiency:** NR	Standalone system *b) Delivery mode:* NR **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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		**5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	methods **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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Justification of decision support via provision of research evidence: Can't tell *d) Auxiliary features:* - 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			
Cavalcanti, Silva, Pereira, et al., 2009 #216 **Comparison 2 of 2**	**Geographical location:** Brazil; multicenter trial in 5 ICUs at 5 different Brazilian institutions **Study dates:** May 4, 2005–Dec 4, 2006 **General setting:** - Academic - Community (3 ICUs associated with teaching hospitals and 2 associated with nonteaching hospitals) **Specific setting:** Inpatient – ICU **Study design:** RCT, parallel group	**Authors' basic description of system:** Computer-assisted insulin protocol (CAIP), with continuous intravenous insulin infusion maintaining BG between 100 and 130 mg/dL. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy, insulin therapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR	**Comparator(s):** Comparator 2: Usual care; conventional treatment was subcutaneous insulin administration according to a sliding scale if glucose > 150 mg/dL	**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 **2) Impact on health care process outcomes:** NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Computer-generated random numbers; centralized randomization using a Web site that assured concealment of the allocation list; no blinding of patients or

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:** 18 months **Sample type(s) (with N randomized for each):** Patients: 168 (56 CAIP, 58 Leuven protocol, 54 conventional) **User level of expertise/ proficiency:** NR	**Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* NR **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y/ - Promotion of action rather than inaction: Y		**4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	investigators; insufficient and ambiguous reporting of methods **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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Justification of decision support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell *d) Auxiliary features:* - 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	**Geographical location:** Philadelphia, PA **Study dates:** Nov 1, 1986–April 30, 1987 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient	**Authors' basic description of system:** A microcomputer reminder system prompting physicians to schedule periodic mammographic screenings for patients. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* 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: Up-to-date (at beginning of intervention period)— Control = 88 of 623 (14/.%) Intervention = 87 of 639 (13.6%) P = 0.793 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 Up-to-date (at the end of the intervention period)—	**General comments:** None **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** A single site study located in an academic medical center Relatively older study involving computerized

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	*Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *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 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 *c) Communication content features:*		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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *d) Auxiliary features:* - 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:** *a) Objective(s):*	**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
	Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 8 months **Sample type(s) (38):** Individual HCPs: > Training MDs: 29 > MDs: 7 > NPs: 2 **User level of expertise/ proficiency:** NR	Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **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 the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed		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 **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	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 **Quality assessment:** Overall rating: Fair Comments: Randomized using electronic random number generator; potential for diffusion of evidence between experimental and control arms **Applicability/ generalizability:** Intervention carried out in a resident teaching clinic of a large, academic hospital

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) Communication content features:* - 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) Auxiliary features:* - 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	**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):** - Clinics/practices: 55 - Patients: 3391 **User level of expertise/ proficiency:** NR	**Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* User-initiated ("pull") **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: Can't tell *b) Clinician-system interaction features:* - 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		**outcomes:** NR **5) Impact on economic outcomes:** - 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 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 "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." **6) Impact on HCP use and implementation:** NR	**Quality assessment:** Overall rating: Good **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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Study dates:** December 2006 –July 2007 **General setting:** Community **Specific setting:** - Outpatient - Chronic **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: 412 - Clinics/practices/ hospitals: 12 - Individual HCPs: > MDs [pediatricians]: 79 **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	in pediatric primary care to assess ADHD. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Diagnosis - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **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		**outcomes:** - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: Adherence to guidelines for recommended interval of followup: Patients with any visit at which ADHD was discussed— Control = 111 (53.9%) Intervention = 146 (70.9%) P =0.04 Patients with non-well child visit during which ADHD was discussed— Control = 69(33.5%) Intervention = 90 (43.7%) P = 0.27 Patients with a well-child visit at which ADHD was discussed— Control = 46 (22.3%) Intervention = 59(28.2%) P = 0.33 - 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	**Quality assessment:** Overall rating: Fair Comments: No details provided on randomization process, blinding or concealment **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) All sites used the Partners Healthcare medical record

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.	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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		**6) Impact on HCP use and implementation:** - 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. 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.	

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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement* Justification for not complying **Information delivery:** *a) Delivery format:* Standalone system *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	**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
		workflow integration: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by		- 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
Davis, Wright, Chalmers, et al., 2007 #2021	**Geographical location:** Seattle, WA **Study dates:** Nov 1999–Dec 2003 **General setting:** - Academic - Community Intervention carried out at 2 sites: academic pediatric care center and pediatric clinic in the community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinicians **Duration of intervention:** 50 months at site 1 (academic primary care center) and 18 months at the site 2 (clinic in the community) **Sample type(s) (44):** Individual HCPs: 44 - Training MDs: 29 - MDs: 15 **User level of expertise/ proficiency:** NR	**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). **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **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:*	**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: 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 **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:** 36 providers based at the academic training facility and 8 providers based in a primary care clinic in the community Main outcome measure was change in prescribing behavior over the course of the trial **Quality assessment:** Overall rating: Fair Comments: Randomization using computer generated random numbers **Applicability/ generalizability:** Study participants were primarily English speaking, fairly well educated and were in an urban and semiurban

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: 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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support results to patients as well as			setting Intervention was implemented at a large academic training facility and a community-based clinic staffed by recent graduates of the academic center

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	**Geographical location:** Utah and Idaho **Study dates:** 5/2007–11/2007 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Individual HCPs: > MDs: 90 - Infobutton sessions: 3729 **User level of expertise/ proficiency:** Study clinicians had to have conducted 10 or	**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. 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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Other: To answer clinicians' questions at the point of care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement	**Comparator(s):** Another CDSS/KMS: 1) Intervention group: Clinicians had access to topic links 2) Control group: Clinicians had access to nonspecific links	**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: NR - Impact on user knowledge: Subjects reported a high positive clinical impact (i.e., decision enhancement or knowledge update) in 62% of the sessions **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 **4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:**	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Inadequate description of study population, incomplete and ambiguous reporting of findings, nonblinded participants, low response rate with followup survey **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
	more medication infobutton sessions; infobuttons have been implemented in the EMR since September 2001 for the laboratory results, problem list, and medication-ordering modules	**Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated ("pull") **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: 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather		NR **6) Impact on HCP use and implementation:** - HCP acceptance: NR - HCP satisfaction: Postsurvey study (n = 25 participants, with a total of 115 (9.9%) individual responses)— 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. - HCP use: Median number of infobutton sessions— Intervention: 22 Control: 17.5, p = 0.21 - Implementation of CDSS/KMS: NR	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
		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 *d) Auxiliary features:* - 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	**Geographical location:** 12 VA medical centers, US **Study dates:** 1/31/1995–6/30/1996 **General setting:** VA medical centers **Specific setting:** Outpatient (primary care), mostly for chronic care. **Study design:** RCT, parallel group **Unit of randomization:** Firms or team system and	**Authors' basic description of system:** Computerized system to remind physicians to provide appropriate care for 13 standards of care (SOCs). **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Chronic disease management - Preventive care - Immunization *b) Relationship to point of care:* 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: 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 Significantly higher adherence rates were found for 9 of the 13 SOCs examined individually General adherence rate to all SOC, # (% adherent)—	**General comments:** None **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** VA study; 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
	half-day blocks of residents **Duration of intervention:** 17 months **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 SOCs - Individual HCPs: > Training MDs, residents: 299 initially randomized, 275 residents completed the study **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	**Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Paper-based *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 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		Intervention: 19,373 (58.8%) Control: 20,575 (53.5%) OR 1.24; 95% CI: 1.08,1.42, p = 0.002 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 Significantly higher adherence rates were found for 5 of the 13 SOC examined individually - 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		c) Communication content features: - 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) Auxiliary features:* - 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	**Geographical location:** Indianapolis, IN **Study dates:** 5/1/1997–10/31/1998 **General setting:** Academic (urban public teaching hospital) **Specific setting:** Inpatient – non-ICU;	**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	**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 hospitalizations during which therapy was ordered for an eligible patient— Pneumococcal vaccine: Intervention: 35.8% Control: 0.8% ($p < 0.001$) Influenza vaccine:	**General comments:** None **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Academic setting;

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	mostly acute care **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic or team **Duration of intervention:** 18 months **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 **User level of expertise/ proficiency:** The study hospital already had computer-generated reminder systems	disease, and (4) prophylactic subcutaneous heparin. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Immunization - Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **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		Intervention: 51.4% Control: 1.0% (p < 0.001) Subcutaneous heparin: Intervention: 32.2% Control: 18.9% (p < 0.001) Aspirin at discharge: Intervention: 36.4% Control: 27.6% (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	locally developed system; site has a 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
		- 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Immunization *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **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	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
		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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Geographical location:** - Central Scotland - London, England **Study dates:** 1999–2002 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** General practices **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Patients: 13,068 registered patients - Practices: 36 workshops, 10 control **User level of expertise/ proficiency:** NR; practices had to be using EMIS or GPASS software for patient records	**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. **Source/origin of system:** Commercially available (EMIS or GPASS software for patient records) **Content:** *a) Objective(s):* - Diagnosis - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of**	**Comparator(s):** Another CDSS/KMS 1) Electronic CD tutorial 2) Decision support software (DSS) 3) Small group workshops at the study practices 4) Control (no intervention)	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - 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) 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. 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 - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care**	**General comments:** None **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Study conducted in Scotland and England Study practices part of a nationalized healthcare system Commercially available system

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: *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: 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* - Diagnosis - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* - 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
	- Clinics/practices/ hospitals: 8 units **User level of expertise/ proficiency:** NR	*b) Delivery mode:* User-initiated ("pull") **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 = 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 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 - Recommended clinical study ordered/completed: NR - Recommended treatment	All 4 sites used a single health care system, i.e. Partners Healthcare system Multi-intervention makes it harder to assess the effectiveness of individual intervention leading to potential bias

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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		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: 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
Eccles, McColl, Steen, et al., 2002 #2 **Comparison 1 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 **Sample type(s) (with N randomized for each):** General practices: 62 **User level of**	**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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **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:*	**Comparator(s):** Another CDSS/KMS <u>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)	**1) Impact on clinical outcomes:** NR **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— Number (%) of patients consulting before and after intervention period: Intervention n = 1200 Control n = 1163 OR (95% CI) Lung function assessed: All patients I: 516 (43); 511 (43) C: 492 (42); 517 (45) OR: 0.94 (0.67 to 1.33) Compliance checked: All patients I: 426 (36); 442 (37) C: 446 (38); 471 (41) OR: 0.82 (0.58 to 1.15) Inhaler technique assessed: All patients I: 203 (17); 224 (19) C: 234 (20); 262 (23) OR: 0.8 (0.5 to 1.28) 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)	**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 no difference Study conducted in England Study practices were chosen

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 *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:*	**Comparator(s):** Another CDSS/KMS 1) Computerized guidelines for the management of asthma (with control patients for the management of angina) 2) Computerized guidelines for the management of angina (with control patients for the management of asthma)	**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
		System-initiated (“push”)		C: 288 (24); 362 (30) OR: 0.86 (0.54 to 1.35)	no difference
	Sample type(s) (with N randomized for each): General practices: 62	**Contextual factors/features influencing the implementation and use of CDSS/KMS:**		Smoking status known: All patients I:222 (20); 243 (22) C: 261 (22); 378 (32) OR: 0.68 (0.42 to 1.11)	Study conducted in England
	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)	*a) General system features:* Integration with charting or order entry system to support workflow integration: Y		Smoking education given: All patients I: 33 (3); 47 (4) C: 41 (3); 48 (4) OR: 1.08 (0.86 to 1.77)	Study practices were chosen because their computer systems were extensively used
		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 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		12 lead electrocardiogram recorded: All patients I: 162 (15); 154 (14) C: 197 (16); 164 (14) OR: 1.01 (0.68 to 1.52) Exercise electrocardiogram recorded: All patients I: 46 (4); 28 (3) C: 46 (4); 30 (3) OR: 1.01 (0.56 to 1.80)	
		c) Communication content features: - 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		Haemoglobin concentration recorded: All patients I: 322 (29); 371 (33) C: 355 (29); 400 (33) OR: 1.01 (0.72 to 1.42) Thyroid function recorded: All patients I:192 (17); 214 (19) C: 215 (18); 264 (22) OR: 0.83 (0.62 to 1.12) Cholesterol or other lipid concentrations recorded: All patients I:395 (35); 482 (43)	

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 *d) Auxiliary features:* - 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
	General setting: Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Practice **Duration of intervention:** 12 months minimum **Sample type(s) (with N randomized for each):** Clinics: 45 **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	management advice regarding a family history of breast/ovarian and colorectal cancer. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Other: referral for genetic counseling *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Not clearly described *b) Delivery mode:* NR **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: Can't tell *b) Clinician-system interaction features:* - Automatic provision of	1: Adaptive subgroup, with opportunity for practice to assess and resolve problems using the software 2) Intervention 2: Fixed subgroup, with no opportunity to assess and resolve problems using software 3) Comparison: "Best practice" (practitioners attended a 45-minute educational session on cancer genetics and received a copy of regional guidelines)	ordered/completed: NR - 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 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) Patients referred from GRAIDS practices had lower cancer worry scores at the point of referral (p = 0.02) - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: The intervention increased GPs' confidence in managing familial cancer **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**	**assessment:** Overall rating: Fair Comments: Incomplete and ambiguous reporting throughout **Applicability/ generalizability:** Study conducted in England Unclear how DSS was integrated into practice Commercially available system

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: 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: N *c) Communication content features:* - Provision of a recommendation, not just an assessment: Cant' 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 *d) Auxiliary features:* - 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		**implementation:** - 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. 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). Median consultation time with the lead clinician was 28 min. - HCP use: Software used with patients 219 times, mean use of 8.27 per 10,000 registered patients per year (intervention only) Software use at 12 months per 10,000 registered patients per year, mean, [SD] Intervention 1 (adaptive practices): 8.8 [4.1]	

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) Objective(s):* Lab test ordering *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Alphanumeric pager *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of**	**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:** - 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	**CDSS/KMS:** *a) General system features:* Integration with charting or order entry system to support workflow integration: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N		Control = 43 min (IQR 5–132) P = 0.67 **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
		- 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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR	**Comparator(s):** Another CDSS/KMS 1) Usual care 2) EMR reminders to physician plus letter sent to patients 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
	- Clinics/practices/ hospitals: 15 - Individual HCPs: > MDs: 159 **User level of expertise/ proficiency:** NR	*b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of CDSS/KMS:** <u>EMR reminders to physicians plus letter to patients</u> *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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision		**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
		support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Y *d) Auxiliary features:* - 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			
Feldstein, Elmer, Smith, et al., 2006 #2858 **Comparison 2 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:**	**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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:*	**Comparator(s):** Another CDSS/KMS 1) Usual care 2) EMR reminders to physician plus letter sent to patients 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	**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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Patient **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Patients: 327 - Clinics/practices/ hospitals: 15 - Individual HCPs: > MDs: 159 **User level of expertise/ proficiency:** NR	Synchronous **Decision support:** *Response requirement:* No response requirement **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:** <u>EMR reminders only</u> *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 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		= 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 **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	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
		c) Communication content features: - 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 *d) Auxiliary features:* - 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:** - 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
	Study design: RCT, cluster randomization **Unit of randomization:** Primary care clinic **Duration of intervention:** 14 weeks **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 **User level of expertise/ proficiency:** NR	sample letter that the PCP could send to the patient to request that he or she go to the laboratory. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **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	3) Automated voice messages (AVM) to patients 4) Pharmacy team outreach	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 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 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 - 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**	Well-established health IT infrastructure and EMR used since 1996 Locally developed system Multiple relevant comparisons

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		**outcomes:** Patient satisfaction: The qualitative interviews found that all 3 interventions were acceptable to PCPs and patients. **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
Field, Rochon, Lee, et al., 2009 #341	**Geographical location:** Canada **Study dates:** NR **General setting:** Academic **Specific setting:** Long-term facility **Study design:** RCT, parallel group **Unit of randomization:** Long-stay units **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Patients: 833 - Long-stay units: 22 **User level of expertise/ proficiency:** NR	**Authors' basic description of system:** We developed a CDSS built on a commercially purchased CPOE system that provided specific dose recommendations for long-term care residents with renal insufficiency. 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 . **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement	**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: 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 **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:** Canadian study Modified, commercially available system Longstanding use of EHR and CPOE, and participants had prior experience with the CDSS

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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) Auxiliary features:* - 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	**Geographical location:** 5 sites in US **Study dates:** NR **General setting:** Academic (2 university clinics and 3 VA clinics) **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of**	**Authors' basic description of system:** Computer-generated recommendations for scheduling next anticoagulation clinic visit. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Other: scheduling next clinic visit *b) Relationship to point of care:* Synchronous	**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: 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) Three intervention patients and three control patients experienced a second	**General comments:** None **Quality assessment:** Overall rating: Poor Comments: Inadequate reporting throughout; no intention-to-treat analysis **Applicability/**

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	randomization: Patient **Duration of intervention:** NR **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 **User level of expertise/ proficiency:** NR	**Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Not clearly described *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: 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 *c) Communication content*		complication during the study. **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 ± SD)— Intervention (n = 301) Recommended: 5.5 ± 2.1 Scheduled: 4.4 ± 1.8 Actual: 4.4 ± 1.8 Control (n =3 19) Recommended: 5.2 ±2.2 Scheduled: 3.5 ± 1.4 Actual: 4.1 ± 1.8 P < 0.05 - 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: Number of visits with recommendation (n = 2472)— Number of modifications (%) Total: 992 (40) Longer than recommended: 99 (10)	**generalizability:** Insufficient reporting to determine generalizability of clinics; locally developed CDSS

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		features: - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Immunization *b) Relationship to point of care:* 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
	General setting: Academic and community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Pediatric practice **Duration of intervention:** - 6 months **Sample type(s) (with N randomized for each):** - Patients: 11,919 - Practices: 20 - Clinic visits: 23,418 **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	**Decision support:** *Response requirement:* NR (unclear whether response requirement) **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 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 *c) Communication content*		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 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 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 **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	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. **Applicability/ generalizability:** Primary care practice based research network; commercially available 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
	the presentation	*features:* - 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 *d) Auxiliary features:* - 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			
Filippi, Sabatini, Badioli, et al., 2003 #4586	**Geographical location:** Italy **Study dates:** 5/1/200 –11/30/2001 **General setting:** Community **Specific setting:** Outpatient	**Authors' basic description of system:** Electronic reminders to physicians for antiplatelet drug prescribing in diabetic patients. **Source/origin of system:** NR **Content:** *a) Objective(s):* Pharmacotherapy	**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: Patients with antiplatelet drug prescription at the end of the followup—	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Insufficient reporting on

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	*b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **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 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
		c) Communication content features: - 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) Auxiliary features:* - 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	**Geographical location:** 12 sites in Birmingham, England **Study dates:** 02/1995–02/1996 **General setting:** Community	**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. **Source/origin of system:** Commercially available	**Comparator(s):** Another CDSS/KMS 1) Near-patient testing for INR along with CDSS 2) Two sets of control patients:	**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: Time spent in the INR range showed significant	**General comments:** None **Quality assessment:** Overall rating: Poor Comments: Insufficient and

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Specific setting: Outpatient **Study design:** Other RCT: 12 primary care practices randomized; patients also randomized, with 2 control groups (intrapractice and interpractice controls) **Unit of randomization:** - Clinic - Patient **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Patients: 367 - Clinics: 12 **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	**Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* NR *b) Delivery mode:* NR **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: Can't tell *b) Clinician-system interaction features:* - 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	(a) patients randomized to no intervention within intervention practices and (b) patients in practices allocated to no intervention	improvement for patients in the intervention group (p = 0.008) - 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: The intervention cost, on average, was approximately $160 per patient per year more than for controls - Cost-effectiveness: NR **6) Impact on HCP use and implementation:** NR	ambiguous reporting of methods, atypical (and not clearly justified) selection of controls **Applicability/ generalizability:** Study conducted in England; multifaceted intervention; uncertain generalizability

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 conventional education: Y			
Flanagan, Doebbeling, Dawson, et al., 1999 #6163	**Geographical location:** Iowa **Study dates:** NR	**Authors' basic description of system:** Online immunization reminders. **Source/origin of system:**	**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: Compliance with	**General comments:** None **Quality assessment:**

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:** Outpatient **Study design:** RCT, crossover **Unit of randomization:** Clinician **Duration of intervention:** 10 months **Sample type(s) (with N randomized for each):** - Patients: NR - Individual HCPs: > MDs: 30 > Trainee MDs: 55 **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	Locally developed **Content:** *a) Objective(s):* Immunization *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* Online access *b) Delivery mode:* User-initiated ("pull") **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: Can't tell *b) Clinician-system interaction features:* - 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		guidelines was improved significantly for tetanus and for hepatitis B in several analyses. No such effects were found for pneumococcal, measles, or influenza vaccines. - 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: 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)	Overall rating: Poor Comments: Inadequate and ambiguous reporting of methods and results; inappropriate analytical methods **Applicability/ generalizability:** Locally developed system Crossover design, 5 months in each arm, in the course of a single year, without regard to flu season Academic setting was a single institution

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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			
Flottorp, Oxman, Havelsrud, 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	**Study dates:** 1/1/2000–1/31/2001 Intervention: 5/2000–1/2001 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** General practices **Duration of intervention:** 7 to 8 months **Sample type(s) (with N randomized for each):** Practices: 142 **User level of expertise/ proficiency:** NR	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. 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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Acute disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR **Information delivery:** *a) Delivery format:* NR *b) Delivery mode:* NR **Contextual factors/features**	Practices randomized to DSS for sore throat vs UTI	- 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." - 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%)." - Impact on user knowledge: NR From the text: "Passively delivered, complex interventions targeted at identified barriers to change had little effect in changing practice." **3) Impact on workload, efficiency, and organization of health care delivery:** NR	**Quality assessment:** Overall rating: Poor Comments: Inadequate reporting throughout; nonvalidated outcome assessments **Applicability/ generalizability:** Study conducted in Norway; multifaceted intervention with short followup period; very little information provided on CDSS

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		influencing the implementation and use of CDSS/KMS: *a) General system features:* Integration with charting or order entry system to support workflow integration: NR *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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		**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
		d) Auxiliary features: - 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:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:*	**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
	- Patients - Training MDs: 62 **User level of expertise/ proficiency:** Faculty oriented each resident to the reminders, explained their purpose, and demonstrated how to use them	Justification for not complying **Information delivery:** *a) Delivery format:* Paper-based *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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y		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) Patient education— Breast exam b coefficient 2.3 (p = 0.679) Mammogram b coefficient 16.7 (p = 0.009) 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) - 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**	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *d) Auxiliary features:* - 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		**outcomes:** NR **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	
Fortuna, Zhang, Ross-Degnan, et al., 2009 #265 **Comparison 1 of 2**	**Geographical location:** 14 sites in Massachusetts **Study dates:** 3/11/2007–3/10/2008 **General setting:** - Academic - Community **Specific setting:** Outpatient **Study design:** RCT, cluster	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:*	**Comparator(s):** Another CDSS/KMS <u>1) Computerized alerts only</u> 2) Computerized alerts plus physician-led educational sessions 3) Control—neither alerts nor educational sessions	**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: 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	**General comments:** Authors concluded that computerized decision support is an effective tool to reduce the prescribing of heavily marketed hypnotic medications in ambulatory settings **Quality assessment:**

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:** Clinic sites **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Clinic sites: 14 - Individual HCPs: > Clinicians, internal medicine including MDs, NPs, and PAs: 257 **User level of expertise/ proficiency:** NR	Synchronous **Decision support:** *Response requirement:* Mandatory response **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:** <u>Alerts only group</u> *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: 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		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) 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) - 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%)	Overall rating: Good **Applicability/ generalizability:** Commercially available system with locally developed modifications Desired outcome was reduction in number of prescriptions Sites have used an Epic EHR for all ambulatory patient encounters since 1997

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		c) Communication content features: - 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 *d) Auxiliary features:* - 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		- 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**	**Geographical location:** 14 sites in Massachusetts **Study dates:** 3/11/2007–3/10/2008 **General setting:** - Academic - Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic sites **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Clinic sites: 14 - Individual HCPs: > Clinicians, internal medicine including MDs, NPs, and PAs: 257 **User level of**	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **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:** <u>Alerts plus educational sessions</u> *a) General system features:*	**Comparator(s):** Another CDSS/KMS 1) Computerized alerts only <u>2) Computerized alerts plus physician-led educational sessions</u> 3) Control—neither alerts nor educational sessions	**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: 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 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) 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) - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care**	**General comments:** Authors concluded that computerized decision support is an effective tool to reduce the prescribing of heavily marketed hypnotic medications in ambulatory settings **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Commercially available system with locally developed modifications Desired outcome was reduction in number of prescriptions Sites have used an Epic EHR for all ambulatory patient encounters since

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	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: 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: Y - Provision of decision support results to patients as well as		**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%) - 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:** *a) Objective(s):* - Initiating discussion with patient - Preventive care *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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:** *a) General system features:* Integration with charting or order entry system to support workflow integration: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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
		d) Auxiliary features: - 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 *e) Other:* Allowed providers to specify or cancel sending patient reminders; including dates; protocols were modifiable without the assistance of programmers			
Frank, Litt, and Beilby, 2004 #4200	**Geographical location:** South Australia, Australia **Study dates:** NR **General setting:** Community **Specific setting:** - Outpatient - Acute and chronic **Study design:** RCT, parallel group	**Authors' basic description of system:** Opportunistic electronic reminders for preventive care in general practice. **Source/origin of system:** NR **Content:** *a) Objective(s):* - Immunization - Preventive care *b) Relationship to point of care:* NR **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: Opportunities taken for preventive activity; relative changes (RC) in preventive activity performed (95% CI)— Tetanus immunization: C = 222 of 15,089 (1.5%) I = 333 of 11,947 (2.8%) RC = 1.89 (1.59, 2.25) Recording of allergies: C = 682 of 13,713 (5.0%) I = 991 of 10,991 (9.0%) RC = 1.81(1.63, 2.02)	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Possible concealment issues because GPs were not blinded; no followup

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	*Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* NR **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: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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
		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 *d) Auxiliary features:* - 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		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	

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	**Geographical location:** Oslo, Norway Tromso, Norway **Study dates:** May 2002–Dec 2003 **General setting:** Community **Specific setting:** Outpatient **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: > Choice of antihypertensive drug (1,968 + 2,184 = 4,152) > Achievement of treatment goals (17,123 + 16,593 = 33,716) > Started on	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* - Pharmacotherapy - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **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	**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: 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 - Recommended clinical study ordered/completed: NR - 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 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 Prescribing of angiotensin II receptor blockers and alpha blockers— C = 945 of 1968 (48.0%) I = 876 of 2184 (40.1%) ICC = 0.084	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Investigators assessing outcomes and conducting analyses were blinded Block randomization with software allocation 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 This was a

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	medication for hypertension and/or hypercholesterolemia (3,316 + 2,863 = 6,179) - Clinics/practices/ hospitals: 146 practices (C = 73, I = 73) - Individual HCPs: > MDs: 501 (257 intervention, 244 control) **User level of expertise/ proficiency:** NR	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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y		RR (95% CI) = 1.21(1.101.30) P < 0.001 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 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 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 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 - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR	multifaceted intervention that included a comparison with baseline data captured 1 year prior to the intervention **Applicability/ generalizability:** Guidelines for antihypertensive and cholesterol-lowering drugs for the prevention of cardiovascular disease may vary in other countries. Study conducted in Norway Practices had to use one of two EHR systems that were compatible with the intervention software

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: Y - CDSS accompanied by conventional education: Y *e) Other:* Supplementary materials for patients were available for print out		**4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** - 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 **6) Impact on HCP use and implementation:** NR	
Gill, Chen, Glutting, et al., 2009 #181	**Geographical location:** 35 sites in US **Study dates:** Nov 1, 2005–Oct 31, 2006 **General setting:** - Academic - Community **Specific setting:** - Outpatient - Chronic	**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. **Source/origin of system:** Commercially available **Content:**	**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: 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	**General comments:** None **Quality assessment:** Overall rating: Poor Comments: Moderate baseline differences in provider and patient characteristics

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 centricity 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:** *Response requirement:* 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
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 *e) Other:* Supplementary materials (reporting tools, access to guidelines, Web sites for patient or physician education,		I = 64.7 C = 68.5 Low risk I = 87.9 C = 90.9 The proportion of patients at lipid goal in creased significantly for all groups except the moderate-risk intervention group. The proportion of high-risk patients on medication if not at goal increased significantly for both the intervention and control groups. Multivariate analysis: High risk (n = 4043) OR = 1.17 Moderate risk (n = 2383) OR = 0.29 Low risk (n = 1955) OR = 1.74 - 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	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:** *a) Objective(s):* - Pharmacotherapy - Chronic disease management - Preventive care *b) Relationship to point of care:* Not clearly described **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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
				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% - 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	multiple clinics Study conducted in Israel 6-month followup period
	User level of expertise/ proficiency: NR	**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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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 *e) Other:* Data integration from hospital discharge diagnosis database, laboratory database, and Clalit Health Services central pharmacy database			
Goud, de Keizer, ter Riet, et al., 2009 #490	**Geographical location:** 21 sites in Netherlands **Study dates:** January 2005–July 2006 **General setting:** - Academic - Community **Specific setting:** - Outpatient - Chronic **Study design:** RCT, cluster	**Authors' basic description of system:** 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. **Source/origin of system:** Locally developed	**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: 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)	**General comments:** None **Quality assessment:** Overall rating: Good Comments: Unknown followup data **Applicability/ generalizability:** Multicenter trials only took place in Netherlands

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:** *a) Objective(s):* - Chronic disease management - Preventive care *b) Relationship to point of care:* - Synchronous - Asynchronous **Decision support:** *Response requirement:* Justification for not complying **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Paper-based *b) Delivery mode:* User-initiated (“pull”) **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: N		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. 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. 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) - 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**	Participants received incentives such as reimbursement of the purchasing costs of CARDSS, free training, and helpdesk services

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *c) Communication content features:* - 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) Auxiliary features:* - 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		**implementation:** - 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) - 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	**Study dates:** Nov 2004–Jan 2007 **General setting:** Academic **Specific setting:** Inpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinician **Duration of intervention:** 26 months **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 **User level of expertise/ proficiency:**	included basic levels of clinical decision support to facilitate communication at the time of hospital discharge to patients, retail pharmacists, and community physicians. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Other—discharge planning *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* Not clearly described **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*		- 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) - Mortality: NR - Validated measure of HRQOL or functional status: NR - 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) **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: Effort for discharge planning—	**Quality assessment:** Overall rating: Good **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. Hospital had a standard medication reconciliation process in place Academic setting

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	*features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		Mean (SD) Control: 7.9 (2.1) Intervention: 6.5 (1.9) Difference (95% CI) = 1.4 (0.3 to 2.4) P value: 0.011 **4) Impact on relationship-centered outcomes:** - Patient satisfaction: Patient perception of discharge preparedness— Mean (SD) Control: 17.2 (4.0) Intervention: 17.7 (4.1) P value: 0.040 (95% CI: 0.006 to 0.288) P value: 0.042 (95% CI: 0.005 to 0.289) (adjusted) * When patient perception of discharge preparedness was the dependent variable, then physician level of training had a nonsignificant coefficient (P > 0.219) Patient satisfaction with medication information score— Mean (SD) Control: 12.1 (4.6) Intervention: 12.3 (4.8) P value: 0.587 (95% CI: -0.987 to 0.544) P value: 0.567 (95% CI: -0.937 to 0.513) (adjusted) * Physician level of training was nonsignificant in models of patient satisfaction with medication information (P > 0.068)	

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 *e) Other:* 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:** *a) Objective(s):* - Diagnosis - Lab test ordering *b) Relationship to point of care:* 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
	Clinician **Duration of intervention:** 7 months **Sample type(s) (with N randomized for each):** - Patients: 65 - Individual HCPs: > MDs: 17 (family medicine) **User level of expertise/ proficiency:** NR	*Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system (PDA) *b) Delivery mode:* User-initiated ("pull") **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - Provision of a		**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: NR - Implementation of CDSS/KMS: Increase use of cardiac stress testing due to PDA use (81% vs 50%)	method Unknown followup data **Applicability/ generalizability:** Small sample size Many physicians belonged to a research network

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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) Auxiliary features:* - 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			
Gurwitz, Field, Rochon, et al., 2008 #840	**Geographical location:** - Connecticut, US - Ontario, Canada **Study dates:** NR **General setting:** Academic **Specific setting:** Long-term facility **Study design:** RCT, cluster	**Authors' basic description of system:** Computerized provider order entry with clinical decision support for preventing adverse drug events in long-term care. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:*	**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: All adverse drug events— C = 340 (100%) Rate/100 resident-years = 10.4 I = 411 (100%) Rate/100 resident-years = 10.8 Rate ratio = 1.06 95% CI = 0.92 to 1.23	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Possible crossover contamination Unknown

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—resident care units **Duration of intervention:** Site 1 – 1 year Site 2 – 6 months **Sample type(s) (with N randomized for each):** - Patients: 1118 - Other: 29 resident care units **User level of expertise/ proficiency:** NR	Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated (“pull”) **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 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 *c) Communication content*		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 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 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 Less severe— C = 24 3(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 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	followup cases Only age as baseline characteristics **Applicability/ generalizability:** Baseline characteristics not reported No comorbid conditions or chronic disease reported Locally developed system implemented in two different geographic areas

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		features: - 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) Auxiliary features:* - 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
	Study design: RCT, cluster randomization **Unit of randomization:** Other—centers **Duration of intervention:** 25 months **Sample type(s) (with N randomized for each):** - Patients: 4993 - Clinics/practices/ hospitals: 7 **User level of expertise/ proficiency:** NR	**Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* User-initiated (“pull”) **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: N *b) Clinician-system interaction features:* - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of		**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: 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)	concealment not clearly described Baseline characteristics unknown **Applicability/ generalizability:** Reliability and ranges of the model

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Study dates:** - Phase 1: Aug 1–Sept 30, 1995 - Phase 2: Nov 10, 1995–March 21, 1996 **General setting:** Academic **Specific setting:** - Inpatient–ICU - Inpatient–non-ICU * Unclear if ICU or non-ICU **Study design:** RCT, parallel group **Unit of randomization:** Orders **Duration of intervention:** (Nonrandomized) Phase 2: 19 weeks **Sample type(s) (with N randomized for each):** - Patients: 491 (Phase 2) - Individual HCPs: > Training MDs > MDs: 127 (85 medicine physicians, 42 surgical physicians) > Nurses: 109 - Other: 864 films	radiographs (KUB) during the use of POE system by physicians. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Diagnosis - Other—radiograph ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated (“pull”) **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	1) Control: Phase 1 critique message 2) Intervention: amended evidence-based critique message	- Recommended preventive care ordered/completed: NR - 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 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%) - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care**	(randomized) merged; no acceptable comparator **General comments:** None **Quality assessment:** Overall rating: Fair Comments: Possible learning or Hawthorn effect due to the two phases Fairly similar baselines Blinding and concealment not reported **Applicability/ generalizability:** Study was conducted at Brigham and Women’s Hospital (academic medical center)

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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) Auxiliary features:* - 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		**delivery:** - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: NR **4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** - 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 **6) Impact on HCP use and implementation:** - HCP acceptance: Response to critique by provider type; does not make a distinction between Phase 1 or Phase 2 and control and intervention Medicine: 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%) Surgery:	
	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
				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%) 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%) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	
Heidenreich, Gholami, Sahay, et al., 2007 #1968	**Geographical location:** Palo Alto, CA **Study dates:** May 2001–Nov 2005 **General setting:** Academic **Specific setting:** - Inpatient–non-ICU - Outpatient	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):*	**Comparator(s):** Usual care/no CDSS or KMS	**1) Impact on clinical outcomes:** - 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 Hazard ratio = 0.99 95% CI = 0.83 to 1.18 - Mortality: NR - Validated measure of HRQOL or functional status: NR	**General comments:** No description of features associated with clinician-system interaction Control group also experienced increase in beta blocker use over time (55% in

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	- Chronic **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 4.5 years **Sample type(s) (with N randomized for each):** Patients: 1546 **User level of expertise/ proficiency:** NR	Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *Delivery format:* Paper-based *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: Can’t tell *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 the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision making: Y		- 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: Prescription for beta blocker at 9 months— I: 74%, 458 of 621, C: 66%, 428 of 650, p = 0.002 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 **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**	2001 versus 68% in 2004) **Quality assessment:** Overall rating: Good Comments: No significant baseline differences between control and intervention; adequate allocation concealment; computerized randomization; adequate intervention period (4.5 yr) **Applicability/ generalizability:** Implemented in a system (VA) where the infrastructure and familiarity with electronic medical records (EHR) and CDSS is extensive Study population was predominantly male and White

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 *c) Communication content features:* - 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) Auxiliary features:* - 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:** - 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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated (“pull”) **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: Can’t tell *b) Clinician-system interaction features:* - 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
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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
Hetlevik, Holmen, Kruger, et al., 2000 #5862	**Geographical location:** Norway **Study dates:** NR **General setting:** Community **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	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* 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:** 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: 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	**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 **Quality assessment:** Overall rating: Fair **Applicability/ generalizability:** 20 of 24 GPs judged the recommended procedures to be too time consuming

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		a) General system features: Integration with charting or order entry system to support workflow integration: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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			
Hicks, Sequist, Ayanian, et al., 2008 #1343	**Geographical location:** 14 sites in MA **Study dates:** July 1, 2003–February 1, 2005 **General setting:** - Academic - Community **Specific setting:** - Outpatient - Chronic **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic or team **Duration of intervention:** 18 months **Sample type(s) (with**	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* 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: 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 **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 **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 Intervention integrated into existing EHR and into the workflow

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	N randomized for each): - Patients: 2027 - Clinics: 14 **User level of expertise/ proficiency:** NR	*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 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 *c) Communication content features:* - 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		**6) Impact on HCP use and implementation:** NR	without the need for additional input from physician

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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			
Hobbs, Delaney, Carson, et al., 1996 #6704	**Geographical location:** Birmingham, UK **Study dates:** January–October 2002 **General setting:** Not clearly described **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic or team **Duration of**	**Authors' basic description of system:** Primed is a rule-based system that guides hyperlipidemia decisions in general practice. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Diagnosis - Lab test ordering - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* 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: 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 (χ^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:	**General comments:** None **Quality assessment:** Overall rating: Poor Comments: Uneven experimental group 8 of 25 dropped out (1 dispute, 1 lost data, 3 failed to record data, 3 lost data due to upgrades) 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
	intervention: 6 months **Sample type(s) (with N randomized for each):** Clinics/practices/ hospitals: 25 (I = 21, C = 4) **User level of expertise/ proficiency:** Practices with previous experience of DSS were excluded Staff attended a university training session ("Recruitment of the practices," page 134); no further information available	**Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* User-initiated ("pull") **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather		Practitioner knowledge of lipid disorders = 24 to 41.7% No distinction between control and intervention practices **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: 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 **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	concealment not described Outcome data were not adequately reported Learning bias (Discussion section, paragraph 2) **Applicability/ generalizability:** CDSS was built using legacy system; 6 months of intervention

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		than inaction: Can't tell - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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 *e) Other:* Hypertext functioned as an educational tool		control and intervention - 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) Objective(s):* - Chronic disease management - Initiating discussion with patient *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Online access *b) Delivery mode:* 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
		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 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 *c) Communication content features:* - 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		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. 192 (75.9%) of the intervention patients were as satisfied or more satisfied with their care since starting to use the tracker system. There were no statistically significant changes in quality-of-life measures, SF-12 and Diabetes-39. **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	**Applicability/ generalizability:** Short intervention period (6 months) Use of surrogate outcomes Participants were already using an EMR in practice

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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:** *a) Objective(s):* - Diagnosis - Preventive care *b) Relationship to point of care:* - Synchronous - Asynchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* 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
	Sample type(s) (with N randomized for each): - Clinics/practices/ hospitals: 19 - Patients: 38,147 **User level of expertise/ proficiency:** NR	*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 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 *c) Communication content features:* - 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		**implementation:** NR **Other (clinical and process outcomes):** Incidence of cardiovascular events: rate ratio = 0.96, 95% CI = 0.85 to 1.10, P = 0.59	already on the CHD Register) - Sudden death from cardiovascular disease **Quality assessment:** Overall rating: Fair Comments: Baseline characteristics of study population not described; blinding and concealment methods not reported **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 Unable to

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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	**Geographical location:** Worcester, MA **Study dates:** March 2002–March 2003 **General setting:** Academic **Specific setting:** Long-term care facility **Study design:** RCT, parallel group **Unit of randomization:** Resident care units of a long-term care facility **Duration of intervention:** 12 months **Sample type(s) (with N randomize** Clinics/practices/ hospitals: 7 resident care units **User level of expertise/ proficiency:** High	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* 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:** 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: 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) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	**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 **Quality assessment:** Overall rating: Fair **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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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: 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:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:*	**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
	each): > MDs: 107 family practitioners > Practices: 66 **User level of expertise/ proficiency:** Family practitioners were instructed on using computer reminder as well as patient reminder form	Integrated with CPOE/EHR *b) Delivery mode:* User-initiated ("pull") **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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: N - Justification of decision support via provision of		**6) Impact on HCP use and implementation:** NR	software Additional stipulation was that the HCPs receive the laboratory glucose results electronically, which a vast majority of them did

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) Auxiliary features:* - 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:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* 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
	Duration of intervention: 2 months **Sample type(s) (with N randomized for each):** - MDs: 107 family practitioners - Practices: 66 **User level of expertise/ proficiency:** Family practitioners were instructed on using computer reminder as well as patient reminder form	**Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated ("pull") **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 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 *c) Communication content features:* - Provision of a		**4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	practitioners used the same commercially available EHR software Additional stipulation was that the HCPs receive the laboratory glucose results electronically, which a vast majority of them did

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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) Auxiliary features:* - 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 3 of 3**	**Geographical location:** Auckland, New Zealand **Study dates:** NR **General setting:** -Community **Specific setting:** - Outpatient - Chronic **Study design:**	**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	**Comparator(s):** 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 = 19,187patients; 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	**General comments:** None **Quality assessment:** Overall rating: Good Methods used for randomization were adequate **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
	RCT, cluster randomization **Unit of randomization:** Clinician **Duration of intervention:** 2 months **Sample type(s) (with N randomized for each):** - MDs: 107 family practitioners - Practices: 66 **User level of expertise/ proficiency:** Family practitioners were instructed on using computer reminder as well as patient reminder form	**Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* - User-initiated ("pull") **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 the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision		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	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 Additional stipulation was that the HCPs receive the laboratory glucose results electronically, which a vast majority of them did

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		making: Y - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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) Auxiliary features:* - 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			
Khan, Maclean, and Littenberg, 2010 #14627 **AND**	**Geographical location:** 38 practices in Vermont and 26 in NY **Study dates:** Observed for at least 24 months	**Authors' basic description of system:** Decision support system designed to help primary care providers and their diabetes patients achieve guideline-based treatment targets.	**Comparator(s):** Usual care/no CDSS or KMS	**1) Impact on clinical outcomes:** - Length of stay: All subjects: Inpatient length of stay (days) — Control: 1.1 Intervention: 0.99 P = 0.01 Seniors (age 65 years and up):	**General comments:** None **Quality assessment:** Overall rating: Good

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 **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic or team **Duration of intervention:** NR **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 **User level of expertise/ proficiency:** NR	**Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *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: N *b) Clinician-system interaction features:* - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of the		Inpatient length of stays (days)— Control: 1.44 Intervention: 1.22 P = 0.002 Age < 65 years: Inpatient length of stay (days)— Control: 0.84 Intervention: 0.79 P < 0.25 Men: Inpatient length of stay (days)— Control: 1.10 Intervention: 0.94 P = 0.03 Women: Inpatient length of stay (days)— Control: 1.10 Intervention: 1.05 P = 0.15 - Morbidity: All subjects: Number of inpatient admissions (hospitalization)— Control: 0.20 Intervention: 0.17 P = 0.01 All subjects: Number of emergency department visits— Control: 0.36 Intervention: 0.27 P < 0.0001 Seniors (age 65 years and up): Number of inpatient admissions— Control: 0.27 Intervention: 0.21	**Applicability/ generalizability:** Locally developed intervention evaluated in a multisite trial across two states; some baseline differences between the control and intervention group

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 - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: N *c) Communication content features:* - 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) Auxiliary features:* - 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: Y - CDSS accompanied by conventional education: N		P =0.001 Seniors (age 65 years and up): Number of emergency department visits— Control: 0.36 Intervention: 0.21 P < 0.001 Age < 65 years: Number of inpatient admissions— Control: 0.15 Intervention: 0.13 P < 0.31 Age < 65 years: Number of emergency department visits— Control: 0.37 Intervention: 0.33 P < 0.11 Men: Number of inpatient admissions— Control: 0.21 Intervention: 0.17 P = 0.02 Men: Number of emergency department visits— Control: 0.36 Intervention: 0.23 P < 0.0001 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
				Women: Number of emergency department visits— Control: 0.37 Intervention: 0.30 P = 0.01 - Mortality: NR - 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 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 Quality of life at followup survey (n = 658)— Audit of diabetes dependent quality of dife (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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				- Adverse events: NR **2) Impact on health care process outcomes:** - Recommended preventive care ordered/completed: NR - 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)	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				- 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: 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
				Intervention: $2572.14 P = 0.30 Age < 65 years: Emergency department charges— Control: $391.76 Intervention: $334.03 P = 0.07 Men: Inpatient charges— Control: $3712.22 Intervention: $3098.26 P = 0.03 Men: Emergency department charges— Control: $410.91 Intervention: $299.18 P < 0.0001 Women: Inpatient charges — Control: $3265.12 Intervention: $3128.00 P = 0.21 Women: Emergency department charges— Control: $417.45 Intervention: $307.80 P < 0.009 - Cost-effectiveness: NR **6) Impact on HCP use and implementation:** NR	
Kline, Zeitouni, Hernandez-	**Geographical location:**	**Authors' basic description of system:**	**Comparator(s):** Usual care/no	**1) Impact on clinical outcomes:** - Length of stay: Median length of	**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:** *a) Objective(s):* Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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	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
		order entry system to support workflow integration: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support results to patients as well as providers: Y		**4) Impact on relationship-centered outcomes:** - Patient satisfaction: Satisfaction with clinician explanation of the problem— Control: 38% Intervention: 49% (95% CI for the difference = 0.9% to 21.0%) **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
		- CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: N			
Krall, Traunweiser, and Towery, 2004 #4293	**Geographical location:** Portland, OR **Study dates:** Jan 15–Feb 16, 2000 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 1 month **Sample type(s) (with N randomized for each):** - Patients: 10,972 - Individual HCPs: > MDs/DOs (family practice and internal medicine): 73 > PAs/NPs: 27	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** Mandatory response **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:*	**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: 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 **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:** Short-term intervention—1 month **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Early adopter of CDSS; short study duration (1 month)

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	> Nurses **User level of expertise/ proficiency:** Comprehensive EMR since 1994	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 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) *c) Communication content features:* - 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 *d) Auxiliary features:* - 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: 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 *e) Other:* Two clicks were required for the clinicians to complete the recommended aspirin order			
Kucher, Koo, Quiroz, et al., 2005 #3517	**Geographical location:** Boston, MA **Study dates:** 9/2000–1/2004 **General setting:** Academic **Specific setting:** Inpatient medical and surgical services **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:**	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care—ordering DVT prophylactic measures *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response	**Comparator(s):** Usual care/no CDSS or KMS Design: eligible patients randomized to have alerts generated for their providers versus no such alerts	**1) Impact on clinical outcomes:** - 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 ($p < 0.001$) 30-day outcomes— DVT: Intervention: 3.3% Control: 5.7%, $p = 0.004$ PE: Intervention: 0.8% Control: 1.7%, $p = 0.05$ - Mortality: Death at 90 days— Intervention: 22.5% Control: 22.3%, $p = 0.74$ Death at 30 days—	**General comments:** Well-designed study with adequate intervention and followup periods **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Early adopter of CDDS Locally developed system Use of relevant,

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	40 months **Sample type(s) (with N randomized for each):** Patients: 2506 **User level of expertise/ proficiency:** Users already using CPOE/EHR	**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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather		Intervention: 13.9% Control: 12.5%, p = 0.56 - Validated measure of HRQOL or functional status: NR - Adverse events: NR **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 **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	valid, and reproducible 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
		than inaction: Y - Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y *d) Auxiliary features:* - 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			
Kuperman, Teich, Tanasijevic, et al., 1999 #5941	**Geographical location:** Boston, MA **Study dates:** 12/1/1994–1/31/1995 and 9/1/1995–10/30/1995 **General setting:** Academic **Specific setting:** Inpatient–non-ICU **Study design:** RCT, parallel group	**Authors' basic description of system:** A computer system to detect critical conditions and automatically notify the responsible physician via the hospital's paging system. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Other—action in response to a critical laboratory value *b) Relationship to point of care:* Synchronous	**Comparator(s):** Usual care/no CDSS or KMS	**1) Impact on clinical outcomes:** - 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: Adverse events among alerting situations (including death)— Control: 27 of 98 (28% per patient) Intervention: 31 of 94 (33% per patient), p = 0.41 **2) Impact on health care process**	**General comments:** None **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Academic setting Early adopter of DCSS 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
	Unit of randomization: Patient **Duration of intervention:** 4 months **Sample type(s) (with N randomized for each):** Alerts: 192 **User level of expertise/ proficiency:** Clinical alerting system that had been in use since June 1994	**Decision support:** *Response requirement:* - Mandatory response **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Other—pager *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 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)		**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 **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	system

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		c) Communication content features: - 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 *d) Auxiliary features:* - 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			
Lee, Chen, Currie, et al., 2009 #312	**Geographical location:** New York, NY **Study dates:** 1/1/2006–8/31/2006 **General setting:** Academic **Specific setting:** Outpatient	**Authors' basic description of system:** A personal digital assistant–based log with and without obesity decision support features. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):*	**Comparator(s):** Another CDSS/KMS (no CDSS for obesity, but CDSS for smoking cessation)	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - 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%) ($p < 0.001$)	**General comments:** None **Quality assessment:** **Overall rating:** **Fair** Comments: Nonblinded participants and

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* Not clearly described **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: N *b) Clinician-system interaction features:* - 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		- 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	outcome assessors; ambiguous reporting of methods **Applicability/ generalizability:** Student nurses as participants Standalone PDA CDSS No patient-centered outcomes
	Study design: RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 8 months **Sample type(s) (with N randomized for each):** - Individual HCPs: > Training Nurses (acute and family): 29 - Other: 1874 patient encounters **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				

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: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** - 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
	Academically-affiliated community practices **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Practice **Duration of intervention:** 9 months **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) **User level of expertise/ proficiency:** Clinicians received an introductory email, one practice visit by an investigator, and periodic emails to	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. (2) Second, for smokers clinicians received various tobacco treatment reminders. (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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Diagnosis - Pharmacotherapy - Chronic disease management *b) Relationship to point of care:*		- 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 **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: 44% (90 of 207) of intervention clinicians used the Tobacco Smart Form at least once - Implementation of CDSS/KMS: NR	documentation. Even though the study was positive, the absolute magnitude of the impact of the intervention was relatively modest. **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** The practices had used an EMR for a number of years previously Included residents Portions of the intervention have been implemented into other EHRs

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	Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* - System-initiated (“push”) - User-initiated (“pull”) (icons were available to users, who then needed to take action in order to fully initiate the process) **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 (reminders, Yes; form, Can’t tell) *b) Clinician-system interaction features:* - Automatic provision of decision support as part of clinician workflow: N - No need for additional clinician data entry: N - Request documentation of			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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
		system containing more than		**outcomes:**	
#7057	**Study dates:** May 1–Oct 31, 1989 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Other—half-day practice session **Duration of intervention:** 6 months **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)	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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Lab test ordering - Preventive care *b) Relationship to point of care:* - Synchronous **Decision support:** *Response requirement:* - Justification for not complying - Mandatory response (nurse/clerk will return incomplete form) **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* System-initiated ("push") **Contextual factors/features**	1) CDSS prints out patient-specific data for each reminder with explanation 2) The comparator is the same CDSS with modifications for the 3 prevention tests targeted for the study; FOBT, mammography, and pap test	- 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 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 Mammography— All physicians: I = 54% C = 47% P = 0.036 Residents only: I = 55% C = 45% P = 0.013	**Quality assessment:** Overall rating: Fair Comments: Randomization by block (half-day practice sessions); possible contamination between physicians during change over New physicians may be added to the session Different practicing patterns between faculty and residents **Applicability/ generalizability:** Regenstrief Medical Record System locally developed Experiment conducted in an academic environment; population may

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:** *a) General system features:* Integration with charting or order entry system to support workflow integration: N *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:*		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
		- 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 *e) Other:* Contains summary of the patient's recent study test results		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) - 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
Lo, Matheny, Seger, et al., 2009 **#748**	**Geographical location:** Boston, MA **Study dates:** 7/21/03–1/20/04 **General setting:** - Community - Academic **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Patients: 2765 - Clinics: 22 - Individual HCPs: 366 (191 control, 175 intervention) - Events: 3673 **User level of expertise/**	**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). 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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:**	**Comparator(s):** Usual care (usual care included access to the EMR, but without the alerts)	**1) Impact on clinical outcomes:** NR **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 **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:** 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 **Quality assessment:** Overall rating: Good Comments: The primary analysis was via logistic regression, which was necessary to control for baseline differences between the groups **Applicability/ generalizability:** These practices had used an EMR for a number of years; 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
	proficiency: NR	*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: N *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 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 *c) Communication content features:* - 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
		support via provision of reasoning: N - Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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			
Lobach and Hammond, 1994 #7001	**Geographical location:** Durham, NC **Study dates:** 9/93–2/94 **General setting:** Academic **Specific setting:** Outpatient, chronic disease management **Study design:** RCT, parallel group **Unit of randomization:** Clinician	**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. 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"). **Source/origin of system:** Locally developed **Content:**	**Comparator(s):** Usual care	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - 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 **3) Impact on workload, efficiency, and organization of health care delivery:** NR **4) Impact on relationship-centered**	**General comments:** The clinical meaning of the primary outcome variable is uncertain **Quality assessment:** Overall rating: Good Comments: Compliance was assessed using chart audit It was not clear precisely how the physician-level

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: 497 - Clinics/practices/ hospitals - Individual HCPs: > Training MDs: 10 > MDs: 20 - Events 1265 **User level of expertise/ proficiency:** NR	*a) Objective(s):* - Lab test ordering - Chronic disease management - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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: N *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 the reason for not following		**outcomes:** NR **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	compliance scores, which were reported as percent compliance, were calculated 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? **Applicability/ generalizability:** The idea could be used elsewhere, but the implementation was dependent on the peculiarities of this particular EMR Guideline recommendations based on the American Diabetes

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: N *c) Communication content features:* - 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) Auxiliary features:* - 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 *e) Other:* Providers could enter data elements that were not automatically captured by the EMR (e.g., foot exams, laboratory tests performed			Association Single clinic

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
Locatelli, Covic, Macdougall, et al., 2009 #220	**Geographical location:** 53 centers in 8 European countries (Bulgaria, Croatia, Germany, Italy, Latvia, Poland, Romania and Serbia, Montenegro) **Study dates:** Enrollment was completed in 9/2005 **General setting:** - Academic - Community **Specific setting:** - Outpatient (nephrology care centers) - Chronic care **Study design:** RCT, cluster randomization **Unit of randomization:** Center **Duration of intervention:** 6 to 8 months **Sample type(s) (with N randomized for each):**	**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. **Source/origin of system:** NR **Content:** *a) Objective(s):* Chronic disease management (primary, the description of the system was too sketchy to determine whether the system had other objectives) *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* Can't tell **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: 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 **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 paper is extremely sketchy regarding the details of the intervention and somewhat sketchy about how the statistical analyses were performed **Quality assessment:** Overall rating: Fair Comments: Details about the intervention were uncertain. No blinding Uncertain how patients with missing values were analyzed The funding sponsor identified the selection of centers and was responsible for data collection and data management

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	- Patients: 599 - Clinics: 53 **User level of expertise/ proficiency:** NR	**implementation and use of CDSS/KMS:** *a) General system features:* Integration with charting or order entry system to support workflow integration: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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			Interpretation of data was performed with close collaboration between the steering committee and the sponsor **Applicability/ generalizability:** These clinics are unlikely to reflect practice in the US; recommendations were based on the European Best Practices Guidelines

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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:** *a) Objective(s):* - Pharmacotherapy - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* 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	*b) Delivery mode:* User-initiated ("pull") **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: Can't tell *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 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 *c) Communication content features:* - 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) Auxiliary features:* - 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) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *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: 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:** *a) Delivery format:* Standalone system *b) Delivery mode:* User-initiated ("pull") **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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
		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 *d) Auxiliary features:* - 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			
Martens, van der Aa, Panis, et al., 2006 #3066 **AND** **Martens, van der Weijden, Severens, et al., 2007** #1633	**Geographical location:** Netherlands **Study dates:** 10/03–4/04 **General setting:** - Academic - Community **Specific setting:** Outpatient **Study design:** RCT, cluster	**Authors' basic description of system:** 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	**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: No differences between groups were found for indicators and volumes related to recommendations advocating certain drugs Although there was a tendency toward	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Lots of providers and practices were ultimately excluded Study was

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:** Clinic or team (practice) **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Practices: 23 - Individual HCPs: > MDs: 53 general practitioners **User level of expertise/ proficiency:** Physicians received individual instruction when the system was installed in the practice	consistent with guidelines. Not explicitly stated whether the reminders could be ignored, or how well the system was integrated with the existing EMR. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **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		clinically relevant results for prescription volumes that were supposed to drop, the difference in sum score between the groups was not significant. 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. Cholesterol sum score prescriptions per 1000 patients per GP: All nonsignificant - 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: 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	underpowered **Applicability/ generalizability:** A somewhat awkward and probably poorly integrated intervention, tested outside the US Physicians were already experienced users of an EHR Prescribing guidelines were set by a regional multidisciplinary committee of opinion leaders (pharmacists, GPs, hospital staff) and prevailing EBM

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		b) Clinician-system interaction features: - 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: N - CDSS accompanied by periodic performance		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. - 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	**Geographical location:** Boston, MA **Study dates:** 1/1/04–6/30/04 **General setting:** - Academic - Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Patients: 1922 - Clinics: 20 - MDs: 303 - Other: 2507 clinic visits	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:*	**Comparator(s):** Usual care/no CDSS or KMS (usual care includes a general EMR)	**1) Impact on clinical outcomes:** NR **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). 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. - 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: The authors partially attribute the negative results to a ceiling effect, the passive nature of the reminders, and guideline overload **Applicability/ generalizability:** Participants were already experienced users of the EMR Practices were part of a health system that has historically been 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
		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: 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 *c) Communication content features:* - 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		**6) Impact on HCP use and implementation:** NR	
	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
		research evidence: N *d) Auxiliary features:* - 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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:*	**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
		Synchronous		change their decision (15.2% KL/MDX, 13.7% KL/SKL, p = 0.7)	**generalizability:** Academic setting
	Sample type(s) (with N randomized for each): - Clinics: 18	**Decision support:** *Response requirement:* No response requirement		- 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	Early adopters of CDSS
	User level of expertise/ proficiency: NR	**Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated (“pull”)			
		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		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	
		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 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		- 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 Usage was statistically significantly higher among those randomized to Micromedex compared to SkolarMD (median 0.56 versus 0.42 uses/month, p = 0.01) - Implementation of CDSS/KMS: NR	
		c) Communication content			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		features: - 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 *d) Auxiliary features:* - 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
	Unit of randomization: Patient **Duration of intervention:** 8 month(s) **Sample type(s) (with N randomized for each):** - Patients: 226 - Visits: 601 **User level of expertise/ proficiency: NR**	**Content:** *a) Objective(s):* - Lab test ordering - Pharmacotherapy *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *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: Can’t tell *b) Clinician-system interaction features:* - 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		- Recommended treatment ordered/prescribed: Clinicians appropriately changed drug regimen— Intervention: 28% (31 of 110) Control: 13% (9 of 68) p = 0.026 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 - 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:** Good applicability, with pertinent findings

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		recommendations: N - Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: N *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** - 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	**Study dates:** Circa 2000 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, cluster **Unit of randomization:** Practice **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Patients: 477 - Practices: 46 **User level of expertise/ proficiency:** NR	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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* User-initiated (“pull”) **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: N		Admissions Control (n = 330): 4 (1%) Intervention (n = 147): 0 OR = 0 (0 to 3.44) - 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: 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) - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR	**Quality assessment:** Overall rating: Fair Comments: Only 17 of 46 practices completed the study, with greater dropout in the intervention group **Applicability/ generalizability:** A rudimentary standalone system tested outside the US

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		b) Clinician-system interaction features: - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		**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: 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. 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. - 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	**Geographical location:** Indianapolis, IN **Study dates:** 1980 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Team **Duration of intervention:** 2 years **Sample type(s) (with N randomized for each):** - Patients: 12,467 - Teams: 27 - Individual HCPs: 115 residents, 11 faculty members, 4 nurse-clinicians **User level of expertise/ proficiency:** NR	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Immunization - Pharmacotherapy - Lab test ordering - Chronic disease management - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* System-initiated ("push")	**Comparator(s):** Another CDSS/KMS Same EMR but with reminders turned off	**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 **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 ($P < 0.001$) 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). 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 ($p < 0.01$). - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR	**General comments:** Intervention included 1491 rules that could generate 751 unique reminder messages **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Good, despite the passage of time

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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		**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: 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 ($p < 0.001$). 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. Among study residents, the physicians' intentions predicted their behavior, explaining 33% of the variance in response rate across the various actions ($p < 0.03$, $r^2 = 0.33$). - 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
		d) Auxiliary features: - 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	
McDonald, Hui, and Tierney, 1992 #7115	**Geographical location:** Indianapolis, IN **Study dates:** Winters from 1978 to 1981 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinician **Duration of intervention:**	**Authors' basic description of system:** On top of the EMR, computerized reminders regarding influenza vaccinations were appended. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Immunization *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:*	**Comparator(s):** Another CDSS/KMS The comparator was the EMR but without the reminders regarding preventive care, specifically influenza vaccination	**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 ($P < 0.001$). - Length of stay: NR - Morbidity: Hospitalization— 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%	**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. **Quality assessment:** Overall rating: Good. **Applicability/ generalizability:** Academic setting

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 *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: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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
		support via provision of reasoning: N - Justification of decision support via provision of research evidence: Can't tell *d) Auxiliary features:* - 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		**2) Impact on health care process outcomes:** - 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% ($p < 0.001$) - 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	

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:** *a) Objective(s):* - Immunization - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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 (χ^2 = 40.7, 1df, p < 0.001) Difference among 3 intervention groups (χ^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
		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 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in		- 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. **6) Impact on HCP use and implementation:** NR	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:** *a) Objective(s):* - Immunization - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement)	**Comparator(s):** Usual care/no CDSS or KMS 1) Intervention 1 = Reminder by letter 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 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
	each): - Patients: 1,420 - Clinics/practices/ hospitals: 6 **User level of expertise/ proficiency:** NR	**Information delivery:** *a) Delivery format:* Paper-based *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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather		**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 - 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. **6) Impact on HCP use and implementation:** NR	concealment were not reported **Applicability/ generalizability:** Academic medical center Short study duration 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
		than inaction: N - Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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			
McDowell, Newell, and Rosser, 1986 #7366 **Comparison 3 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	**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:** *a) Objective(s):*	**Comparator(s):** Usual care/no CDSS or KMS 1) Intervention 1 = Reminder by letter 2) Intervention 2 = Telephone reminder by nurse 3) Intervention 3 = Personal reminder by physician (CDSS)	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - 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 ($z = 3.4$, $p < 0.005$)	**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

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: Family **Duration of intervention:** 10 weeks **Sample type(s) (with N randomized for each):** - Patients: 1,420 - Clinics/practices/ hospitals: 6 **User level of expertise/ proficiency:** NR	- Immunization - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Paper-based *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 the reason for not following CDSS recommendations: N - Provision of decision support at time and location of decision	Control 1 = Randomized control group Control 2 = Control practices	Rates of vaccination for patients contacted who had not been vaccinated before the trial—Intervention 3: 46 of 102 (45.1%) - 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 - 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. **6) Impact on HCP use and implementation:** NR	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 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
		making: Y - Recommendations executed by noting agreement: N *c) Communication content features:* - 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) Auxiliary features:* - 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	**Geographical location:** 6 sites in Ottawa, Canada **Study dates:** 1985 **General setting:** Academic **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):** - Patients: 1406 - Clinics: 4 **User level of expertise/ proficiency:** NR	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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	**Comparator(s):** Usual care/no CDSS or KMS 4 arms: 1) Physician reminder (n = 332) 2) Letter reminder (n = 367) 3) Telephone reminder (n = 377) 4) No intervention control (n = 330)	**1) Impact on clinical outcomes:** NR **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% 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). 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%)	**General comments:** 4 arms but only one aimed at MD and one control **Quality assessment:** Overall rating: Fair Comments: Possible contamination, inadequate reporting of methods and results, inadequate statistical analysis **Applicability/ generalizability:** Multiple interventions aimed at patients and nurses; Canadian practices

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: Can't tell - Provision of decision support results to patients as well as		- 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 - Cost-effectiveness: Cost including staff and material costs— 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 Letter reminder cost (including stationery, stamps, prepaid replies, 158 followup letters, and clerical staff to assemble the letters was $444.06 Telephone reminder cost was $196 to call 280 women (salary of $15 an hour); Cost per screening gained was $11.26 for a nurse salary $10 per hour; $4.38 for a nurse salary $5 per hour **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
		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) Objective(s):* Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:*	**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
	- Patients: 6167 families; 8298 patients - Practices: 6 **User level of expertise/ proficiency:** NR	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 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 *c) Communication content features:* - 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		**3) Impact on workload, efficiency, and organization of health care delivery:** - Number of patients seen/unit time: NR - Clinician workload: NR - Efficiency: NR **4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** - 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 **6) Impact on HCP use and implementation:** NR	results, inadequate statistical analysis **Applicability/ generalizability:** Multiple interventions aimed at patients and nurses; Canadian practices

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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* 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
	Duration of intervention: 12 weeks **Sample type(s) (with N randomized for each):** Patients: 4507 patient admissions; 2237 to intervention and 2270 to control **User level of expertise/ proficiency:** High	*Response requirement:* NR (unclear whether response requirement) **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 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 *c) Communication content features:*		ordered/completed: NR - 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 **3) Impact on workload, efficiency, and organization of health care delivery:** - 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. **4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** - 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
		- 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 *d) Auxiliary features:* - 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	**Geographical location:** 6 clinics in the US **Study dates:** NR **General setting:** NR **Specific setting:** Outpatient **Study design:** RCT, cluster	**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 ≥ 95th percentile, then "AB" was displayed next to the value as an abnormal flag. **Source/origin of system:** Locally developed	**Comparator(s):** Group 1: Paper normative pediatric BP table affixed to the growth chart Group 2: PDA Group 3: Usual care	**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:**	**General comments:** None **Quality assessment:** Overall rating: Poor Comments: 4 clinics dropped from study.

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:** Clinic or team **Duration of intervention:** NR **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] **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.	**Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* -Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Standalone system *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: N *b) Clinician-system interaction features:* - 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		NR **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 - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	Unknown number of pediatricians (from 40) left in the pool of clinicians accepted for randomization. Missing outcome data; no discussion of randomization, blinding, or allocation concealment process **Applicability/ generalizability:** Multisite trial across pediatric clinics Locally developed PDA application Included residents, but exact number was unclear

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		at time and location of decision making: Y - Recommendations executed by noting agreement: N *c) Communication content features:* - 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: N *d) Auxiliary features:* - 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			
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 1) Intervention 1 = CDSS + cardiovascular	**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	**General setting:** Community **Specific setting:** - Outpatient - Chronic **Study design:** RCT, cluster randomization **Unit of randomization:** Clinic or team **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Patients: 614 - Clinics/practices/ hospitals: 27 - Individual HCPs: > MDs: 74 GP > Practice nurse: 11 **User level of expertise/ proficiency:** GPs and nurses were trained to use the computer-based CDSS by one of the authors	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. 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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* - Diagnosis - Pharmacotherapy *b) Relationship to point of care:* Not clearly described **Decision support:** *Response requirement:* NR (assume no response	risk chart 2) Intervention 2 = cardiovascular risk chart Control = usual care	ordered/completed: NR - Recommended treatment ordered/prescribed: Number (%) of patients prescribed different numbers of cardiovascular drugs at baseline and 6-month followup— 0-1 classes of drugs: Intervention 1 (n = 207): 81 (39) Control (n = 137): 50 (37) 2 classes of drugs: Intervention 1: 74 (36) Control: 47 (34) More than 3 classes of drugs: Intervention 1: 52 (25) Control: 40 (29) - 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	Fair Comments: Simple randomization using table random numbers. GPs, nurses, and patients were not blinded Greater than 10% attrition rate at 12-month followup Outcomes not consistently reported **Applicability/ generalizability:** The use of New Zealand guidelines may affect adoption in other care providers Only involved general practice Only older patients involved in the study (60 to 80 years old)

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated ("pull") **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: 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: N			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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) Auxiliary features:* - 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 2) Intervention 2 = cardiovascular risk chart 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— 0-1 classes of drugs: 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
	randomization **Unit of randomization:** Clinic or team **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Patients: 614 - Clinics/practices/ hospitals: 27 - Individual HCPs: > MDs; 74 GP > Practice nurse: 11 **User level of expertise/ proficiency:** GPs and nurses were trained to use the computer based CDSS by one of the authors.	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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* - Diagnosis - Pharmacotherapy *b) Relationship to point of care:* Not clearly described **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated ("pull")		2 classes of drugs: Intervention 2: 67 (32) Control: 47 (34) More than 3 classes of drugs: Intervention 2: 73 (35) Control: 40 (29) - 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	patients were not blinded Greater than 10% attrition rate at 12-month followup Outcomes not consistently reported **Applicability/ generalizability:** The use of New Zealand guidelines may affect adoption in other care providers Only involved general practice. Only older patients involved in the study (60 to 80 years old)

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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: 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 *c) Communication content features:* - 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
		d) Auxiliary features: - 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:** *a) Objective(s):* Chronic disease management (hypertension) *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:*	**Comparator(s):** Usual care/no CDSS or KMS 2 x 2 factorial design: 1) Control (n = 171) <u>2) 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 ± 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 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
		Integrated with CPOE/EHR *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of CDSS/KMS:** <u>Physician Intervention:</u> *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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y		Dual intervention (n = 116): 38 ± 22 - 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: n = 171 Physician intervention: n = 181 Pharmacist intervention: n = 180 Dual intervention: n = 180 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 ± 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) Mean patient adherence score ± SD: Control: 26 ± 33 Physician: 29 ± 36 Pharmacist: 25 ± 33 Dual: 35 ± 39 Start or increase ACE inhibitor, # (%) of patients with any suggestion:	
	Sample type(s) (with N randomized for each): Patients: 712 **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
		- Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: Y *d) Auxiliary features:* - 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		Control: 91 (53) Physician: 92 (51) Pharmacist: 89 (42) Dual: 96 (53) Mean patient adherence score ± SD: Start or increase ACE inhibitor: Control: 30 ± 46 Physician: 44 ± 50 Pharmacist: 33 ± 47 Dual: 41 ± 49 Start diuretic, # (%) of patients with any suggestion: Control: 58 (34) Physician: 55 (30) Pharmacist: 54 (30) Dual: 52 (29) Mean patient adherence score ± SD: Control: 31 ± 47 Physician: 22 ± 42 Pharmacist: 22 ± 42 Dual: 25 ± 44 Start or increase calcium channel blocker, # (%) of patients with any suggestion: Control: 51 (30) Physician: 56 (31) Pharmacist: 38 (21) Dual: 46 (26) Mean patient adherence score ± SD: Control: 49 ± 51 Physician: 34 ± 48 Pharmacist: 47 ± 51 Dual: 39 ± 49 Start or increase β-blocker, # (%) of patients with any suggestion: Control: 20 (12)	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				Physician: 31 (17) Pharmacist: 35 (14) Dual: 34 (19) Mean patient adherence score ± SD: Control: 45 ± 51 Physician: 45 ± 51 Pharmacist: 29 ± 46 Dual: 47 ± 51 - 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 (mean ± SD): Total charges— 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	

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 **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	**Pharmacist intervention** **Authors' basic description of system:** Computer-based pharmacist intervention for hypertension management. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management (hypertension) *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* 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:**	**Comparator(s):** Usual care/no CDSS or KMS 2 x 2 factorial design: 1) Control (n = 171) 2) Physician intervention (n = 181) 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 ± 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	**General comments:** None **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
		Pharmacist Intervention: *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 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in		- Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed— Control: n = 171 Physician intervention: n = 181 Pharmacist intervention: n = 180 Dual intervention: n = 180 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 ± 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) Mean patient adherence score ± SD: Control: 26 ± 33 Physician: 29 ± 36 Pharmacist: 25 ± 33 Dual: 35 ± 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 ± SD: Control: 30 ± 46 Physician: 44 ± 50 Pharmacist: 33 ± 47 Dual: 41 ± 49	

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		Start diuretic, # (%) of patients with any suggestion: Control: 58 (34) Physician: 55 (30) Pharmacist: 54 (30) Dual: 52 (29) Mean patient adherence score ± SD: Control: 31 ± 47 Physician: 22 ± 42 Pharmacist: 22 ± 42 Dual: 25 ± 44 Start or increase calcium channel blocker, # (%) of patients with any suggestion: Control: 51 (30) Physician: 56 (31) Pharmacist: 38 (21) Dual: 46 (26) Mean patient adherence score ± SD: Control: 49 ± 51 Physician: 34 ± 48 Pharmacist: 47 ± 51 Dual: 39 ± 49 Start or increase β-blocker, # (%) of patients with any suggestion: Control: 20 (12) Physician: 31 (17) Pharmacist: 35 (14) Dual: 34 (19) Mean patient adherence score ± SD: Control: 45 ± 51 Physician: 45 ± 51 Pharmacist: 29 ± 46 Dual: 47 ± 51 - Impact on user knowledge: NR	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				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 (mean ± SD): Total charges— 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	
Murray, Harris, Overhage, et al., 2004 #4153	**Geographical location:** Indianapolis, IN **Study dates:** January 1, 1994–May	**Dual intervention** **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:	**1) Impact on clinical outcomes:** - Length of stay: NR - Morbidity (all hospitalizations)— Control: 0.25 ± 0.89 Physician: 0.25 ± 0.69	**General comments:** None **Quality assessment:**

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) **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	for hypertension management. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management (hypertension) *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* 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:** <u>Dual Intervention:</u> *a) General system features:* Integration with charting or order entry system to support workflow integration: Y *b) Clinician-system interaction features:* - Automatic provision of	1) Control (n = 171) 2) Physician intervention (n = 181) 3) Pharmacist intervention (n = 180) <u>4) Dual intervention [physician + pharmacist] (n = 180)</u>	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 ± 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 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed— Control: n = 171 Physician intervention: n = 181 Pharmacist intervention: n = 180 Dual intervention: n = 180	Overall rating: Good Comments: Potential for contamination, 1 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
		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 *c) Communication content features:* - 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) Auxiliary features:* - 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 ± 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) Mean patient adherence score ± SD: Control: 26 ± 33 Physician: 29 ± 36 Pharmacist: 25 ± 33 Dual: 35 ± 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 ± SD: Control: 30 ± 46 Physician: 44 ± 50 Pharmacist: 33 ± 47 Dual: 41 ± 49 Start diuretic, # (%) of patients with any suggestion: Control: 58 (34) Physician: 55 (30) Pharmacist: 54 (30) Dual: 52 (29) Mean patient adherence score ± SD: Control: 31 ± 47 Physician: 22 ± 42	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				Pharmacist: 22 ± 42 Dual: 25 ± 44 Start or increase calcium channel blocker, # (%) of patients with any suggestion: Control: 51 (30) Physician: 56 (31) Pharmacist: 38 (21) Dual: 46 (26) Mean patient adherence score ± SD: Control: 49 ± 51 Physician: 34 ± 48 Pharmacist: 47 ± 51 Dual: 39 ± 49 Start or increase β-blocker, # (%) of patients with any suggestion: Control: 20 (12) Physician: 31 (17) Pharmacist: 35 (14) Dual: 34 (19) Mean patient adherence score ± SD: Control: 45 ± 51 Physician: 45 ± 51 Pharmacist: 29 ± 46 Dual: 47 ± 51 - 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 (mean ± SD): Total charges—	

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 #7209 **Comparison 1 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 **User level of expertise/ proficiency:** NR	**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) Objective(s):* - Lab test ordering - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of CDSS/KMS:** *a) General system features:*	**Comparator(s):** Usual care/no CDSS or KMS Control <u>1) Intervention 1 = MD reminders</u> 2) Intervention 2 = MD+PT reminders 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 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 to16.8), 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

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 *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 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support results to patients as well as		- 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) Rescheduled— Cholesterol = 182 (10) FOBT = 172 (9)	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
		providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		Mammography = 148 (14) Pap Smear = 248 (22) Tetanus = 281 (12) Total = 1027 (13) Not indicated— Cholesterol = 472 (25) FOBT = 320 (18) Mammography = 183 (18) Pap smear = 356 (32) Tetanus = 646 (28) Total = 1977 (24) Patient refused— Cholesterol = 44 (2) FOBT = 48 (3) Mammography = 183 (18) Pap smear = 32 (3) Tetanus = 135 (6) Total = 442 (5) Did not discuss— Cholesterol = 394 (21) FOBT = 379 (21) Mammography = 251 (24) Pap smear = 158 (14) Tetanus = 593 (26) Total = 1775 (22) Blank— Cholesterol = 145 (8) FOBT = 133 (7) Mammography = 61 (6) Pap smear = 66 (6) Tetanus = 192 (8) Total = 597 (7) - 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
				- 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) Objective(s):* - Lab test ordering - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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 2) Intervention 2 = MD+PT reminders 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	*a) General system features:* Integration with charting or order entry system to support workflow integration: Can't tell *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support		- 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) Rescheduled— Cholesterol = 182 (10)	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
		results to patients as well as providers: N - CDSS accompanied by periodic performance feedback: N - CDSS accompanied by conventional education: Y		FOBT = 172 (9) Mammography = 148 (14) Pap Smear = 248 (22) Tetanus = 281 (12) Total = 1027 (13) Not indicated— Cholesterol = 472 (25) FOBT = 320 (18) Mammography = 183 (18) Pap smear = 356 (32) Tetanus = 646 (28) Total = 1977 (24) Patient refused— Cholesterol = 44 (2) FOBT = 48 (3) Mammography = 183 (18) Pap smear = 32 (3) Tetanus = 135 (6) Total = 442 (5) Did not discuss— Cholesterol = 394 (21) FOBT = 379 (21) Mammography = 251 (24) Pap smear = 158 (14) Tetanus = 593 (26) Total = 1775 (22) Blank— Cholesterol = 145 (8) FOBT = 133 (7) Mammography = 61 (6) Pap smear = 66 (6) Tetanus = 192 (8) Total = 597 (7) - HCP satisfaction: NR	

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:** *a) Objective(s):* - Lab test ordering - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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 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 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:** *a) General system features:* Integration with charting or order entry system to support workflow integration: Can't tell *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		Rescheduled— Cholesterol = 182 (10) FOBT = 172 (9) Mammography = 148 (14) Pap Smear = 248 (22) Tetanus = 281 (12) Total = 1027 (13) Not indicated— Cholesterol = 472 (25) FOBT = 320 (18) Mammography = 183 (18) Pap smear = 356 (32) Tetanus = 646 (28) Total = 1977 (24) Patient refused— Cholesterol = 44 (2) FOBT = 48 (3) Mammography = 183 (18) Pap smear = 32 (3) Tetanus = 135 (6) Total = 442 (5) Did not discuss— Cholesterol = 394 (21) FOBT = 379 (21) Mammography = 251 (24) Pap smear = 158 (14) Tetanus = 593 (26) Total = 1775 (22) Blank— Cholesterol = 145 (8) FOBT = 133 (7) Mammography = 61 (6) Pap smear = 66 (6) Tetanus = 192 (8)	

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) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Paper-based *b) Delivery mode:* 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	**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 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 *c) Communication content features:* - 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 *d) Auxiliary features:*			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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:** *a) Objective(s):* - Pharmacotherapy - Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR	**Comparator(s):** Usual care/no CDSS or KMS	**1) Impact on clinical outcomes:** - 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:** - 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
	each): - Patients: 2181 (for which 1686 had at least one order written) - Training MDs, internal medicine: 86 **User level of expertise/ proficiency:** NR	*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 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 *c) Communication content features:* - 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 < 0.0001 Hospital stay compliance— Intervention: 55.9% Control: 37.1% 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: 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 **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
		- Justification of decision support via provision of research evidence: Y *d) Auxiliary features:* - 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			
Palen, Price, Snyder, et al., 2010 #14780	**Geographical location:** 8 sites in Denver, Colorado **Study dates:** January 2005-September 2007 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:**	**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. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response	**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: - Recommended clinical study ordered/completed: Rate of completed D-dimer tests per 1000 visits among patients 65 years and older— Intervention clinics: Prealert: 5.02 Postalert:1.52 (95% CI -4.20 to –2.80; P < 0.001) Control clinics: Prealert: 2.11 Postalert: 0.81 (95% CI -1.79 to -0.80; P <.001).	**General comments:** Single crossover cluster randomization was the actual study type **Quality assessment:** Overall rating: Fair Comments: Some patient baseline differences Outcome assessors not blind to

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 **Duration of intervention:** 19 month(s) **Sample type(s) (with N randomized for each):** Clinics/practices/ hospitals: 8 **User level of expertise/ proficiency:** NR	requirement) **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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y		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) Control clinics: Prealert: 3.84 Postalert: 4.35 (95% CI, -0.460 to 0.460) - 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	intervention status Simple cluster by assigning half to control and intervention—not true randomization **Applicability/ generalizability:** Large multisite trial 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
		- 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) Auxiliary features:* - 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:** *a) Objective(s):* Lab test ordering	**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: 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
	randomization: Clinician **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Patients: 26,586 - Individual HCPs, internal medicine and family practice: 207 **User level of expertise/ proficiency:** Intervention physicians received one-on-one training	*b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement (nonintrusive alerts) **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 the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed		**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
		by noting agreement: N *c) Communication content features:* - 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) Auxiliary features:* - 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) Objective(s):* - Diagnosis - Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Standalone system *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		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%) <u>OR (95% CI) P value</u> 1.48 (1.03 to 2.11) 0.033 1.48 (0.95 to 2.29) 0.082 (adjusted)	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
		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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		- 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: Direct costs in Euros, mean (SD) per patient— Control: 37.9 (54.2) Intervention: 40.2 (57.6) P value: 0.473 Overall side effect costs in Euros, mean (SD) per patient— Control: 99.5 (1154.0) Intervention: 100.1 (1085.1) P value: 0.960 Ecological costs in Euros, mean (SD) per patient— Control: 499.3 (414.1) Intervention: 439.5 (388.4) P value: 0.002 Total antibiotic costs in Euros, mean (SD) per patient— Control: 623.2 (502.2) Intervention: 565.4 (483.4) P value: 0.007 - 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
		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) Objective(s):* Chronic disease management: *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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 ± 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:** *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:*		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
		- 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		SBP < 130 Intervention: 45% Control: 40.6% P < 0.001 LDL < 100 Intervention: 43% Control: 35.5% 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	
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:** - 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
	Specific setting: - Inpatient–ICU - Inpatient–non-ICU **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 9 months **Sample type(s) (with N randomized for each):** - Patients: 2987 - Individual HCPs: 778 **User level of expertise/ proficiency:** NR	advisor follows guidelines for elderly patients. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* 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		ordered/prescribed: Physicians used recommended doses— Intervention: 28.6% Control: 24.1% P < 0.001 - 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: Poor description of control group, contamination, low use by MD, inadequate reporting of methods and results **Applicability/ generalizability:** One academic center Proxy decisionmakers existed Well-established 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
		- 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* - Pharmacotherapy - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of CDSS/KMS:**	**Comparator(s):** 2 x 2 factorial design: 1) Control <u>2) Reminders only</u> 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 <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	**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	<u>Computerized reminders-only group</u>: *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: 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 *c) Communication content features:* - 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) Auxiliary features:*		feedback + reminders group than among controls (P < 0.001 for both), but not in the reminders-only group compared with controls (P = 0.06). 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). 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). 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,	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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)		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). - 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	

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 2 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 about the trial	**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. 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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Pharmacotherapy - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement	**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 + feedback: -0.0808, 0.46 - 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 + feedback group at baseline: -0.0204, 0.95 Reminders + feedback group during intervention period: 0.0125, 0.89 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 feedback + reminders group than	**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
		Information delivery: *a) Delivery format:* Paper-based *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of CDSS/KMS:** <u>Computerized reminders + feedback group</u>: *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: 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 *c) Communication content features:* - Provision of a		among controls (P < 0.001 for both), but not in the reminders-only group compared with controls (P = 0.06). 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). 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). 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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) Auxiliary features:* - 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)		the intervention site but did not change in other primary care sites (final A1C 7.5 vs. 8.2%, *P* = 0.001). - 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	
Player, Gill, Mainous et al., 2010 #14814	**Geographical location:** 27 sites in US States not reported **Study dates:** NR **General setting:** NR **Specific setting:** - Outpatient - Chronic **Study design:**	**Authors' basic description of system:** An EMR-based tool incorporating decision support for diagnosis and treatment of Gastro-esophageal reflux disease (GERD). **Source/origin of system:** Commercial **Content:** *a) Objective(s):* - Diagnosis	**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: Percentage of total patients newly diagnosed with GERD— Intervention (n = 24,111): 3.06% Control (n = 29,926): 2.33% P < 0.01	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: No concealment and blinding information

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	- RCT, cluster randomization **Unit of randomization:** - Clinic or team **Duration of intervention:** NR **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 **User level of expertise/ proficiency:** NR	- Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **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 the reason for not following CDSS recommendations: N - Provision of decision support at time and location of		Odds ratio (CI 95%): 1.33 (1.13 to 1.56) 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) - 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) 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) Percentage of patients newly prescribed GERD medications among those experiencing atypical symptoms without prior GERD prescription— Intervention (n = 2532): 8.81%	No baseline information >10 % of patients were not followed up **Applicability/ generalizability:** Large sample of patient population Large number of study sites including rural, suburban, and urban practices Study clinics had been using the Centricity office EMR for at least one year

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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 **General setting:** NR **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 2 months **Sample type(s) (with N randomized for each):** - Patients: 80 - Individual HCPs: 8 **User level of expertise/ proficiency:** High	**Source/origin of system:** Commercially available (Palm OS PDA) **Content:** *a) Objective(s):* Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system (Palm Pilot) *b) Delivery mode:* User-initiated (“pull”) **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: N *b) Clinician-system interaction features:* - Automatic provision of decision support as part of clinician workflow: N		ordered/completed: Control: n = 40 Intervention: n = 39 Cervical cancer: 88% 100% Hyperlipidemia: 64% 94% Colorectal cancer: 38% 65% Prophylaxis with aspirin: 33% 81% Hypertension: 97% 94% - 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	**assessment:** Overall rating: Poor Comments: Small; nonblinded; contamination; physicians selected patients nonrandomly; nonrandom, selected subset of users **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
		- 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Geographical location:** Denver, CO **Study dates:** 5/18/05–5/17/06 **General setting:** Academic **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):** Patients: 59,680 **User level of expertise/ proficiency:** NR	**Authors' basic description of system:** Computerized pharmacy alert system plus collaboration between health care professionals in decreasing potentially inappropriate medication dispensing in elderly. **Source/origin of system:** Not clearly described **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **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	**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: 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 **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:** Monitored 11 medications inappropriate for elderly patients **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** One Kaiser group, all patients older than age 65 Very low rate of inappropriate medications used Only looked at prescriptions written and not sold

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* 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
		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 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 *c) Communication content features:* - 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
		- Justification of decision support via provision of research evidence: Can't tell *d) Auxiliary features:* - 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			
Raebel, Lyons, Chester, et al., 2005 #3125	**Geographical location:** Denver, CO **Study dates:** 9/9/02–12/31/03 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of**	**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. **Source/origin of system:** Not clearly described **Content:** *a) Objective(s):* Lab test ordering	**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: 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 - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR	**General comments:** Studied 15 medications **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Physicians, patients, and pharmacists blinded to study group 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
	intervention: 16 months **Sample type(s) (with N randomized for each):** Patients: 10,169 **User level of expertise/ proficiency:** NR	*b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **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 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		**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
		c) Communication content features: - 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 *d) Auxiliary features:* - 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	**Geographical location:** Melbourne, Australia **Study dates:** NR **General setting:** Academic **Specific setting:**	**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.	**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: Overall documented clinical intervention rate— Intervention: 1.74 per 100 patients (95% CI 1.55, 1.93) Control: 0.91 (0.77, 1.05)	**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
	Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Pharmacy **Duration of intervention:** 6 weeks **Sample type(s) (with N randomized for each):** - Pharmacies: 15 Intervention: 31 pharmacies Usual care: 21 pharmacies - Pharmacists: 150 **User level of expertise/ proficiency:** NR	**Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system-pharmacy system *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		Mann–Whitney U-test, P < 0.001 Intervention— 2.55 aspirin treatment per 100 diabetic patients - 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	**generalizability:** Community-based pharmacies not linked to medical record; not blinded

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *c) Communication content features:* - 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) Auxiliary features:* - 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	Pittsburgh, PA **Study dates:** NR; recruitment started between April 1997 and December 1998 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinician **Duration of intervention:** 20 months **Sample type(s) (with N randomized for each):** - Patients: 212 - Individual HCPs: > MDs: 16 internists **User level of expertise/ proficiency:** NR	EMR system generates interactive email alert (flag) to notify PCPs when the mood module identifies a patient as having major depression. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* Diagnosis *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Email *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:*	CDSS or KMS All received email alert “flag”— 1) Intervention 1 (active): Reminder plus patient-specific recommendation on paper/online encounter form; also, electronic prompts to schedule followup appointment 2) Intervention 2 (passive): Reminder on paper encounter form; no other intervention prompts 3) Control: usual care Note that the analysis did not compare findings across groups, so only a single evidence table was prepared for this study	**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: 3 days after notification— Agree: 120 of 186 (65%) Disagree: 24 of 186 (13%) Uncertain: 42 of 186 (23%) 1 month after notification— Agree: 147 of 186 (71%) Disagree: 34 of 186 (16%) Uncertain: 27 of 186 (13%) 154 days after notification— Agree: 166 of 186 (78%) Disagree: 36 of 186 (17%) Uncertain: 10 of 186 (5%) “There were no differences in the agreement rate or treatments provided across guideline exposure conditions.” Stratification of results by intervention groups were done in graph format; actual value not available	The email alert flag required a response (per procedure paragraph 1); justification via interactive email sent after the initial response (per procedure paragraph 2) The email alert flag was asynchronous; the reminder plus patient-specific recommendation (active) on paper/online encounter form was synchronous Authors’ description seems to suggest that email alerts and paper encounter forms were used to remind physicians **Quality assessment:** Overall rating: Poor Comments:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 (Note: researcher has to enter "major depression" manually into the problem list and forward a flag to the clinic's scheduling secretary; page 190). *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in development process: N - Provision of decision support		- HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	Interviewer (outcome assessor) masked to randomization status of a patient's PCP. PCPs were not blinded to their assignment condition Small sample size (physicians) 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 15 of 227 (7%) patients dropped out. Did not adequately report outcome according to intervention groups

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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:*	**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
		Integrated with CPOE/EHR		**outcomes:** NR	
	Sample type(s) (with N randomized for each): - Patients: > Computerized decision support intervention: 66 patients > Paper-based: 54 patients - Individual HCPs: > Training MDs: 6 fellows >MDs: 5 intensive care > Nurses: 93 **User level of expertise/ proficiency:** Trained very well	*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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision		**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
		support via provision of reasoning: Can't tell - Justification of decision support via provision of research evidence: Can't tell *d) Auxiliary features:* - 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			
Rosser, Hutchison, McDowell, et al., 1992 #7131	**Geographical location:** Ottawa, Ontario, Canada **Study dates:** 4/1/85–3/1/86 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient	**Authors' basic description of system:** 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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):*	**Comparator(s):** Usual care/ no CDSS or KMS 4 arms, 3 of which involved computerized reminder systems: 1) Control 2) Physician reminders 3) Telephone reminders 4) Letter	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - 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	**General comments:** After adjusting for multiple comparisons, the intervention groups differed from the randomized controls but not from each other **Quality assessment:** Overall rating: Poor Comments:

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		Immunization *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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: 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	reminders Data from a nonrandomized sample were reported as well	- 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 - 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. 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. Letter reminder group— The cost for each additional vaccination recorded was $6.05. **6) Impact on HCP use and implementation:** NR	Incomplete reporting of methods and results; potential for contamination across intervention arms **Applicability/ generalizability:** Study conducted in Canada in 1985 Patient computer database since 1976
	Duration of intervention: 12 months **Sample type(s) (with N randomized for each):** - Patients: 5589 - Clinics: 4 - Individual HCPs: > Training: 12 to 16 > MDs: 4 > Nurses: 4 **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
		by noting agreement: N *c) Communication content features:* - 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) Auxiliary features:* - 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
	Specific setting: Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Patients: 5589 - Clinics: 4 - Individual HCPs: > Training: 12 to 16 > MDs: 4 > Nurses: 4 **User level of expertise/ proficiency:** NR	the patient intervention groups, patients were either contacted by telephone (practice nurse attempted a maximum of 5 calls) or by letter. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Immunization - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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:*	1) Control 2) Physician reminders 3) Telephone reminders 4) Letter reminders Data from a nonrandomized sample were reported as well	Physician reminder 22.9 Letter reminder: 35.2 Telephone reminder: 37.0 Measure blood pressure: Nonrandomized control: 18.6 Randomized control: 21.1 Physician reminder 30.7 Letter reminder: 40.5 Telephone reminder: 37.2 Assess smoking status: Nonrandomized control: 9.5 Randomized control: 11.9 Physician reminder 37.9 Letter reminder: 49.1 Telephone reminder: 55.8 Obtain Papanicolau smear: Nonrandomized control: 11.2 Randomized control: 13.7 Physician reminder 16.5 Letter reminder: 29.7 Telephone reminder: 30.0 Administer tetanus vaccine: Nonrandomized control: 2.3 Randomized control: 3.2 Physician reminder 22.8 Letter reminder: 30.6 Telephone reminder: 24.0 - Recommended clinical study ordered/completed: NR - Recommended treatment ordered/prescribed: NR - Impact on user knowledge: NR **3) Impact on workload, efficiency,**	from each other **Quality assessment:** Overall rating: Poor Comments: Incomplete reporting of methods and results; potential for contamination across intervention arms **Applicability/ generalizability:** Study conducted in Canada in 1985 Patient computer database since 1976

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		**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
Rossi and Every, 1997 #6440	**Geographical location:** - Puget Sound VA - Seattle, WA **Study dates:** 3/96–8/96 **General setting:** VA **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Patients: 719 - Individual HCPs: > General internal medicine: 71 > Training MDs: 44 > MDs: 15 > NPs : 12 **User level of**	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* - Justification for not complying **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* System-initiated ("push")	**Comparator(s):** Usual care (although usual care at this site involved a sophisticated EMR)	**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 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 **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: 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:	**General comments:** None **Quality assessment:** Overall rating: Good Comments: An excellent study in all its elements. The authors provide some informal cost and cost-effectiveness numbers in the discussion section. **Applicability/ generalizability:** Participants had to already be successful users of a sophisticated EMR VA setting

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	**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 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 *c) Communication content features:* - 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		33 (10%) - 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
		d) Auxiliary features: - 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 *e) Other:* 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			
Rothschild, McGurk, Honour, et al., 2007 #2216	**Geographical location:** Boston, MA **Study dates:** April 2003–June 2004 **General setting:** Academic **Specific setting:** Inpatient **Study design:** RCT, cluster	**Authors' basic description of system:** 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. **Source/origin of system:** Locally developed	**Comparator(s):** 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: Transfusion guideline adherence, decision support-evaluated orders— Final total appropriateness ratings, appropriate (%):	**General comments:** Very stringent criteria were used to classify orders as appropriate. Study also included a posteducation phase; table only presents data for the DS intervention

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:** Clinician **Duration of intervention:** 4 months **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 **User level of expertise/ proficiency:** NR	**Content:** *a) Objective(s):* Transfusion ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Justification for not complying **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: N - Request documentation of the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision		Assigned staff: 343 (32.6) Housestaff control: 503 (32.5) Housestaff intervention: 546 (40.4) Final total appropriateness ratings, inappropriate (%): Assigned staff: 708 (67.4) Housestaff control: 1043 (67.5) Housestaff intervention: 804 (59.6) DS-agree orders: Assigned staff: 321 Housestaff control: 470 Housestaff intervention: 411 Chart review confirms DS-agree: Assigned staff: 238 Housestaff control: 349 Housestaff intervention: 305 Chart review changes to DS-disagree: Assigned staff: 83 Housestaff control: 121 Housestaff intervention: 106 DS-disagree orders: Assigned staff: 730 Housestaff control: 1,076 Housestaff intervention: 939 Chart review changes to DS-agree appropriate (%): Assigned staff: 105 (14.4) Housestaff control: 154 (14.3) Housestaff intervention: 108 (11.5) Chart review confirms DS-disagree inappropriate (%): Assigned staff: 625 (85.6)	**Quality assessment:** Overall rating: Good **Applicability/ generalizability:** 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
		making: Y - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 (although the trial was preceded by an education period)		Housestaff control: 922 (85.7) Housestaff intervention: 698 (74.3) - 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: Physicians accepted 14% (133 of 939) of new DS-recommended orders, especially recommendations to increase transfusion doses (73%) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	
Roukema, Steyerberg, van der Lei, et al., 2008	**Geographical location:** Rotterdam, Netherlands **Study dates:**	**Authors' basic description of system:** All patients were followed with the basic CDS, which required approximately 2 minutes for	**Comparator(s):** Usual care (with the other components of the CDS	**1) Impact on clinical outcomes:** - 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	**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
#1540	9/1/03–12/31/05 **General setting:** NR **Specific setting:** Emergency department **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 28 months **Sample type(s) (with N randomized for each):** Patients: 164 **User level of expertise/ proficiency:** Nurses received training on how to use system	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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Diagnosis (or risk assessment preliminary to a diagnosis) - Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **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:**	working)	median length of stay at the ED in the control group was 123 (83–179) minutes. - Morbidity: NR - 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: Adherence to the advice to order laboratory tests— Intervention: 82% (61 of 74) Control: 44% (40 of 90) $p < 0.001$, x^2 test - 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	**assessment:** Overall rating: Good 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 **Applicability/ generalizability:** Study conducted in the Netherlands Study aim is of limited applicability in the U.S.

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		a) General system features: Integration with charting or order entry system to support workflow integration: Can't tell *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 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in development process: Y - 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: 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) Objective(s):* - Chronic disease management - Pharmacotherapy *b) Relationship to point of care:* Not clearly described **Decision support:** *Response requirement:* NR (assume no response requirement)	**Comparator(s):** Usual care (included an EMR) Three groups were compared, including two interventions: 1) Provider education (control) 2) Provider education + alert 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
	assigned to groups - Individual HCPs: 205 randomized, 182 included (101 staff physicians, 36 residents, 45 NPs/PAs) **User level of expertise/ proficiency:** High; must already be users of a sophisticated EMR	**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:** <u>Provider education + alert group:</u> *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 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 *c) Communication content features:* - Provision of a recommendation, not just an		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) - 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		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 *d) Auxiliary features:* - 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			
Roumie, Elasy, Greevy, et al., 2006 #2556 **Comparison 2 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:**	**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	**Comparator(s):** Usual care (included an EMR) Three groups were compared, including two interventions: 1) Provider education (control) 2) Provider	**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	**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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	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 assigned to groups - Individual HCPs: 205 randomized, 182 included (101 staff physicians, 36 residents, 45 NPs/PAs) **User level of expertise/ proficiency:** High; must already be users of a sophisticated EMR	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) Objective(s):* - Chronic disease management - Pharmacotherapy *b) Relationship to point of care:* Not clearly described **Decision support:** *Response requirement:* NR (assume no response requirement) **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:** **Contextual factors/features influencing the implementation and use of CDSS/KMS:**	education + alert 3) Provider education + alert + patient education	(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, 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) - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR	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
		Provider education + alert + patient education group: *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:*		**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
		- 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) Objective(s):* 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:** - 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
	N randomized for each): - Patients: 1768 patients enrolled, 1645 patients analyzed - Clinics/practices: 20 **User level of expertise/ proficiency:** NR	*b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* User-initiated (“pull”) **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: N *b) Clinician-system interaction features:* - 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		**5) Impact on economic outcomes:** NR **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	sound. **Applicability/ generalizability:** This is not an intervention that is likely to be used in the U.S.

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) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Geographical location:** 12 rural areas of Utah and Idaho **Study dates:** 1/01–9/03 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Community **Duration of intervention:** 2 years **Sample type(s) (with N randomized for each):** 12 communities **User level of expertise/ proficiency:** NR	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Diagnosis - Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:*	**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: 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. 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. 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	**General comments:** The study also had a community intervention that is not relevant for our purposes **Quality assessment:** Overall rating: Fair Comments: The complex and difficult-to-follow statistical analyses probably do not help get around the fact that there were only 12 communities studied **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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		User-initiated ("pull") **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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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		community with a population size equal to the mean of the CDSS group. - 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: 71% of physicians in the intervention communities used the decision support system - Implementation of CDSS/KMS: NR	acceptable, even for underresourced rural practices

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 *d) Auxiliary features:* - 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 *e) Other:* 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.			
Schriefer, Landis, Turbow, et al., 2009 #326	**Geographical location:** Western NC **Study dates:** Early 2006 **General setting:** Academic	**Authors' basic description of system:** In addition to height and weight, for intervention patients the EMR additionally calculated BMI. **Source/origin of system:** NR **Content:**	**Comparator(s):** 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: Obese patients in the intervention group were more likely than controls to receive a diagnosis of	**General comments:** The methods did not mention that physicians were prompted to take any action as a result of a high BMI

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Specific setting: Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Team **Duration of intervention:** 2 months **Sample type(s) (with N randomized for each):** - Patients: 846 - Individual HCPs: > Family medicine: 37 (13 faculty, 24 residents) **User level of expertise/ proficiency:** NR	*a) Objective(s):* - Diagnosis - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **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 the reason for not following CDSS recommendations: N		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) - 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	**Quality assessment:** Overall rating: Good Comments: Not knowing whether the intervention prompted physicians into action limits the ability to interpret the results **Applicability/ generalizability:** A single practice, plus an intervention that could easily be strengthened by adding some recommendations

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Geographical location:** 20 sites in MA **Study dates:** October 2002–April	**Authors' basic description of system:** An integrated, patient-specific electronic clinical reminder system on diabetes and coronary artery disease (CAD).	**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: Diabetes—	**General comments:** Both groups received paper-based reminders

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 **Specific setting:** - Outpatient - Chronic **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 6243 (4549 patients with diabetes, 2199 patients with coronary artery disease [CAD]) - Clinics/practices/ hospitals: 20 - Individual HCPs: > MDs: 194 primary care physicians **User level of expertise/ proficiency:** NR	**Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Pharmacotherapy - Lab test ordering - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Paper-based *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		Annual cholesterol exam: Baseline = 4957 (58%) Enrolled = 1185 (14%) Hazard ratio (95% CI) = 1.41 (1.15-1.72) P < 0.001 Biennial hemoglobin A1c exam: Baseline = 4868 (57%) Enrolled = 2245 (26%) Hazard ratio (95% CI) = 1.14 (0.89-1.46) P = 0.29 Annual dilated eye exam: Baseline = 1464 (17%) Enrolled = 4049 (47%) Hazard Ratio (95% CI) = 1.38 (0.81-2.32) P = 0.23 CAD— Annual cholesterol exam: Baseline = 5039 (53%) enrolled = 1151 (12%) Hazard Ratio (95% CI) = 0.99 (0.75-1.29) P = 0.92 - 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)	**Quality assessment:** Overall rating: Poor Comments: Clinically significant difference in baseline (race and insurance status) Table 2 contains results that combine both intervention and control arms 255 PCPs were surveyed: 159 (62%) responded (Intervention, 78; Control, 81) **Applicability/ generalizability:** Locally developed system Primary care physicians practicing at all 20 centers received electronic reminders in their practice

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 *c) Communication content features:* - 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) Auxiliary features:* - 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 *e) Other:*		P = 0.10 Statin use for LDL cholesterol ≥130mg/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 Statin use for LDL cholesterol ≥130mg/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	previously 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
		- 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)		**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: 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	
Sequist, Zaslavsky, Marshall, et al., 2009 #616	**Geographical location:** 11 sites in MA **Study dates:** April 200 –June 2007 **General setting:** Community **Specific setting:**	**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	**Comparator(s):** Usual care/no CDSS or KMS; patient mailing intervention group	**1) Impact on clinical outcomes:** - 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:	**General comments:** Two types of intervention: patient mailing and physician electronic reminders Results of patient intervention are

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** 15 months **Sample type(s) (with N randomized for each):** - Patients: 21,860 - Clinics/practices/ hospitals: 11 - Individual HCPs: > MDs: 110 primary care physicians **User level of expertise/ proficiency:** Physicians in both intervention and control groups were educated about electronic reminders via a 1-hour presentation and discussion	user when placing orders. **Source/origin of system:** Commercially available **Content:** *a) Objective(s):* - Lab test ordering - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response (active) **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		I: 17 (0.2%) C: 17 (0.2%) Percentage point difference (95% CI) = 0.0 (-0.1 to 0.1) P = 0.99 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 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 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 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	not included in this abstraction 43 of 55 physicians in the intervention group surveyed; only 33 responded **Quality assessment:** Overall rating: Fair Comments: Patients in the intervention group and control group were similar for both the patient-level and physician-level randomizations Interaction of patient and physician intervention status possibly affecting outcomes (results indicated that it is not statistically significant) 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
		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 (active) *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 *e) Other:* Passive and active alerts are available		**2) Impact on health care process outcomes:** - Recommended preventive care ordered/completed: Receipt of colorectal cancer screening by intervention status (all patients: N = 21,860)— Physician reminder group: I: 41.9% C: 40.2% Percentage point difference (95% CI) = 1.6 (-2.7 to 5.9) P = 0.47 0 primary care visits, N = 7643: I: 19.1% C: 16.0% Percentage point difference (95% CI) = 3.0 (-1.1 to 7.2) P = 0.15 1 to 2 primary care visits, N = 9011: I: 53.2% C: 51.5% Percentage point difference (95% CI) = 1.6 (-3.8 to 7.1) P = 0.56 More than 3 primary care visits, N = 5206: I: 59.5% C: 52.7% Percentage point difference (95% CI) = 6.0(-0.5 to 12.5) P = 0.07 Patient mailing intervention group: I: 44% C: 38.1% Percentage point difference: 5.8 (4.5, 7.1)	differences **Applicability/ generalizability:** Integrated medical groups using advanced electronic health record Use of EHR in ambulatory settings since 1997

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				P < 0.001 0 primary care visits, N = 7643: I: 19.6% C: 15.6% Percentage point difference (95% CI) = 3.9(2.2 to 5.6) P < 0.001 1 to 2 primary care visits, N = 9011: I: 55.6% C: 49.0% Percentage point difference (95% CI) = 6.6 (4.7 to 8.4) P <0.001 More than 3 primary care visits, N = 5206: I: 59.5% C: 52.3% Percentage point difference (95% CI) = 7.1 (4.4 to 9.8) P < 0.001 Types of colorectal cancer screening tests - 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:**	

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) Objective(s):*	**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)— #, ± SD, mean (25-75% quartiles): Control (n = 1911): 16.7, ± 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
		Pharmacotherapy		Intervention (n = 1345): 11.3, ± 19.9, 3.0 (1.0-11)	
	Study design: RCT, parallel group	*b) Relationship to point of care:* Synchronous		- Impact on user knowledge: NR	No patient-centered outcomes
	Unit of randomization: Clinician	**Decision support:** *Response requirement:* Mandatory response		**3) Impact on workload, efficiency, and organization of health care delivery:** NR	
	Duration of intervention: 7 months	**Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR		**4) Impact on relationship-centered outcomes:** NR	
	Sample type(s) (with N randomized for each): - Patients: 1798 - Individual HCPs: 396 MDs - Events: 5536	*b) Delivery mode:* System-initiated (“push”)		**5) Impact on economic outcomes:** NR	
	User level of expertise/ proficiency: All users familiar with CPOE	**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		**6) Impact on HCP use and implementation:** NR	
		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 the reason for not following CDSS recommendations: Y - Provision of decision support at time and location of decision making: Y - Recommendations executed			

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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Geographical location:** Oregon and Washington **Study dates:** November 2000–June 2004	**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.	**Comparator(s):** Another CDSS/KMS 1) Control is drug-specific computerized alert system	**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	**General comments:** None **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
	General setting: Community **Specific setting:** Outpatient **Study design:** Designed as cluster RCT, but data not analyzed as such **Unit of randomization:** Practice **Duration of intervention:** 18 months **Sample type(s) (with N randomized for each):** - Patients: 30,924 - Clinics/practices/ hospitals: 15 - Individual HCPs: 126 MDs **User level of expertise/ proficiency:** Familiar with CPOE	**Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **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: Can’t tell - Request documentation of the reason for not following	2) Intervention is age/drug-specific computerized alert system	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 **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: Data not analyzed and reported according to a priori analytic plan **Applicability/ generalizability:** Locally developed system Control arm was a previously implemented CDSS No patient-centered results

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		CDSS recommendations: N - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Y *c) Communication content features:* - 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 *d) Auxiliary features:* - 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	**Geographical location:** NR **Study dates:** NR	**Authors' basic description of system:** In the EMR intervention, a patient-specific electronic	**Comparator(s):** Another CDSS/KMS	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** 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
#440	**General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 25 days **Sample type(s) (with N randomized for each):** Patients: 961 **User level of expertise/ proficiency:** Users were familiar with EMS system used to deliver alerts	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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **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:*	4 groups: 1) EMR reminder to PCP 2) Automated voice message to patients 3) Pharmacy team outreach 4) Usual care	**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: 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 **6) Impact on HCP use and implementation:** NR	**Quality assessment:** Overall rating: Good **Applicability/ generalizability:** 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
		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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* - Pharmacotherapy - Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* - Online access - Email *b) Delivery mode:*	**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: 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
	- Patients: 639 - Clinics/practices/ hospitals: 6 - Individual HCPs: > MDs: 97 internists and family medicine **User level of expertise/ proficiency:** New system for users	System-initiated ("push") (email messages) **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 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 *c) Communication content features:* - 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		**5) Impact on economic outcomes:** - 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 **6) Impact on HCP use and implementation:** - 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) Auxiliary features:* - 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	**Geographical location:** Canada (12 hospitals in several provinces) **Study dates:** NR **General setting:** - Academic - Community **Specific setting:** Emergency department **Study design:** RCT, matched pair cluster randomization **Unit of randomization:** Hospitals **Duration of intervention:** 2 years **Sample type(s) (with N randomized for each):** - Patients: 11,824 - Clinics/practices/ hospitals: 12 **User level of expertise/ proficiency:** Users familiar with CPOE system used for	**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 imagining 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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* 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: 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 **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:** Study conducted in Canada

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	intervention	**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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* 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
	Patients: 96 Individual HCPs: 1971 Training MDs: 1872 NPs: 99 **User level of expertise/ proficiency:** NR	*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 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 *c) Communication content features:* - 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		**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: 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) Auxiliary features:* - 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) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:*	**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
		Integrated with CPOE/EHR		Control = 4.5	settings
	Sample type(s) (with N randomized for each): Patients: 528 Individual HCPs: 1963 > Training MDs: 1865 > NPs: 98 **User level of expertise/ proficiency:** NR	*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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y - Justification of decision support via provision of		- 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		reasoning: Y - Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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			
Subramanian, Fihn, Weinberger, et al., 2004 #4111	**Geographical location:** Indianapolis, IN Seattle, WA **Study dates:** NR **General setting:** VA **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinician	**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). **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management	**Comparator(s):** Another CDSS/KMS; this study compares EMR-based suggestions (control) with EMR and symptom-based suggestions (intervention)	**1) Impact on clinical outcomes:** - Length of stay: NR - Morbidity: Hospitalization at 6 and 12 months (mean ± SD)— At 6 months (P = 0.0002): Control (n = 365): 0.7 ± 0.4 Intervention (n = 355): 1.5 ± 1.1 At 12 months (P = 0.05): Control (n = 365): 1.7 ± 0.7 Intervention (n = 355): 2.3 ± 1.2 - Mortality: NR - Validated measure of HRQOL or functional status: SF-36: Physical component scale (mean ± SD)— Change from enrollment to 6 months (P = 0.2): Control (n = 319): 1.8 ± 1.8 Intervention (n = 311): 0.8 ± 1.9	**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 **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
	Duration of intervention: 1 year **Sample type(s) (with N randomized for each):** - Patients: 720 - Clinicians: 91 (44 control, 47 intervention) **User level of expertise/ proficiency:** Users already familiar with receiving notifications. Intervention is simply modification to notifications in patient charts.	*b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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 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		Change from enrollment to 12 months (P = 0.03): Control (n = 280): 1.3 ± 2.0 Intervention (n = 269): -0.6 ± 2.0 - 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: 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%]) - 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**	Comments: Randomization by coin flip; insufficient methods reporting **Applicability/ generalizability:** General setting: VA hospital

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		c) Communication content features: - 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 *d) Auxiliary features:* - 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	
Sundaram, Lazzeroni, Douglass, et al., 2009 #258	**Geographical location:** Palo Alto, CA **Study dates:** January 2001–September 2001 **General setting:** VA	**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. **Source/origin of system:**	**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: Change in HIV screening rates (P = 0.75)— Control: 0.52%	**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
		Locally developed		Intervention: 0.29%	**generalizability:** Set at VA hospital associated with Stanford Hospital
	Specific setting: Outpatient	**Content:**		- Recommended treatment ordered/prescribed: NR	
		a) Objective(s):		- Impact on user knowledge: NR	
	Study design: RCT, parallel group	Lab test ordering			
		b) Relationship to point of care:		**3) Impact on workload, efficiency, and organization of health care delivery:** NR	
	Unit of randomization: Clinician	Synchronous			
		Decision support:		**4) Impact on relationship-centered outcomes:** NR	
	Duration of intervention: 9 months	*Response requirement:* Justification for not complying			
		Information delivery:		**5) Impact on economic outcomes:** NR	
	Sample type(s) (with N randomized for each): Individual HCPs: 32 MDs	*a) Delivery format:* Integrated with CPOE/EHR		**6) Impact on HCP use and implementation:**	
		b) Delivery mode: System-initiated (“push”)		- HCP acceptance: Reasons for not following recommendations on reminders—	
	User level of expertise/ proficiency: All users familiar with EMR used for CDSS	**Contextual factors/features influencing the implementation and use of CDSS/KMS:**		Lack of time:	
		a) General system features:		Preintervention: 21 (66)	
		Integration with charting or order entry system to support workflow integration: Y		Postintervention: 18 (64)	
				Disagree with recommendation in general:	
		b) Clinician-system interaction features:		Preintervention: 6 (19)	
				Postintervention: 3 (11)	
		- Automatic provision of decision support as part of clinician workflow: Y		Disagree with recommendation for that patient visit:	
				Preintervention: 22 (69)	
		- No need for additional clinician data entry: Y		Postintervention: 20 (17)	
				Recommendation not received concurrently with visit:	
		- Request documentation of the reason for not following CDSS recommendations:		Preintervention: 8 (25)	
				Postintervention: 9 (32)	
				- HCP satisfaction: Clinical practice reminders are useful (Preintervention: n = 32 clinicians; postintervention =	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		Can't tell - Provision of decision support at time and location of decision making: Y - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		28) Agree: Preintervention: 21 (66) Postintervention: 17 (61) Disagree: Preintervention: 5 (16) Postintervention: 5 (18) - 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
Tamblyn, Huang, Perreault, et al., 2003 #4434	**Geographical location:** Quebec, Canada **Study dates:** January 1997–February 1998 **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinician **Duration of intervention:** 13 months **Sample type(s) (with N randomized for each):** - Patients: 12,560 - Individual HCPs: > MDs: 107 primary care **User level of expertise/ proficiency:** New system for all	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* System-initiated ("push")	**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: Percentage of patients with at least one potentially inappropriate prescription— At baseline: Control: 33.3% Intervention: 31.8% 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) - 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:** Set in Canada

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	users	**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 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 *c) Communication content features:* - 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			

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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			
Tamblyn, Huang, Taylor, et al., 2008 #1158 **Comparison 1 of 2**	**Geographical location:** Montreal, Quebec, Canada **Study dates:** February 1, 2004–September 30, 2004 **General setting:** NR **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** Clinician **Duration of**	**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. <u>Computer-triggered alerts</u> **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous	**Comparator(s):** Another CDSS/KMS: 1) Intervention is computer-triggered alerts 2) Comparator is on-demand drug decision support	**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: 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	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: No true control; study compared two new interventions with no usual care control arm **Applicability/ generalizability:** Set in Canada Academic setting Control arm did

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	intervention: 6 months **Sample type(s) (with N randomized for each):** - Patients: 3449 - Individual HCPs: > MDs: 28 general practitioners or family physicians **User level of expertise/ proficiency:** NR	**Decision support:** *Response requirement:* Justification for not complying **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 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 *c) Communication content features:* - Provision of a		**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: Total number of prescribing problems— Computer-triggered (N = 14 MDs, 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%) 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%)	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
		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 *d) Auxiliary features:* - 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		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%) On-demand: 0 (0%) - HCP satisfaction: NR - HCP use: Total number of prescribing problems— Computer-triggered (N = 14 MDs, 1899 patients): 6505 On-demand (N = 14 MDs, 1550 patients): 4445 Prescribing problem alerts seen by study MD— Computer-triggered: 668 (10.3%) On-demand: 41 (0.9%) 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%)	

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
Tamblyn, Huang, Taylor, et al., 2008 #1158 **Comparison 2 of 2**	**Geographical location:** Montreal, Quebec, Canada **Study dates:** February 1, 2004–September 30, 2004 **General setting:** NR **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: 3449 - Individual HCPs: > MDs: 28 general practitioners or family physicians **User level of expertise/ proficiency:** NR	**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. <u>On-demand decision support</u> **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* Justification for not complying **Information delivery:** *a) Delivery format:* Integrated with CPOE/HER *b) Delivery mode:* User-initiated ("pull") **Contextual factors/features influencing the implementation and use of CDSS/KMS:**	**Comparator(s):** Another CDSS/KMS: 1) Intervention is computer-triggered alerts 2) Comparator is on-demand drug decision support	**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: 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 **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: Total number of prescribing problems— Computer-triggered (N = 14 MDs,	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: No true control; study compared two new interventions with no usual care control arm **Applicability/ generalizability:** Set in Canada Academic setting Control arm did 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
		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: 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: Can't tell		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%) 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%)	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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		On-demand: 0 (0%) - HCP satisfaction: NR - HCP use: Total number of prescribing problems— Computer-triggered (N = 14 MDs, 1899 patients): 6505 On-demand (N = 14 MDs, 1550 patients): 4445 Prescribing problem alerts seen by study MD— 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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* 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: NR - Recommended treatment ordered/prescribed: Drug profile reviewed— 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	*Response requirement:* NR (unclear whether response requirement) **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 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 *c) Communication content features:*		**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
		- 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 *d) Auxiliary features:* - 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		Control N (%): Adherent: 10 of 625 1.6% Nonadherent (< 80%) 13 of 502 2.6% Intervention N (%): Adherent: 18 of 649 2.8% Nonadherent (< 80%) 9 of 517 1.7% Odds ratio = 1.01 95% CI = 0.52 to 1.94, P = 0.98 Change in therapy during the 6-months followup period for increase in therapy— Control (N = 1127): N = 328 (29.1%) Odds ratio = 1 Intervention (N = 1166): N = 332 (28.5%) Odds ratio = 0.98 95% CI = 0.80 to 1.21, P = 0.86 Adherence status to change in therapy during the 6-months followup period adherence status for increase in therapy— Control N (%): Adherent: 169 of 625 (27.0%) Nonadherent (< 80%): 159 of 502 (31.7%) Intervention N (%): Adherent: 177 of 649 (27.3%) Nonadherent (< 80%): 155 of 517 (30.0%) Odds ratio = 1.14 95% CI = 0.94 to 1.38, P = 1.93 Adherence to cardiovascular medications in the 6 months before and after the intervention for lipid-lowering and antihypertensive	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				therapy— Control (N = 1127): Before mean = 79.2 After mean = 72.9 Difference (SD) = -6.4 (24.1) Intervention (N = 1166): Before mean = 79.7 After mean = 73.5 Difference (SD) = -6.2 (24.1) Adjusted difference = 0.11 95% CI = -1.8 to 2.1, P = 0.90 Adherence status to cardiovascular medications in the 6 months before and after the intervention for lipid-lowering and antihypertensive therapy— Control: Adherent before mean: 95.5; after mean: 80.3; diff (SD): –15.1 (18.6) Nonadherent before mean: 59.1; after mean: 63.6; diff (SD): 4.5 (25.8) Intervention: Adherent before mean: 95.3; after mean: 80.2; diff (SD): –15.1 (17.9) Nonadherent before mean: 60.2; after mean: 65.1; diff(SD) 4.9 (26.3) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	
Taylor, Thompson, Lessler, et al., 1999 #6112	**Geographical location:** Seattle, WA **Study dates:** September 1995–	**Authors' basic description of system:** The intervention program included a computer-generated provider mammography prompt that routinely appeared	**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: Mammography	**General comments:** CDSS was only one part of a multi-intervention strategy including

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
	November 1996 **General setting:** - Academic - Community **Specific setting:** Outpatient **Study design:** RCT, firm system **Unit of randomization:** - Clinician - Patient **Duration of intervention:** 15 months **Sample type(s) (with N randomized for each):** - Patients: 314 - Individual HCPs: > Training MDs: 17 > Attending physicians: 15 **User level of expertise/ proficiency:** Academic detailing session for intervention firms	on intervention firm patient profile reports (for those women never screened at the hospital or out of compliance with institutional guidelines for interval screening). **Source/origin of system:** Not clearly described **Content:** *a) Objective(s):* - Lab test ordering - Initiating discussion with patient - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Paper-based *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		completion within 8 weeks of index clinic visit— Intervention (n = 232): 49% Control (n = 82): 22% 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	physician education, provider prompts, patient education, patient transportation assistance **Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Approximately one-third age-eligible women were not entered in the study Urban setting

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		workflow integration: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* - Pharmacotherapy - Preventive care *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* 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
	department MDs - Patients visits: 7458, of which 5,162 (69%) led to an ED discharge **User level of expertise/ proficiency:** Intervention was integrated into an electronic prescribing system the users were already familiar with	**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 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 *c) Communication content features:* - 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		**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 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		d) Auxiliary features: - 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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response	**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: 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
		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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Y		Control: 86% Intervention: 47% Effect size: 39%; 95% CI 2% to 75% - 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	Long study duration Majority of study patients were women or African American Single site study prevents having a more generalizable result
	Sample type(s) (with N randomized for each): - Patients: 2783 - Individual HCPs: 42 > Training MDs > MDs [emergency medicine] **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
		- Justification of decision support via provision of reasoning: Y - Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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:** *a) Objective(s):* More effective mental health	**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: Mean quality-of-life (QOL) scores at baseline and at followup adjusted for baseline scores with analysis of covariance— Control: 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) Intervention: 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
		treatment, assessed by lower score on standardized scoring system *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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 (printout integration with paper chart) *b) Clinician-system interaction features:* - 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		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 6-month QOL score (n = 243): Mean (95% CI): 6.4 (6.0 to 6.9) P = 0.52 - 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 implementation:** NR	guidelines Intervention was locally developed
	Duration of intervention: 6 months **Sample type(s) (with N randomized for each):** Patients: 762 **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.				

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- Provision of decision support at time and location of decision making: Can't tell - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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 #7374	**Geographical location:** Indianapolis, IN **Study dates:**	**Authors' basic description of system:** Reminder system to compare the effect of monthly feedback reports of compliance with	**Comparator(s):** Another CDSS/KMS The effects of	**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
Comparison 1 of 2	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	immediate specific reminders given to physicians at the time of patient visits on 13 preventive care protocols. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Preventive care - Immunization - Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* Paper-based *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: Can’t tell *b) Clinician-system interaction*	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 **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	**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
		features: - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* - Preventive care - Immunization - Lab test ordering *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Paper-based *b) Delivery mode:* 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: *a) General system features:* Integration with charting or order entry system to support workflow integration: Can't tell *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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) Auxiliary features:* - 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:** *a) Objective(s):* - Diagnosis - Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* 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
	- Patients 9496 - Individual HCPs:112 > Training MDs 98 > MDs [general internists] 14 **User level of expertise/ proficiency:** NR	*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: 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 *c) Communication content features:* - 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		Control = $26.65 - Cost-effectiveness: NR **6) Impact on HCP use and implementation:** - HCP acceptance: NR - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: Before the intervention, there were no differences in charges for study tests between intervention and control patients. During the intervention period, these charges dropped 10.8% for intervention patients ($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.	required to use microcomputers to enter orders since November 1984 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
		support via provision of research evidence: N *d) Auxiliary features:* - 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	**Geographical location:** Indianapolis, IN **Study dates:** NR **General setting:** Academic **Specific setting:** Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 16 weeks **Sample type(s) (with N randomized for each):** - Patients 5946 - Individual HCPs: 111 > Training MDs: 97 > MDs [general internists] 14 - Events: 8148 visits **User level of expertise/ proficiency:** NR	**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. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **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	**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 ordered per 1000 visits— All study tests: Control = 558 Intervention = 510 Number of study tests ordered per patient— Control = 0.56 ± 0.03 [SE] Intervention = 0.51 ± 0.03 P = 0.05 Number of non-study tests ordered per patient— Control = 1.00 ± 0.05 Intervention = 0.97 ± 0.04 - Recommended treatment ordered/prescribed: NR - 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: Intervention took 4.5 seconds (8%) longer than control to order study tests (P < 0.01)	**General comments:** None **Quality assessment:** Overall rating: Fair Comments: Physicians were not blinded to the intervention and no information on concealment Baseline information not available Learning bias **Applicability/ generalizability:** Single study site enrolled in an academic setting with a well-established health IT infrastructure Short intervention duration Physicians were required to use microcomputers

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		b) Clinician-system interaction features: - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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		**4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** - 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 **6) Impact on HCP use and implementation:** NR	to enter orders since November 1984

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) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Paper-based *b) Delivery mode:* System-initiated ("push")	**Comparator(s):** Usual care/no CDSS or KMS <u>1) Physician Intervention</u> 2) Pharmacist Intervention	**1) Impact on clinical outcomes:** - Length of stay: NR - Morbidity: Number of hospitalizations, ± SD [all]— Control (N = 181): 0.5 ± 1.1 Intervention (N = 197): 1.1 ± 1.9 Number of hospitalizations, ± 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, ± 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 Recommendations 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
	> Nurse practitioner: 1 > Pharmacists: 20 **User level of expertise/ proficiency:** Intervention modified the electronic medical record users were already familiar with	**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 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 *c) Communication content features:* - 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		- 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) Physician intervention (N = 197) Patients with any suggestions, n (%): 174 (88) Suggestions, mean/patient ± SD: 648 (3.7 ± 1.9) Suggestions complied with, n (%): 152 (23) - 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: Direct health care charges ± SD— Control: 7025 ± 17,024 Physician intervention: 6302 ± 10,928 - 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
		d) Auxiliary features: - 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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:**	**Comparator(s):** Usual care/no CDSS or KMS: 1) Physician Intervention 2) Pharmacist Intervention	**1) Impact on clinical outcomes:** - Length of stay: NR - Morbidity: Number of hospitalizations, ± SD [all]— Control: 0.5 ± 1.1 Intervention: 0.5 ± 1.0 Number of hospitalizations, ± 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, ± 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
		Response requirement: Noncommittal acknowledgement **Information delivery:** *a) Delivery format:* - Integrated with CPOE/EHR - Paper-based *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: 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 *c) Communication content features:*		± 1.2 - 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: 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) <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) - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR **4) Impact on relationship-centered outcomes:** NR	Care Policy and Research and national professional organizations
	Sample type(s) (with N randomized for each): - Patients: 706 - Clinics/practices/ hospitals: 32 - Individual HCPs: > Training MDs: 61 > MDs: 33 general internists > Nurse practitioner: 1 > Pharmacists: 20 **User level of expertise/ proficiency:** Intervention modified the electronic medical record users were already familiar with				

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *d) Auxiliary features:* - 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		**5) Impact on economic outcomes:** - Cost: Direct health care charges ± SD— Control (N = 181): 7025 ± 17,024 Pharmacist intervention (N = 158): 7387 ± 13,206 - Cost-effectiveness: **6) Impact on HCP use and implementation:** NR	
Tierney, Overhage, Murray, et al., 2005 #3487 **Comparison 1 of 2**	**Geographical location:** Indiana **Study dates:** 1/1/1994–5/1/1996 **General setting:** Academic **Specific setting:** - Outpatient - Chronic	**Authors' basic description of system:** Patient-specific, guideline-based care suggestions. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous	**Comparator(s):** Another CDSS/KMS 2 x 2 factorial design with 4 resulting groups: 1) No intervention (control) 2) Physician intervention	**1) Impact on clinical outcomes:** - Length of stay: NR - Morbidity: All hospitalizations— Control: 0.4 ± 0.8 Physician: 0.5 ± 1.6 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	**General comments:** None **Quality assessment:** Overall rating: Poor Comments: Study arm allocation not fully random (post-randomization

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: 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	**Decision support:** *Response requirement:* NR (unclear whether response requirement) **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:** <u>Physician intervention</u> *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: 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	3) Pharmacist intervention 4) Both interventions	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 **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%)	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

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 *c) Communication content features:* - 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) Auxiliary features:* - 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 preventive care ordered/completed: Influenza vaccination, N (%) of suggestions adhered to— Control: 36 (42%) Physician: 37 (40%) Pharmacist: 34 (43%) Both: 37 (37%) Pneumococcal vaccination, N (%) of suggestions adhered to— Control: 7 (9%) Physician: 7 (8%) Pharmacist: 6 (8%) Both: 15 (16%) - 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
				Control: 80 Physician: 81 Pharmacist: 80 Both: 82 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 N (%) of subjects with ≥ 2 prescription refills— Control: 96 (87%) Physician: 128 (95%) Pharmacist: 89 (81%) Both: 109 (92%) Medication possession ratio (mean ± 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 - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care delivery:** NR **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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				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 **5) Impact on economic outcomes:** - Cost: Outpatient charges— Control: $3,129 ± 2,921 Physician: $3,142 ± 3,381 Pharmacist: $2,814 ± 3,282 Both: $3,177 ± 3,558 Inpatient charges:-- Control: $2,671 ± 6,805 Physician: $4,864 ± 17,257 Pharmacist: $2,519 ± 7,267 Both: $2,475 ± 8,699 Total health care charges— Control: $5,800 ± 8,536 Physician: $8,006 ± 18,720 Pharmacist: $5,333 ± 9,400 Both: $5,652 ± 10,579 - Cost-effectiveness: NR **6) Impact on HCP use and implementation:** NR	
Tierney, Overhage, Murray, et al., 2005 #3487	**Geographical location:** Indiana **Study dates:** 1/1/1994–5/1/1996	**Authors' basic description of system:** Patient-specific, guideline-based care suggestions. **Source/origin of system:**	**Comparator(s):** Another CDSS/KMS 2 x 2 factorial design with 4	**1) Impact on clinical outcomes:** - Length of stay: NR - Morbidity: All hospitalizations— Control: 0.4 ± 0.8 Physician: 0.5 ± 1.6	**General comments:** None **Quality assessment:**

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:** *a) Objective(s):* Chronic disease management *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **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:** <u>Pharmacist intervention</u> *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: N	resulting groups: 1) No intervention (control) 2) Physician intervention <u>3) 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

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *c) Communication content features:* - 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) Auxiliary features:* - 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		**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%) - Recommended preventive care ordered/completed: Influenza vaccination, N (%) of suggestions adhered to— Control: 36 (42%) Physician: 37 (40%) Pharmacist: 34 (43%) Both: 37 (37%) Pneumococcal vaccination, N (%) of suggestions adhered to— Control: 7 (9%) Physician: 7 (8%) Pharmacist: 6 (8%) Both: 15 (16%) - 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%)	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				Pharmacist: 15 (25%) Both: 23 (35%) Start inhaled β-agonist, N (%) of suggestions adhered to— Control: 23 (70%) Physician: 18 (60%) Pharmacist: 13 (52%) 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	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				suggestions adhered to— Control: 2 (22%) Physician: 5 (50%) Pharmacist: 2 (50%) Both: 3 (33%) Mean medication compliance score (Inui measure) (%)— Control: 80 Physician: 81 Pharmacist: 80 Both: 82 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 N (%) of subjects with ≥ 2 prescription refills— Control: 96 (87%) Physician: 128 (95%) Pharmacist: 89 (81%) Both: 109 (92%) Medication possession ratio (mean ± 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 - Impact on user knowledge: NR **3) Impact on workload, efficiency, and organization of health care**	

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
				delivery: NR **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 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 **5) Impact on economic outcomes:** - Cost: Outpatient charges— Control: $3,129 ± 2,921 Physician: $3,142 ± 3,381 Pharmacist: $2,814 ± 3,282 Both: $3,177 ± 3,558 Inpatient charges— Control: $2,671 ± 6,805 Physician: $4,864 ± 17,257 Pharmacist: $2,519 ± 7,267 Both: $2,475 ± 8,699 Total health care charges— Control: $5,800 ± 8,536 Physician: $8,006 ± 18,720 Pharmacist: $5,333 ± 9,400 Both: $5,652 ± 10,579 - 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

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	**Geographical location:** New York, NY **Study dates:** Physician recruitment occurred in 2002–2004 **General setting:** Community Specific setting: Outpatient **Study design:** RCT, parallel group **Unit of randomization:** Clinician **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Patients: 580 - Individual HCPs: > MDs: 70 family or internal medicine **User level of expertise/ proficiency:** NR	**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 …" **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Initiating discussion with patient *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based. *b) Delivery mode:* 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: NR GEE generalized linear modeling indicated that intervention physicians exceeded controls on "Assess," "Advise," "Assist," and "Arrange" ($p < 0.0001$) More intervention than control physicians advised their patients to quit smoking (OR 2.79; 95% CI 1.70, 4.59) 7-day point prevalence abstinence— Intervention: 12% Control: 8% OR: 1.77; 95% CI 0.94, 3.34, p-value: 0.078 - 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:**	**General comments:** None **Quality assessment:** Overall rating: Fair 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 **Applicability/ generalizability:** Community setting Locally developed system All physicians were paid $150, and physicians in the intervention

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		implementation and use of CDSS/KMS: *a) General system features:* Integration with charting or order entry system to support workflow integration: Can't tell *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 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in		NR **6) Impact on HCP use and implementation:** NR	group received an additional $50. Patients were paid $20 for completing initial assessments and $10 for the followup interview.

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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* 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
	each): Patients: 148 **User level of expertise/ proficiency:** NR	**Information delivery:** *a) Delivery format:* Standalone system *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: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y		**4) Impact on relationship-centered outcomes:** NR **5) Impact on economic outcomes:** NR **6) Impact on HCP use and implementation:** NR	intervention patients, so control arm may have been biased

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		- 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 *d) Auxiliary features:* - 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:** *a) Objective(s):* Pharmacotherapy	**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: 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
	Unit of randomization: Patient **Duration of intervention:** 1 month **Sample type(s) (with N randomized for each):** - Patients: 177 - Individual HCPs: > Training MDs: 3 > PAs/NPs: 1 **User level of expertise/ proficiency:** NP given training in the use of the CDSS over a period of 1 month	*b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Standalone system *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: Can’t tell *b) Clinician-system interaction features:* - 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/		**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: 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%) 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%) - HCP satisfaction: NR - HCP use: NR - Implementation of CDSS/KMS: NR	problems, and hence there may have been some learning and carryover effect in the decisions made in the clinician group **Applicability/ generalizability:** Set in England

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: Can't tell *c) Communication content features:* - 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 *d) Auxiliary features:* - 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			
van Wijk, van der Lei, Mosseveld, et al., 2001 #5433	**Geographical location:** 44 sites in the Delft region, Netherlands **Study dates:** 03/1996–02/1997	**Authors' basic description of system:** CDSS for blood test ordering that included two different versions of the same set of tests: (1) BloodLink-Guideline	**Comparator(s):** Another CDSS/KMS: 1) BloodLink-Guideline (an indication-oriented order	**1) Impact on clinical outcomes:** NR **2) Impact on health care process outcomes:** - Recommended preventive care ordered/completed: NR - Recommended clinical study ordered/completed: Relative risk of the	**General comments:** Users had the choice of using BloodLink or a paper form to order tests

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: Community **Specific setting:** Outpatient **Study design:** Cluster RCT **Unit of randomization:** Practice **Duration of intervention:** 12 months **Sample type(s) (with N randomized for each):** - Clinics/practices/ hospitals: 46 - Individual HCPs: > MDs: 62 general practitioners **User level of expertise/ proficiency:** After BloodLink was installed, one of the authors gave a brief orientation presentation to the participating practitioners	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 (2) BloodLink-Restricted presented the physician with an order form with a restricted number of tests available **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Lab test ordering *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User initiated (“pull”) **Contextual factors/features influencing the implementation and use of CDSS/KMS:** *a) General system features:*	form) 2) BloodLink-Restricted (an order form with a restricted number of tests)	# 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 Number of tests ordered per form mean [±SD], median: GPs who had access to BloodLink-Guideline ordered 20% fewer tests per form than did GPs who had access to BloodLink-Restricted (mean [±SD], 5.5 ± 0.9 tests versus 6.9 ± 1.6 tests [median, 6.6 versus 4.6], respectively; p = 0.003). - 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: 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	**Quality assessment:** Overall rating: Good **Applicability/ generalizability:** Study conducted in the Netherlands Community setting, with apparently good generalizability to other GPs in the Netherlands Locally developed system

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: Y *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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) Auxiliary features:* - Local user involvement in development process: Y - Provision of decision support results to patients as well as		paper order forms. Of the 12,668 orders placed by the practices using Blood-Link-Guideline, 9091 (71%) were generated by using the decision support system. - 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
		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
van Wyk, van Wijk, Sturkenboom, et al., 2008 #1487 **Comparison 1 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 randomization **Unit of randomization:** Clinic or team **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Clinics/practices/ hospitals: 38 - Individual HCPs: > Training MDs > MDs, GPs: 80 **User level of expertise/**	**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:** Commercially available (ELIAS EHR) **Content:** *a) Objective(s):* - Screening and treatment of dyslipidemia - Preventive care - Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:*	**Comparator(s):** Another CDSS/KMS 3 Groups: 1) Alerting: recommen-dations automatically shown to the user 2) On-demand: user has to actively initiate the overview screen 3) Control: no overview screen available	**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) - Recommended clinical study ordered/completed: NR - 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) Adjusted RR for total patients requiring treatment, with on-demand group as referent (95% CI)— Alerting group: 1.18 (0.96,1.45) - Impact on user knowledge: NR	**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:** Netherlands study Community setting Appears to be locally developed modification of a commercially available system

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 *b) Delivery mode:* System-initiated ("push") **Contextual factors/features influencing the implementation and use of CDSS/KMS:** <u>Alerting DSS group</u> *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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: Y - Promotion of action rather than inaction: Can't tell		**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
		- Justification of decision support via provision of reasoning: N - Justification of decision support via provision of research evidence: N *d) Auxiliary features:* - 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: recommen-dations automatically shown to the user 2) On-demand: user has to actively initiate the overview screen	**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
	randomization **Unit of randomization:** Clinic or team **Duration of intervention:** NR **Sample type(s) (with N randomized for each):** - Clinics/practices/ hospitals: 38 - Individual HCPs: > Training MDs > MDs, GPs: 80 **User level of expertise/ proficiency:** High; only practices with full EHRs for more than 1 year included	Commercially available (ELIAS EHR) **Content:** *a) Objective(s):* - Screening and treatment of dyslipidemia - Preventive care - Diagnosis *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:* User-initiated (“pull”) **Contextual factors/features influencing the implementation and use of CDSS/KMS:** <u>On-demand DSS group</u> *a) General system features:* Integration with charting or order entry system to support workflow integration: Y *b) Clinician-system interaction features:* - Automatic provision of	3) Control: no overview screen available	- Recommended clinical study ordered/completed: NR - 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) Adjusted RR for total patients requiring treatment, with on-demand group as referent (95% CI)— Alerting group: 1.18 (0.96,1.45) - 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	Netherlands study Community setting Appears to be locally developed modification of a commercially available system

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 *c) Communication content features:* - 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 *d) Auxiliary features:* - 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
Vissers, Biert, van der Linden, et al., 1996 #6717 **AND** **Vissers, 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:** *a) Objective(s):* - Diagnosis - Other [general reference] *b) Relationship to point of care:* - Synchronous - Asynchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Standalone system *b) Delivery mode:* 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
		a) General system features: Integration with charting or order entry system to support workflow integration: N *b) Clinician-system interaction features:* - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: N		- 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 - 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
		- 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:** *a) Objective(s):* - Lab test ordering - Initiating discussion with patient *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:*	**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
	N randomized for each): - Clinics/practices/ hospitals 68 - Individual HCPs: 225 > MDs [general practice] **User level of expertise/ proficiency:** NR	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 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 *c) Communication content features:* - Provision of a recommendation, not just an assessment: N - Promotion of action rather than inaction: N - Justification of decision support via provision of		**6) Impact on HCP use and implementation:** NR	of low female patients

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) Auxiliary features:* - 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) Objective(s):* Pharmacotherapy *b) Relationship to point of 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 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
	Clinic or team **Duration of intervention:** 6 months **Sample type(s) (with N randomized for each):** - Patients: 1952 - Clinics/practices/ hospitals: 16 **User level of expertise/ proficiency:** NR	Asynchronous **Decision support:** *Response requirement:* NR (assume no response requirement) **Information delivery:** *a) Delivery format:* Paper-based *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: 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		**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:** From Physician Survey (N = 9)— - HCP acceptance: NR - 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. - 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
		c) Communication content features: - 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 *d) Auxiliary features:* - 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			
White, Lindsay, Pryor, et al., 1984 #7405	**Geographical location:** Salt Lake City, UT **Study dates:** NR **General setting:** Community **Specific setting:** - Inpatient–ICU	**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.	**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: Physician actions, any action taken—	**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
	- Inpatient–non-ICU **Study design:** RCT, parallel group **Unit of randomization:** Patient **Duration of intervention:** 3 month(s) **Sample type(s) (with N randomized for each):** Patients: 396 **User level of expertise/ proficiency:** NR	**Source/origin of system:** Locally developed **Content:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Asynchronous **Decision support:** *Response requirement:* No response requirement **Information delivery:** *a) Delivery format:* Paper-based *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 the reason for not following		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 **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	Locally developed Not patient-centered outcomes Well-established 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
		CDSS recommendations: N - Provision of decision support at time and location of decision making: N - Recommendations executed by noting agreement: Can't tell *c) Communication content features:* - 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) Auxiliary features:* - 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	**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
#2468	**Study dates:** January 1, 2000–June 30, 2002 **General setting:** Community **Specific setting:** Outpatient **Study design:** RCT, cluster randomization **Unit of randomization:** - Clinician - Practice **Duration of intervention:** 8 months **Sample type(s) (with N randomized for each):** - Clinics/practices/ hospitals: 86 - Individual HCPs: > MDs: 346 general practitioners **User level of expertise/ proficiency:** NR	patient and assisted users in making a rapid decision about whether or not a patient met Scottish referral guidelines. **Source/origin of system:** Locally developed **Content:** *a) Objective(s):* - Initiating discussion with patient - Providing information to GP to enable informed discussions with patients *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* NR (unclear whether response requirement) **Information delivery:** *a) Delivery format:* Not clearly described *b) Delivery mode:* User-initiated (“pull”) **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: Can’t tell		ordered/completed: NR - 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) - 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: 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 **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	**assessment:** Overall rating: Poor 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 Implications for limitations related to incomplete outcome data and inappropriate control arms **Applicability/ generalizability:** Conducted in Scotland Locally developed Intervention providers not required to use intervention

Evidence table (key questions 2–4) (continued)

Study ID	Study and Sample Characteristics	CDSS/KMS Test Intervention	Comparator(s)	Results	Comments/ Quality/ Applicability
		b) Clinician-system interaction features: - 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 *c) Communication content features:* - 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 *d) Auxiliary features:* - Local user involvement in development process: Y - Provision of decision support results to patients as well as providers: Y - CDSS accompanied by		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). - 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:** *a) Objective(s):* Pharmacotherapy *b) Relationship to point of care:* Synchronous **Decision support:** *Response requirement:* Mandatory response **Information delivery:** *a) Delivery format:* Integrated with CPOE/EHR *b) Delivery mode:*	**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
		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 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 *c) Communication content features:* - 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		**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	
	User level of expertise/ proficiency: New CDSS for all users in intervention group				

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 *d) Auxiliary features:* - 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 = nonsterioidal 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

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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

Ageno 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.
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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.
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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):I54.
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Anonymous. Summaries for patients. Reducing the prescription of hormone replacement therapy after the release of study results. Ann Intern Med 2004;141(2):I47.
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.
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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.
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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.
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Arnold SR, Straus SE. Interventions to improve antibiotic prescribing practices in ambulatory care. Cochrane Database Syst Rev 2005(4):CD003539.
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Aronsky D, Fiszman M, Chapman WW, et al. Combining decision support methodologies to diagnose pneumonia. Proc Amia Symp 2001:12-6.
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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.
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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.
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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.
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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.
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Baird TK, Broekemeier RL, Anderson MW. Effectiveness of a computer-supported refill reminder system. Am J Hosp Pharm 1984;41(11):2395-7.
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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.
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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.
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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.
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Bakken S. Informatics for patient safety: a nursing research perspective. Annu Rev Nurs Res 2006;24:219-54.
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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.
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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.
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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.

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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

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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	11	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**	**16**	**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 to1.306)	✓	✓	✓		✓		✓	✓			✓			
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

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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
Litzleman 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
Vissers et al., 1995[134] and Vissers 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 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
Litzleman 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
Vissers et al., 1995[134] and Vissers 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

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Appendix J: Analyses of Potential Publication Bias

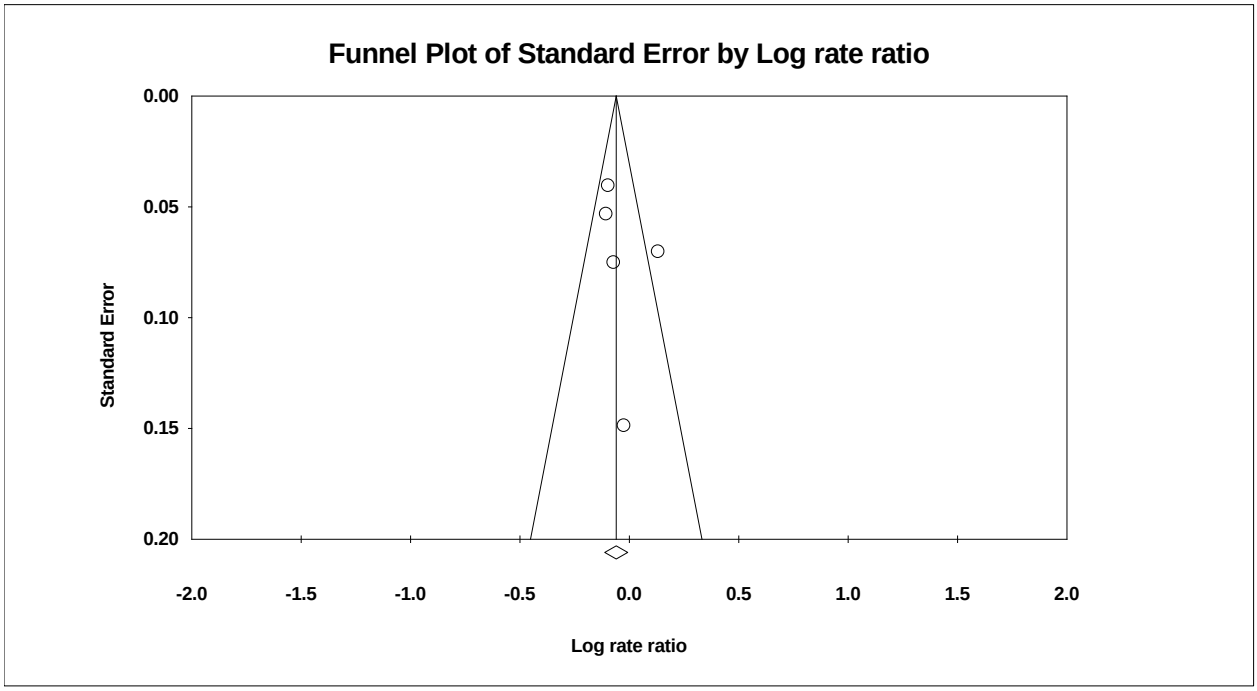
Testing for publication bias is difficult at best. In effect, one is testing for the number of studies that have not been reported based on the results of those that have been reported. To look for bias, we used three tools: (1) the funnel plot, which looks for an uneven number of studies falling to 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

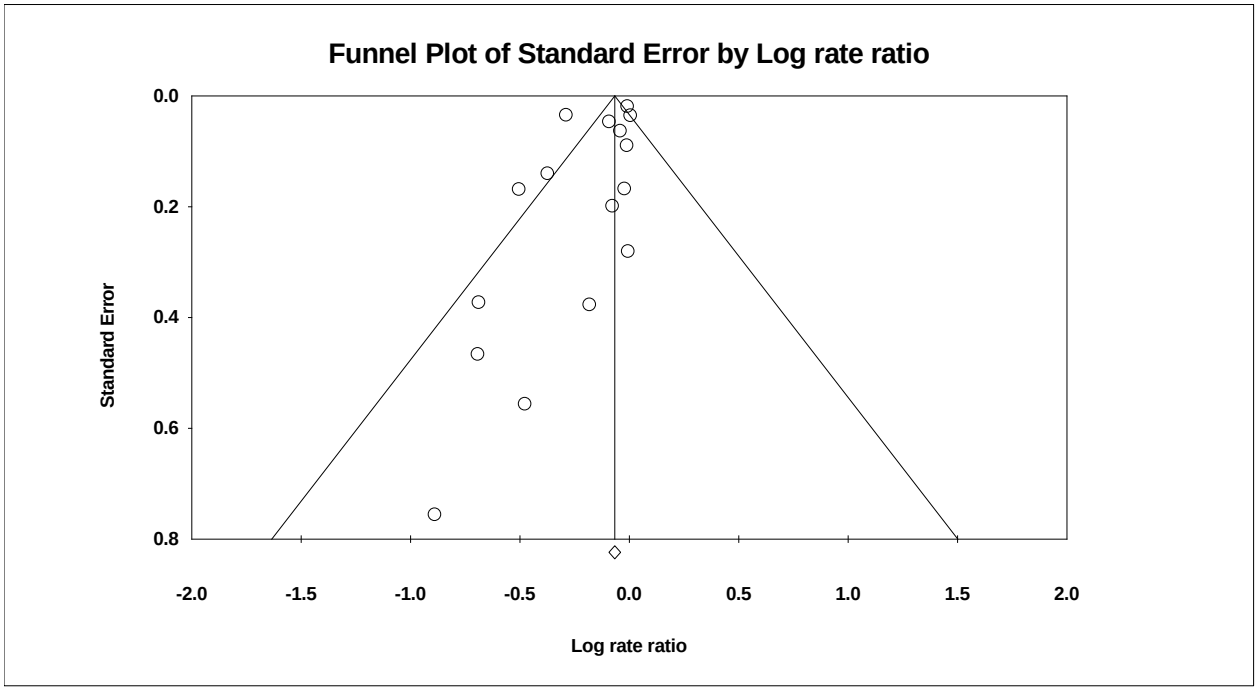


Note that only one of the studies lies outside of the funnel. Begg and Mazumdar's correlation was 0.50 (two-tailed p-value = 0.221). Egger's regression intercept was 1.637 (two-tailed p-value = 0.463). Thus, there was no evidence of publication bias in this meta-analysis.

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

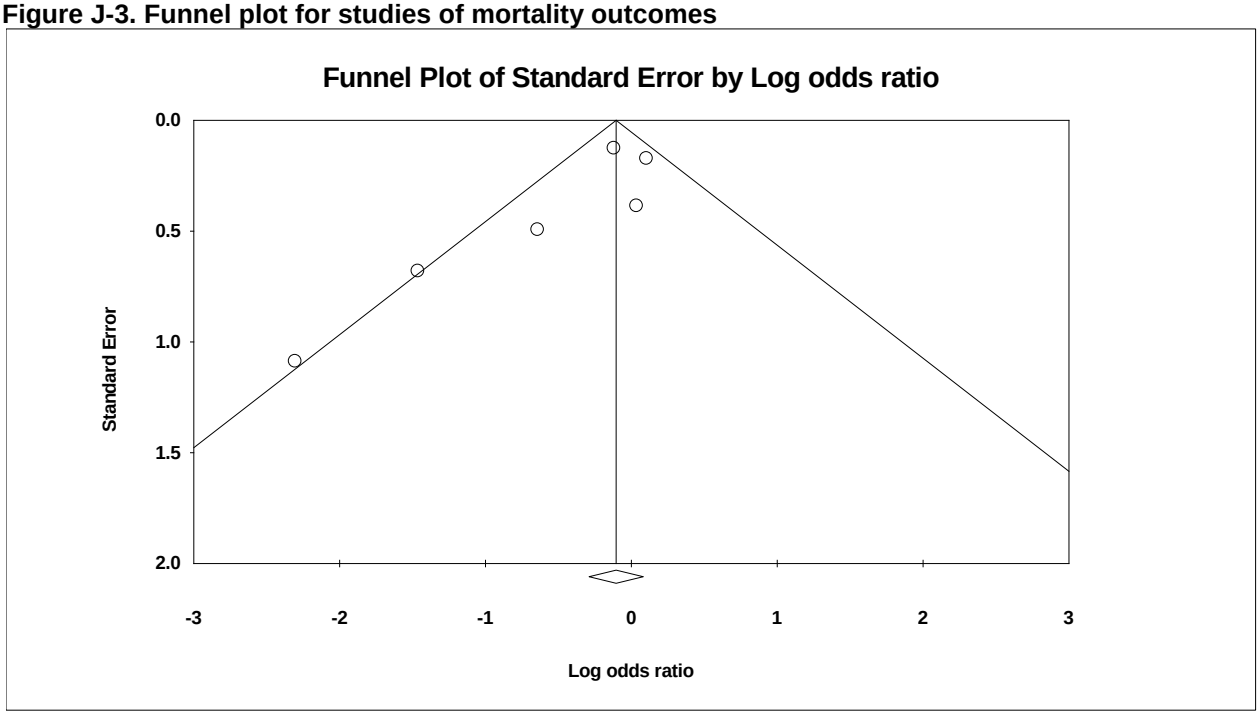


Note that re three studies lie to the left of the funnel, and two studies lie to the right. Begg and Mazumdar's correlation was -0.275 (two-tailed p-value = 0.137). Egger's regression intercept was -1.145 (two-tailed p-value = 0.126). Thus, there was no strong evidence of publication bias in this meta-analysis.

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

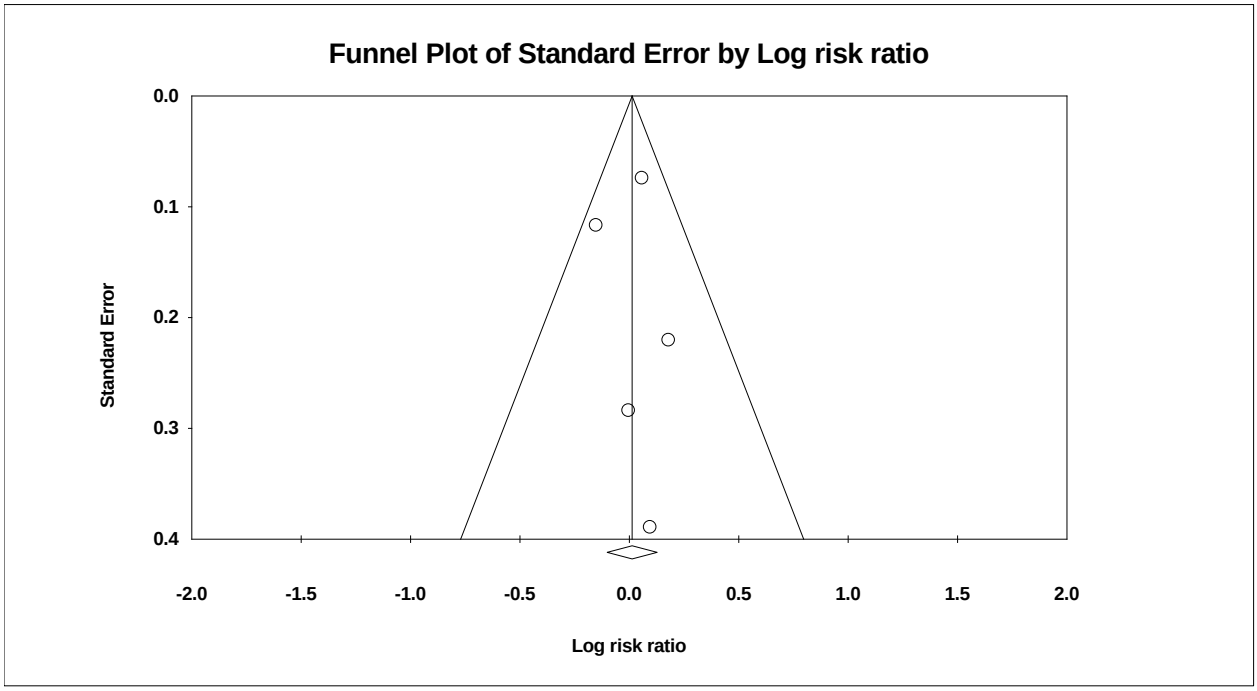


Note that two studies lie to the left of the funnel, and no studies lie to the right. Begg and Mazumdar's correlation was -0.667 (two-tailed p-value = 0.060). Egger's regression intercept was -1.737 (two-tailed p-value = 0.077). Thus, there was some evidence of bias based on the two correlation tests, 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

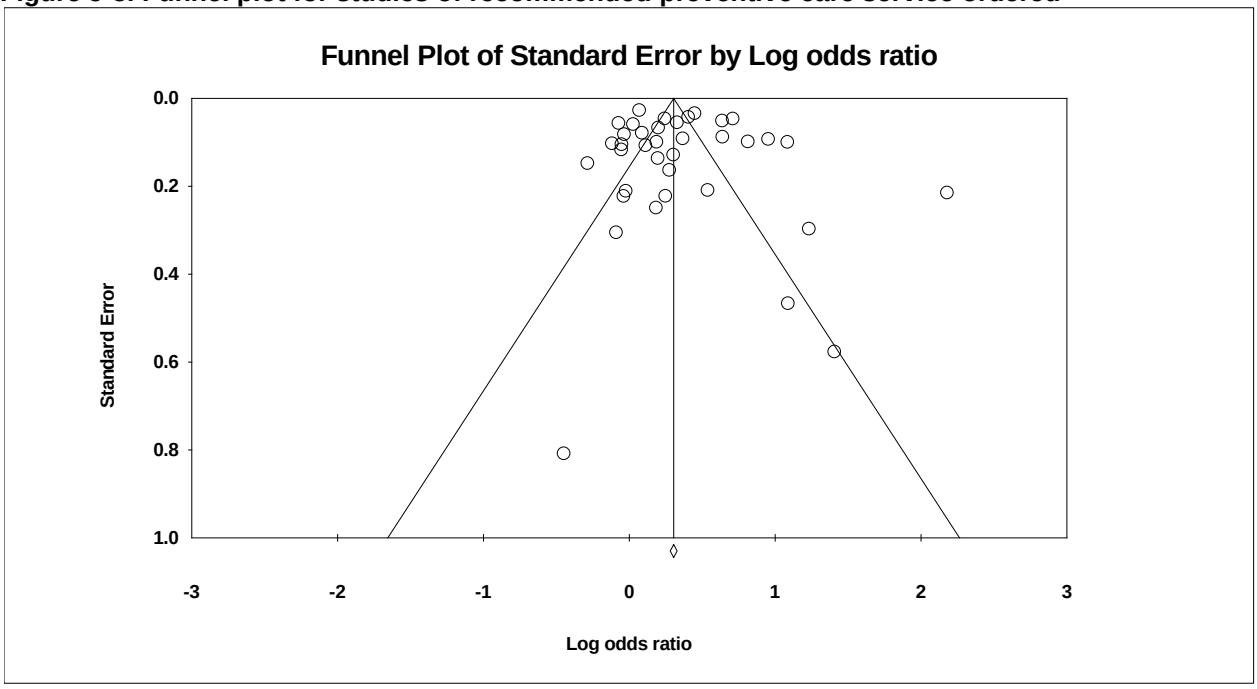


None of the studies lie outside the funnel. Begg and Mazumdar's correlation was -0.1000 (two-tailed p-value = 0.807). Egger's regression intercept was 0.086 (two-tailed p-value = 0.926). Thus, there was no evidence of publication bias in this meta-analysis.

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

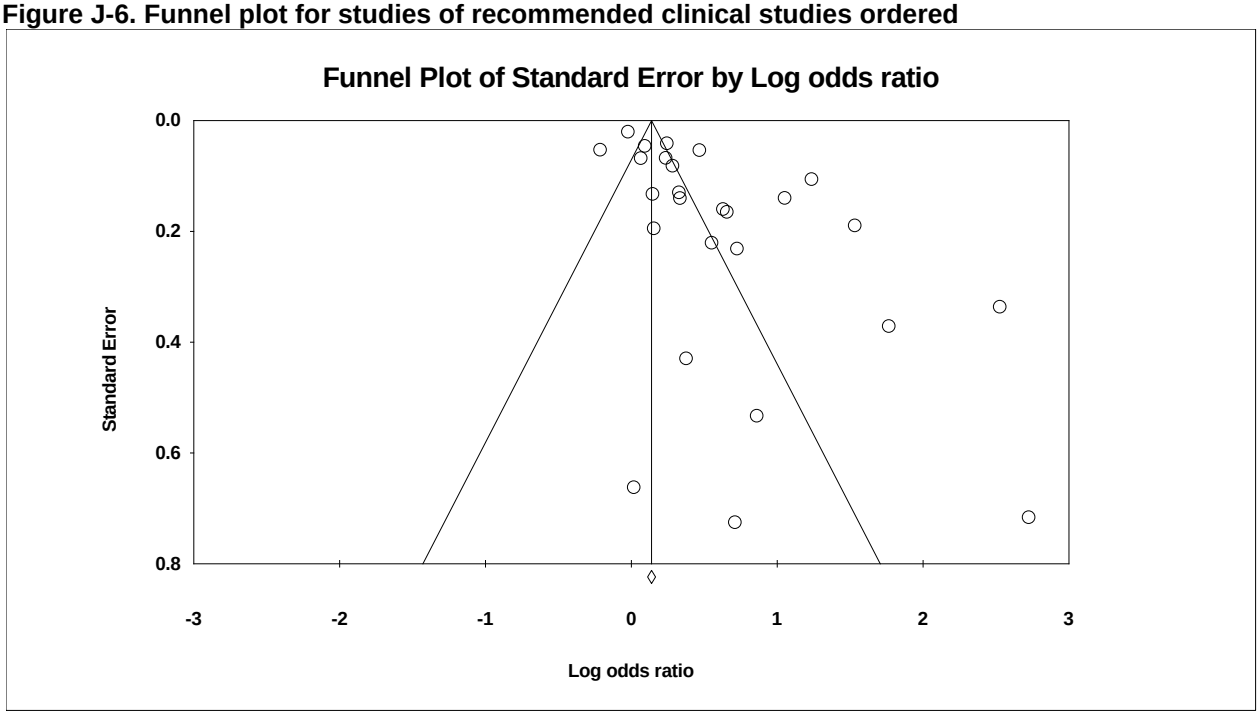


Note that eight studies lie to the left of the funnel, and nine studies lie to the right. Begg and Mazumdar's correlation was 0.071 (two-tailed p-value = 0.539). Egger's regression intercept was 0.789 (two-tailed p-value = 0.512). Thus, there was no evidence of publication bias in this meta-analysis.

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

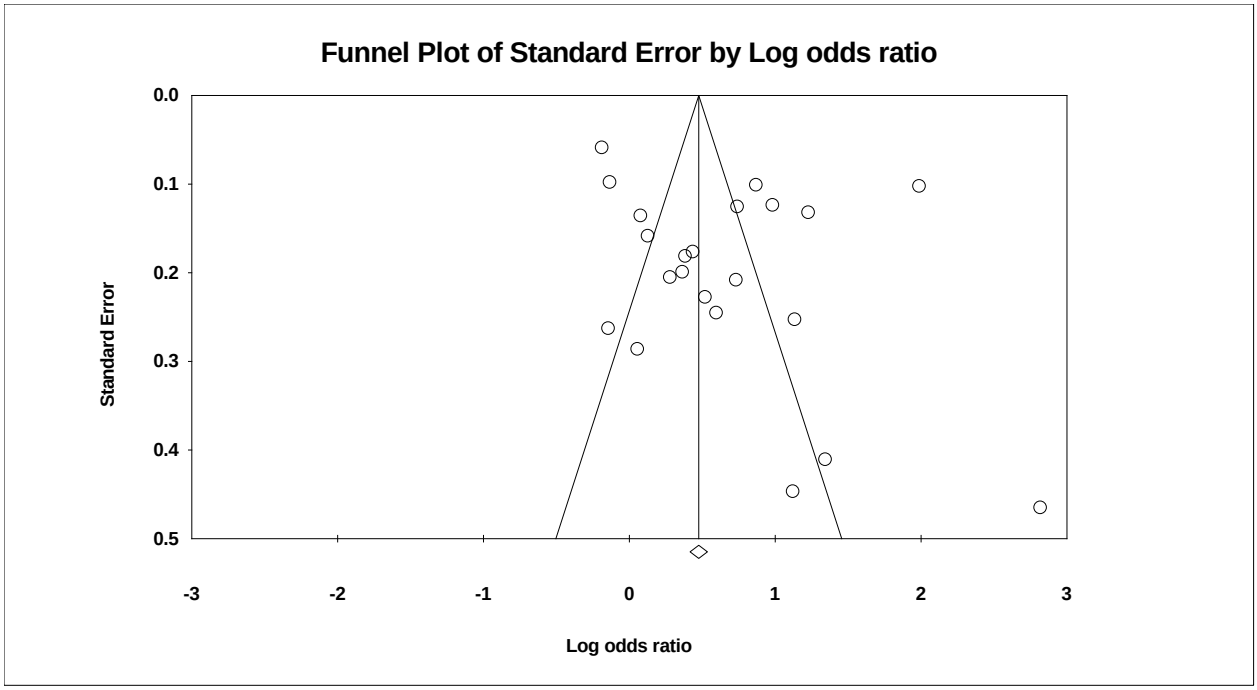


Note that two studies lie to the left of the funnel, and eleven studies lie to the right. Begg and Mazumdar's correlation test was 0.129 (two-tailed p-value = 0.354). Egger's regression intercept was 3.911 (two-tailed p-value = 0.0003). There was evidence of potential publication bias in this meta-analysis 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 to1.306)									✓		✓
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
Tamblyn 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

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