Published in final edited form as:
Cochrane Database Syst Rev. ; (3): CD001096. doi:10.1002/14651858.CD001096.pub2.

The effects of on-screen, point of care computer reminders on processes and outcomes of care

Kaveh G Shojania[1], **Alison Jennings**[2], **Alain Mayhew**[3], **Craig R Ramsay**[4], **Martin P Eccles**[5], and **Jeremy Grimshaw**[2]

[1]Director, University of Toronto Centre for Patient Safety, Sunnybrook Health Sciences Centre, Toronto, Canada

[2]Clinical Epidemiology Program, Ottawa Health Research Institute, Ottawa, Canada

[3]Institute of Population Health, University of Ottawa, Ottawa, Canada

[4]Health Services Research Unit, Division of Applied Health Sciences, University of Aberdeen, Aberdeen, UK

[5]Institute of Health and Society, Newcastle University, Newcastle upon Tyne, UK

Abstract

Background—The opportunity to improve care by delivering decision support to clinicians at the point of care represents one of the main incentives for implementing sophisticated clinical information systems. Previous reviews of computer reminder and decision support systems have reported mixed effects, possibly because they did not distinguish point of care computer reminders from e-mail alerts, computer-generated paper reminders, and other modes of delivering 'computer reminders'.

Objectives—To evaluate the effects on processes and outcomes of care attributable to on-screen computer reminders delivered to clinicians at the point of care.

Contact address: Kaveh G Shojania, Director, University of Toronto Centre for Patient Safety, Sunnybrook Health Sciences Centre, Room D474, 2075 Bayview Avenue, Toronto, Ontario, M4N 3M5, Canada. kaveh.shojania@utoronto.ca.
Editorial group: Cochrane Effective Practice and Organisation of Care Group.
Publication status and date: Edited (no change to conclusions), published in Issue 1, 2011.
Review content assessed as up-to-date: 10 January 2009.
CONTRIBUTIONS OF AUTHORS KS led the project, including preparing the data abstraction form, screening and dealing with consensus issues, and led the analysis.
AJ participated in screening, data extraction and data analysis.
AM participated in data extraction and screening.
CRR provided support for the analysis.
MPE provided input into overall structure of the review.
JG was involved in the protocol publication and also provided input into the overall structure of the review.

DECLARATIONS OF INTEREST ME and JG are authors on one included study and three excluded studies in this review. Four authors (AM, ME, CRR, JG) are editors or staff within the Cochrane EPOC Review Group. Editors and staff are required to conduct at least one Cochrane review. This requirement ensures that editors are aware of the processes and commitment needed to conduct reviews. This involvement does not seem to be a source of conflict of interest in the Cochrane EPOC Review Group. Any editor or staff who is a review author is excluded from editorial decisions on the review in which they are contributors.

Europe PMC Funders Author Manuscripts

Search methods—We searched the Cochrane EPOC Group Trials register, MEDLINE, EMBASE and CINAHL and CENTRAL to July 2008, and scanned bibliographies from key articles.

Selection criteria—Studies of a reminder delivered via a computer system routinely used by clinicians, with a randomised or quasi-randomised design and reporting at least one outcome involving a clinical endpoint or adherence to a recommended process of care.

Data collection and analysis—Two authors independently screened studies for eligibility and abstracted data. For each study, we calculated the median improvement in adherence to target processes of care and also identified the outcome with the largest such improvement. We then calculated the median absolute improvement in process adherence across all studies using both the median outcome from each study and the best outcome.

Main results—Twenty-eight studies (reporting a total of thirty-two comparisons) were included. Computer reminders achieved a median improvement in process adherence of 4.2% (interquartile range (IQR): 0.8% to 18.8%) across all reported process outcomes, 3.3% (IQR: 0.5% to 10.6%) for medication ordering, 3.8% (IQR: 0.5% to 6.6%) for vaccinations, and 3.8% (IQR: 0.4% to 16.3%) for test ordering. In a sensitivity analysis using the best outcome from each study, the median improvement was 5.6% (IQR: 2.0% to 19.2%) across all process measures and 6.2% (IQR: 3.0% to 28.0%) across measures of medication ordering.

In the eight comparisons that reported dichotomous clinical endpoints, intervention patients experienced a median absolute improvement of 2.5% (IQR: 1.3% to 4.2%). Blood pressure was the most commonly reported clinical endpoint, with intervention patients experiencing a median reduction in their systolic blood pressure of 1.0 mmHg (IQR: 2.3 mmHg reduction to 2.0 mmHg increase).

Authors' conclusions—Point of care computer reminders generally achieve small to modest improvements in provider behaviour. A minority of interventions showed larger effects, but no specific reminder or contextual features were significantly associated with effect magnitude. Further research must identify design features and contextual factors consistently associated with larger improvements in provider behaviour if computer reminders are to succeed on more than a trial and error basis.

Medical Subject Headings (MeSH)

*Decision Support Systems, Clinical; *Outcome and Process Assessment (Health Care); *Point-of-Care Systems; *Reminder Systems; Decision Making, Computer-Assisted

MeSH check words

Humans

BACKGROUND

Description of the condition

Gaps between recommended practice and routine care are widely known (McGlynn 2003; Quality of Health Care 2001; Schuster 1998). Interventions designed to close these gaps fall

into a number of different categories: educational interventions (directed at clinicians or at patients), reminders (again, directed at clinicians or patients), audit and feedback of performance data, case management, and financial incentives to name a few (Shojania 2005). However, none of these categories of interventions confers large improvements in care, especially when evaluated rigorously. In fact, they often produce quite small benefits (Grimshaw 2004;Oxman 1995; Shojania 2006; Walsh 2006) and these benefits tend to involve process measures only, not patient outcomes.

Description of the intervention

Given the difficulty of changing the behaviour of healthcare providers and the resources required by many of the interventions that aim to do so, provider reminders offer a promising strategy, especially given their low marginal cost. Reminders delivered at the point of care prompt healthcare professionals to recall information that they may already know but could easily forget in the midst of performing other activities of care, or, in the case of decision support, provide information or guidance in an accessible format at a particularly relevant time. Paper-based reminders have existed for many years and have ranged from simple notes attached to the fronts of charts (for example reminding providers of the need to administer an influenza vaccine) to more sophisticated pre-printed order forms that include decision support (for example protocols for ordering and monitoring anti-coagulants). Computer-based reminders have the potential to address multiple topics and are automatic; therefore they represent a subset of reminders of great interest to those involved in quality improvement efforts.

How the intervention might work

A number of systematic reviews over the years have evaluated computerised reminders and decision support systems (Dexheimer 2008; Garg 2005; Hunt 1998; Kawamoto 2005). However, these reviews have tended to lump all forms of computerised reminders and decision support together, including, for instance, computer-generated paper reminders and e-mail alerts sent to providers, along with reminders generated at the point of care. It is this last category, computer reminders that prompt providers at the point of care, which represents the most promising form of computerised reminders. Such reminders, embedded into computerised provider order entry systems or electronic medical records, alert providers to important clinical information relevant to a targeted clinical task at the time the provider is engaged in performing the task.

Why it is important to do this review

While point of care computerised reminders have produced some well-known successes (Dexter 2001; Kucher 2005; Overhage 1997), other trials have shown no improvements in care (Ansari 2003; Eccles 2002a; Montgomery 2000), including studies from institutions with well-established computerised order entry systems (Dexter 2004; Sequist 2005; Tierney 2003). Therefore, we sought to quantify the expected magnitudes of improvements in processes and outcomes of care through the use of computerised reminders and decision support delivered at the point of care, and identify any features consistently associated with larger effects.

OBJECTIVES

In this review, we address the following questions:

1. Do on-screen computer reminders effectively improve processes or outcomes of care?
2. Do any readily identifiable elements of on-screen reminders influence their effectiveness (e.g. inclusion of patient-specific information as opposed to generic reminders for a given condition, requiring a response from users).
3. Do any readily identifiable elements of the targeted activity (e.g. chart documentation, test ordering, medication prescribing) influence the effectiveness of on-screen reminders?

METHODS

Criteria for considering studies for this review

Types of studies—We included randomised controlled trials (with randomisation at the level of the patient or the provider) and quasi-randomised trials, where allocation to intervention or control occurred on the basis of an arbitrary but not truly random process (for example even or odd patient identification numbers).

Types of participants—Any study in which the majority of participants (> 50%) consisted of physicians or physician trainees; we excluded studies that primarily targeted dentists, pharmacists, nurses, or other health professionals.

Types of interventions—The original protocol for this review defined ‘on-screen computer reminders’ as follows:

> *Patient or encounter specific information that is provided via a computer console (either visually or audibly) and intended to prompt a healthcare professional to recall information usually encountered through their general medical education, in the medical records or through interaction with peers, and so remind them to perform or avoid some action to aid individual patient care (*Gordon 1998).

This original definition served primarily to distinguish computer reminders that were literally presented to users on a computer screen (hence ‘on-screen reminders’) from computer-generated reminders that were simply printed out and placed in a paper chart. While this distinction remains germane (i.e. some studies still involve ‘computer reminders’ that are really paper-based reminders that happen to have been generated by a computer), the use of computers in healthcare is now sufficiently widespread that the more important concept has become ‘at the point of care’, rather than merely ‘on-screen’. A reminder that is ‘on screen’ but not noticeable to clinicians during the target activities of interest is no more useful than a paper reminder placed in such a manner that clinicians must deviate from their usual charting activities in order to find it.

Thus, from an operational point of view, the focus of this review should be regarded as evaluating ‘point-of-care computer reminders’. By ’point of care’ we refer to delivery of the

computer reminder to clinicians at the time they are engaged in the target activity of interest, such as prescribing medications, documenting clinical encounters in the medical record, and ordering investigations.

Operationally, we considered a reminder to qualify as delivered at the point of care if the following three criteria applied.

1. The reminder was delivered via the computer system routinely used by the providers targeted by the intervention - typically an electronic medical record or computerised order entry program. For instance, a dedicated computer used solely for performing dose calculations for anticoagulants would not count as 'on-screen/ point of care', since it requires clinicians to depart from their usual workflow in order to avail themselves of the reminder or decision support provided by this separate system. We excluded such systems because they in effect require providers to remember to use the reminder system, thus undermining the fundamental purpose of a reminder.
2. The reminder was accessible from within the routinely used clinical information system (typically via a pop-up screen or an icon that indicates the availability of the reminder or decision support feature). A decision support module that could only be accessed by remembering to call up a separate program or website would not count as a point of care reminder (again, because depending on clinicians' remembering to call up the program without any prompting violates the notion of a 'reminder').
3. The reminder targeted the person responsible for the relevant clinical activity. For instance, if handwritten physician orders were entered by a clerk or pharmacist into a computer order entry system, any alert or decision support delivered via the computer system would not qualify as 'point of care' since, for the physician, it was the handwritten order that occurred at the point of care.

For settings without general computer order entry or electronic medical record systems, we allowed the possibility that some specific activities might still routinely occur using a computer system. For instance, an ambulatory clinic might have developed a computer-based system for supporting preventive care activities, even if the rest of the ambulatory record remained paper-based. Or, a hospital might have developed a computer program for ordering certain high-risk drugs (for example chemotherapy or anticoagulants). If a study documented that over 90% of the target activity occurred using the computer system, we regarded such a system as delivering a *de-facto* point of care computer reminder (since the documentation of > 90% use of the computer system for that activity implies that providers would generally not have to remember to use to the reminder).

Types of outcome measures

Eligible outcomes: In order to enhance the interpretability of the results, we categorised eligible outcomes as follows.

- *Dichotomous process adherence outcomes*: the percentage of patients receiving a target process of care (e.g. prescription of a specific medication, documentation of

performance of a specific task, such as referral to a consultant) or whose care was in compliance with an overall guideline.

- *Dichotomous clinical outcomes*: true clinical endpoints (such as death or development of a pulmonary embolism), as well as surrogate or intermediate endpoints, such as achievement of a target blood pressure or serum cholesterol level.
- *Continuous clinical outcomes*: various markers of disease or health status (e.g. mean blood pressure or cholesterol level).
- *Continuous process outcomes*: any continuous measure of how providers delivered care (e.g. duration of antibiotic therapy, time to respond to a critical lab value).

We planned to include studies in the analysis only if they reported at least one clinical or process outcome (i.e. we excluded articles that reported only costs, lengths of stay, and other measures of resource use). As it turned out, meaningful analyses were possible only with the measures of process adherence. For these measures, in order to permit pooling across studies, we required that studies present data as the absolute percentage of patients who received the target process care in each study group (or in a manner that allowed us to calculate these percentages). For instance, we would not include a study that only reported the odds of patients receiving the process of care in the intervention group compared with the control. We made this decision partly because initial review revealed that the vast majority of studies reported their data as percentages of patients who received the process of interest, and partly because this format is most conducive to conveying the expected impacts of computer reminders, namely absolute improvements in adherence to a target process of care or clinical behaviour.

Primary outcomes: Although we planned to include any otherwise eligible study that reported the effect of computerised reminders on clinical outcomes, evaluating the impact of reminders on adherence to target processes of care represented the primary goal of our analysis. We recognise that improving patient outcomes represents the ultimate goal of any quality improvement activity. However, we focused on process improvements for this review because we wanted to capture the degree to which computer reminders achieve their main goal, namely changing provider behaviour (Mason 1999). The degree to which such behaviour changes ultimately improve patient outcomes will vary depending on the strength of the relationship between the targeted process of interest and patient level outcomes. In some cases, no such relationship may exist. For instance, the incentive to improve appropriate antibiotic use is usually the population level goal of reducing emergence of resistant microorganisms, not improving the outcomes of care for individual patients. In other cases, a presumed relationship between a given process of care and patient outcomes may be incorrect (for example we would no longer expect a reminder that encourages the use of hormone replacement therapy to improve cardiovascular outcomes in post-menopausal women). Consequently, if we had focused on improvements in clinical endpoints and found that reminders achieved negligible improvements in such outcomes, we would not know if this reflected consistent failure of computer reminders to achieve their

intended goal (changes in provider behaviour) or the fact that reminders had targeted processes with limited connections to patient outcomes.

Direction of improvements: Some studies target quality problems that involve 'underuse,' so that improvements in quality correspond to increases in the percentage of patients who receive a target process of care (for example increasing the percentage of patients who receive the influenza vaccine). However, other studies target 'overuse', so that improvements correspond to reductions in the percentage of patients receiving inappropriate or unnecessary processes of care (for example reducing the percentage of patients who receive antibiotics for viral upper respiratory tract infections). In order to standardise the direction of effects, all process outcomes were defined so that higher values represented an improvement. For example, data from a study aimed at reducing the percentage of patients receiving inappropriate medications would be captured as the complementary percentage of patients who did not receive inappropriate medications. Increasing this percentage of patients for whom providers did not prescribe the medications would thus represent an improvement.

Search methods for identification of studies

Electronic searches—We searched the MEDLINE database up to July 2008 using Medical Subject Headings for relevant forms of clinical information systems (for example Medical Order Entry Systems, Point-of-Care Systems, Ambulatory Care Information Systems) and combinations of text words such as 'computer' or 'electronic' with terms such as 'reminder', 'prompt', 'alert', 'cue', and 'support' (Appendix 1 to Appendix 4). We applied a methodological filter for any type of clinical trial. We also searched the EMBASE, CINAHL and CENTRAL databases using modified search strategies up to July 2008. In addition, we retrieved all articles related to computers and reminder systems or decision support from the Cochrane Effective Practice and Organisation of Care Group (EPOC) database (EPOC 2008) Finally, we scanned bibliographies from key articles. For non-English language articles, we screened English translations of titles and abstracts and pursued full-text translation where possible (i.e. either to include or confirm exclusion).

Data collection and analysis

Study selection and data abstraction—Two investigators (from KS, AJ, AM) independently screened citations and abstracted included articles using a structured data entry form. In the initial screening, authors based their judgments about inclusion and exclusion solely on the titles and abstracts, but promoted articles to the next stage of the screening process whenever a decision could not be made with confidence. For the second stage of screening, we obtained full text for all references, with each article again judged independently by two authors.

Two authors independently abstracted the following information from articles that met all the inclusion criteria after the second stage of screening: clinical setting, participants, methodological details, characteristics of the reminders design and content, the presence of co-interventions (for example educational materials or performance report cards distributed to clinicians in both study groups), and outcomes. The data abstraction form (available upon

request) was based on the checklist developed by the Cochrane EPOC Group (EPOC 2008). The form was pilot tested and revised iteratively prior to its use for final data abstraction. We resolved discrepancies between authors during either the screening or abstraction stages by discussion between the two authors to achieve consensus. When a conflict could not be resolved, a third author was consulted to achieve consensus or generate a majority decision.

Quality assessment—As part of the data abstraction process, authors assessed the following quality criteria based on the Cochrane EPOC Group Data Collection Checklist: concealment of allocation, blinded assessment of primary outcomes, proportion of patients/providers followed up, baseline disparities in process adherence or outcomes in the study groups, protection against contamination, and unit of analysis errors (EPOC 2008).

***Data* analysis:** We anticipated that the eligible studies would exhibit significant heterogeneity, due to variations in target clinical behaviours, patient and provider populations, methodological features, characteristics of the interventions, and the contexts in which they were delivered. One approach for addressing these sources of variation would involve meta-regression. Given the number of potentially relevant covariates, however, meta-regression would require many more studies than we anticipated finding. We also expected that many eligible studies would assign intervention status to the provider, rather than the patient, but would not take into account 'cluster effects' in the analysis (i.e. they would exhibit 'unit of analysis errors'). Performing either a conventional meta-analysis or meta-regression using studies with unit of analysis errors would require us to make a number of assumptions about the magnitude of unreported parameters, such as the intra-class correlation coefficients and the distributions of patients across clusters, in order to avoid spurious precision in 95% confidence intervals.

To preserve the goal of providing a quantitative assessment of the effects associated with computerised reminders, without resorting to numerous assumptions or conveying a misleading degree of confidence in the results, we chose to report the median improvement in process adherence (and inter-quartile range) among studies that shared specific features of interest. This approach was first developed in a large review of strategies to foster the implementation of clinical practice guidelines (Grimshaw 2004) and subsequently applied to reviews of quality improvement strategies in a series of reports for the US Agency for Healthcare Research and Quality (Shojania 2004a; Shojania 2004b; Steinman 2006;Walsh 2006).

This method of reporting the median effect sizes across groups of studies involves two distinct uses of the term 'median'. First, in order to handle multiple outcomes within individual studies, we calculated for each study the median improvement in process adherence across the various outcomes reported by that study. For example, if a study reported 10 process adherence outcomes, we would calculate the absolute difference between intervention and control values for each outcome in order to obtain the median improvement (and interquartile range) across all 10 such differences. This median would then contribute the single effect size for that study. We also captured whenever a study identified a primary outcome and separately analysed those studies. Further, we performed a sensitivity analysis in which, instead of the median outcome, we used the best outcome from

each study. With each study then represented by a single, median outcome, we then calculated the median effect size and interquartile range across all included studies. It is this second use of the 'median' that is crucial to the method. Instead of providing a conventional meta-analytic mean (an average weighted on the basis of the precision of the results from each study), we highlight the median effect achieved by included studies, along with an interquartile range for these effects.

The main potential drawback of this method of reporting the median effects of an intervention across a group of studies lies in the equal weight given to all studies (for example no weighting occurs on the basis of study precision). Note, however, that by using the median rather than the mean, the summary estimate is less likely to be driven by a handful of outlying results (such as large effects from small or methodologically poor studies). Moreover, we included an analysis of the impact of study size and various other methodological features on reported effect size. For instance, we compared the median effects across large and small studies (where large was defined as greater than or equal to the median sample size across all included studies). We performed the analysis of potential associations between study size and effect magnitude using various measures of sample size, including the numbers of patients (or episodes of care) without any adjustment for clustering, the effective sample size taking into account cluster effects (using values for intra-class correlation coefficients available in the published literature (Campbell 2000)) and, finally, using the numbers of providers (or other cluster units) as the sample size.

We also compared the median effects across studies with and without various methodological markers of study quality, as well as certain features of the study context (for example ambulatory versus inpatient setting) and characteristics of the reminders (for example inclusion of patient-specific information versus a generic alert, provision of an explanation for the reminder, requiring users to enter a response to the reminder before continuing with their work, requiring users to navigate through more than one reminder screen). We made all such comparisons using a non-parametric rank-sum test (Mann-Whitney). We performed all statistical analyses using SAS version 9.1 (SAS Institute, Inc, Cary, NC).

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

Results of the search—Our search identified 2036 citations, of which 1662 were excluded at the initial stage of screening and an additional 374 on full-text review, yielding a total of 28 articles that met all inclusion criteria (Figure 1)(Bates 1999; Christakis 2001; Dexter 2001; Eccles 2002a; Filippi 2003; Flottorp 2002; Frank 2004; Hicks 2008;Judge 2006; Kenealy 2005; Kralj 2003; Krall 2004; Kucher 2005;McCowan 2001; Meigs 2003; Overhage 1996; Overhage 1997;Peterson 2007; Rothschild 2007; Roumie 2006; Safran 1995a;Sequist 2005; Tamblyn 2003; Tape 1993; Tierney 2003; Tierney 2005; van Wyk 2008; Zanetti 2003). Four studies contained two comparisons (Eccles 2002a; Flottorp 2002; Kenealy 2005; van Wyk 2008), resulting in 32 included comparisons.

Of the 32 included comparisons, 19 came from US centers and 24 took place in outpatient settings (see 'Characteristics of included studies'). Most (26) trials used a true randomised design, with only six comparisons involving a quasi-random design (typically allocating intervention status on the basis of even or odd provider identification numbers). Twenty-six of the 32 included comparisons allocated intervention status at the level of providers or provider groups, rather than allocating patients (i.e. they were cluster trials).

Risk of bias in included studies

Allocation—Of the 32 comparisons in the review, concealed allocation definitely occurred in 14 comparisons (Christakis 2001; Dexter 2001;Flottorp 2002; Frank 2004; Kenealy 2005; McCowan 2001; Meigs 2003; Rothschild 2007; Roumie 2006; Safran 1995a; van Wyk 2008). The process of allocation concealment was unclear in 14 comparisons (Bates 1999; Eccles 2002a; Filippi 2003; Hicks 2008;Judge 2006; Krall 2004; Overhage 1996; Overhage 1997; Peterson 2007; Sequist 2005; Tierney 2003; Tierney 2005; Tamblyn 2003) and not done in four comparisons (Kralj 2003; Kucher 2005; Tape 1993; Zanetti 2003).

Incomplete outcome data—The proportion of eligible practices or providers with complete follow up was reported in 14 comparisons (Christakis 2001; Flottorp 2002; Kenealy 2005; Krall 2004; McCowan 2001; Meigs 2003;Overhage 1997; Rothschild 2007; Roumie 2006; Tamblyn 2003;van Wyk 2008). The proportion of eligible patients with complete follow up was reported in 12 comparisons (Filippi 2003; Hicks 2008; Kucher 2005; Meigs 2003; Overhage 1997; Rothschild 2007; Roumie 2006; Safran 1995a; Tamblyn 2003; Tierney 2003;Tierney 2005; Zanetti 2003). The number of subjects (professionals, practices or patients) lost to follow up was not clear in 11 comparisons (Bates 1999; Dexter 2001; Eccles 2002a; Frank 2004; Judge 2006; Kralj 2003; Overhage 1996; Peterson 2007;Sequist 2005; Tape 1993).

Baseline disparities between study groups—Only seven comparisons reported data in a format that permitted calculation of baseline disparities between study groups. Across these studies, the median difference between adherence in the intervention and control groups was 0.00% (interquartile range (IQR): 2.0% greater adherence in the control to 0.0%).

Unit of analysis errors—Of the 26 comparisons with a clustered design, only 12 analysed their results in a manner that took clustering effects into account. Thus, the remaining 14 clustered comparisons exhibited unit of analysis errors.

Other quality criteria—Blinded assessment of study outcomes was generally not relevant, as data were typically derived from electronic systems that documented delivery of the target processes of care. Though not the focus of the review, many of the clinical outcomes were also objective ones, such as laboratory data, and so also did not require blinded assessment.

Effects of interventions

Of the 32 comparisons that provided analysable results for improvements in process adherence, (Bates 1999; Christakis 2001;Dexter 2001; Eccles 2002a; Filippi 2003; Flottorp 2002; Frank 2004; Hicks 2008; Judge 2006; Kenealy 2005; Kralj 2003; Krall 2004; Kucher 2005; McCowan 2001; Meigs 2003; Overhage 1996; Overhage 1997; Peterson 2007; Rothschild 2007; Roumie 2006; Safran 1995a; Sequist 2005; Tamblyn 2003; Tape 1993;Tierney 2003; Tierney 2005; van Wyk 2008; Zanetti 2003), 21 reported outcomes involving prescribing practices, six specifically targeted adherence to recommended vaccinations, 13 reported outcomes related to test ordering, three captured documentation, and seven reported adherence to miscellaneous other processes (for example composite compliance with a guideline).

Only nine comparisons reported pre-intervention process adherence for intervention and control groups. For these comparisons, the marginal improvement in the intervention (i.e. the median improvement in the intervention group minus the improvement in the control group) was 3.8% (IQR): 0.4% to 7.9%).

Given the small number of studies that reported baseline adherence, improvements attributable to interventions were calculated as the absolute difference in post-intervention adherence (i.e. the post-intervention improvement in the target process of care observed in the intervention group minus that observed in the control group). Using this post-intervention difference between study groups, the median improvements in process adherence associated with computer reminders were: 4.2 % (IQR: 0.8% to 18.8%) across all process outcomes, 3.3% (IQR: 0.5% to 10.6%) for improvements in prescribing behaviours, 3.8% (IQR: 0.5% to 6.6%) for improvements in vaccination, and 3.8% (IQR: 0.4% to 16.3%) for test ordering behaviours (Table 1). Table 1 also shows the results obtained when we used the outcome with the largest improvement from each study instead of the outcome with the median improvement.

Eight comparisons reported dichotomous clinical endpoints; intervention patients experienced a median absolute improvement of 2.5% (IQR: 1.3% to 4.2%). These endpoints included intermediate endpoints, such as blood pressure and cholesterol targets, as well as clinical outcomes, such as development of pulmonary embolism and mortality. Blood pressure represented the most commonly reported outcome. Patients in intervention groups experienced a median reduction in their systolic blood pressure of 1.0 mmHg (IQR: 2.3 mmHg reduction to 2.0 mmHg increase). For diastolic blood pressure, the median reduction was 0.2 mmHg (IQR: 0.8 mm reduction to 1.0 mm increase).

Impacts of study features on effect sizes

There were sufficient comparisons involving process adherence to permit various analyses of potential associations between various study features and the magnitude of effects (Figure 2). The six quasi-randomised controlled trials reported larger improvements in process adherence than the 26 truly randomised comparisons (7.0%, IQR: 1.2% to 28.0% versus 3.4%: IQR 0.6% to 16.3%), but this difference was not statistically significant (P = 0.53).

Sample size did not correlate with effect size, whether calculated on the basis of numbers of patients or providers (Figure 2).

One might expect studies with low adherence in control groups to report larger improvements in care, but in fact studies with control adherence rates higher than the median across all studies had a non-significant trend towards larger effect sizes (Figure 2). We analysed the potential impact of baseline adherence in several other ways (for example studies with baseline adherence in top quartile versus all others to look for a 'ceiling effect', and studies with baseline adherence in bottom quartile versus all others to look for a floor effect) but found no indication that baseline adherence significantly affected the magnitude of effect in the intervention group.

Interventions that targeted inpatient settings showed a trend towards larger improvements in processes of care than did those that occurred in outpatient settings: 8.7% (IQR: 2.7% to 22.7%) versus 3.0% (0.6% to 11.5%) for outpatient settings (P = 0.34). However, all interventions delivered in inpatient settings occurred at Brigham and Women's Hospital in Boston or the Regenstreif Institute at the University of Indiana. Both of these institutions have mature 'homegrown' computerized provider order entry systems, and the recipients of computer reminders from these institutions consisted primarily of physician trainees, either of which factors may be more relevant than the fact of the inpatient setting.

Studies from the US reported slightly larger improvements in process adherence: 5.0% (IQR: 2.0% to 23.2%) versus 1.2% (IQR: 0.4% to 6.2%) for non-US studies), but this difference was not significant (P = 0.12). Moreover, this trend at least partly reflected the results of studies from US institutions with long track records with clinical information systems (for example the Regenstreif Institute and Brigham and Women's Hospital in Boston).

Grouping studies on the basis of track records in clinical informatics (for example analysing studies from Brigham and Women's Hospital, the Regenstreif Institute and Vanderbilt University versus all others) did not result in significant differences, except in the case of Brigham and Women's Hospital. The four studies from Brigham and Women's Hospital by themselves reported significantly higher improvements in process adherence than all other studies: 16.8% (IQR: 8.7% to 26.0%) versus 3.0% (IQR: 0.5% to 11.5%; P = 0.04).

Lastly, the magnitude of effects attributable to computer reminders appeared to vary with the presence of co-interventions (delivered to intervention and control groups). The 32 comparisons that reported process adherence outcomes included 18 that evaluated a computer reminder versus usual care and 14 that evaluated a computer reminder plus at least one other quality improvement intervention (for example educational materials) versus this same co-intervention in the control group. Comparisons involving no co-interventions (that is computer reminder alone versus usual care) showed a median improvement in process adherence of 5.7% (IQR: 2.0% to 24.0%), whereas studies of multifaceted interventions (that is computer reminders plus additional interventions versus those additional interventions alone) showed a median improvement in adherence of only 1.9% (IQR: 0.0% to 6.2%; P = 0.04 for this difference).

This apparent difference might reflect a ceiling effect, with co-interventions delivered to the intervention and control groups leaving little room for computer reminders to demonstrate additional improvements. If this were the case, one would expect higher post-intervention adherence rates in the control groups of studies that combined computer reminders with other interventions. However, the opposite proved true: post-intervention values for process adherence (in both intervention and control groups) were in fact slightly higher in the studies involving comparisons of computer reminders by themselves, not in the studies involving additional interventions.

This relationship between comparison type and effect size at least partially reflected confounding by other studies features. For instance, dropping the four studies from Brigham and Women's Hospital from the analysis substantially decreased the magnitude of the difference between studies with and without co-interventions (median improvement of 0.9%, IQR: 0.0% to 5.0% versus 3.8%, IQR: 1.2% to 23.2%), and the difference was no longer statistically significant (P = 0.08). Also, of note, none of the P values reported in the analysis adjusted for multiple comparisons nor was stratification by the presence of co-interventions a prespecified hypothesis for our analysis, further adding to the possibility that the observed difference reflects a chance association.

Features of computer reminders

We analysed a number of characteristics of the computer reminders (or the larger clinical information system) to look for associations with the magnitude of impact (Figure 3). The degree of improvement did not differ significantly between studies based on the type of quality problem targeted (underuse versus overuse of a given process of care), the conveyance of patient specific information versus a more generic alert, provision of an explanation for the alert, whether or not the reminder conveyed a specific recommendation, whether or not the authors of the study had developed the reminder, or the type of system used to deliver the reminder (CPOE versus electronic medical record).

There was a trend towards larger effects with reminders that required users to enter a response of some kind (12.9%, IQR 2.7% to 22.7%) versus those that did not (2.7%, IQR: 0.6% to 5.6%; P = 0.09). However, this trend was confounded by the fact that all four comparisons from Brigham and Women's Hospital involved reminders that required responses from users. Dropping these four studies decreased the median effect of reminders that required user responses to 10.6% (IQR: 0.3% to 21.4%) and removed any appearance of statistical significance (P = 0.48). Of note, though, the magnitude of the difference remains substantial (10.6% versus 2.7%); it is possible that the lack of significance reflects lack of power.

We also analysed whether effect sizes differed between reminders that were 'pushed' onto users (that is users automatically received the reminder) versus reminders that required users to perform some action to receive it (that is users had to 'pull' the reminders). Only four comparisons involved 'pull' reminders and these showed comparable effects to 'push' reminders. Of note, however, one trial (van Wyk 2008) directly compared these two modes of reminder delivery. In this three-armed cluster-RCT of reminders for screening and treatment of hyperlipidemia, patients cared for at practices randomised to automatic alerts

Europe PMC Funders Author Manuscripts

were more likely to undergo testing for hyperlipidemia and receive treatment than were patients seen at clinics where reminders were delivered to clinicians only ‘on-demand.’

Sensitivity analysis

We reanalysed the potential predictors of effect size (study features and characteristics of the reminders) using a variety of alternate choices for the representative outcome from each study, including the outcome with the middle value (rather than a calculated median) and the best outcome (that is the outcome associated with the largest improvement in process adherence). None of these analyses substantially altered the main findings, including the lack of any significant association between study or reminder features and the magnitude of effects achieved by computer reminders. Of note, using the best outcome from each study rather than the median outcome, improvements attributable to reminders in studies at Brigham and Womens Hospital were no longer significantly larger than those achieved in studies from other centers (16.8%, IQR: 8.7% to 26.0% versus 4.6%, IQR: 2.0% to 13.4%; P = 0.09 for the comparison). However, the difference still appears large, so loss of significance may simply reflect the lack of power.

DISCUSSION

Across 32 comparisons, computer reminders achieved small to modest improvements in care. The absolute improvement in process adherence was less than 4% for half of the included comparisons. Even when we included the best outcome from each comparison, the median improvement was only 5.6%. For improvements in prescribing, perhaps the behaviours of greatest general interest, improvements were even smaller.

With the upper quartile of reported improvements beginning at a 15% increase in process adherence, some studies clearly did show larger effects. However, we were unable to identify any study or reminder features that predicted larger effect sizes, except for a statistically significant (albeit unadjusted for multiple comparisons) difference in effects seen in studies involving the computer order entry system at Brigham and Women’s Hospital. A trend towards larger effects was seen for reminders that required users to enter a response in order to proceed, but this finding may have been confounded by the uneven distribution of studies from Brigham and Women’s Hospital. Thus, we do not know if the success of computer reminders at the Brigham partially reflects the design of reminders requiring user responses or if other features of the computer system or institutional culture of Brigham play the dominant role.

The finding that comparisons of computer reminders alone versus usual reported larger effect sizes than comparisons involving computer reminders and other co-interventions represented an unexpected finding. Exploratory analyses did not reveal a plausible explanation for this result except that it may have reflected uneven distribution of confounders. One additional explanation might be that investigators chose to incorporate computer reminders in multifaceted interventions when attempting to change more complex (and therefore difficult to change) behaviours than those addressed by reminders alone. However, this unexpected finding may also constitute a chance association, especially as none of the P values reported in the analysis adjust for multiple comparisons.

A major potential limitation of our analysis was the heterogeneity of the interventions and the variable degree with which they were reported, including limited descriptions of key intervention features of the reminders and the systems through which they were delivered. We attempted to overcome this problem by abstracting basic attributes, such as whether user responses were required and whether or not the reminder contained patient-specific information, but heterogeneity within even these apparently straightforward categories could mask important differences in effects. Also, other characteristics which we found difficult to operationalise for example the 'complexity' of the reminder), or which were inadequately reported, may also correlate with important differences in impact. This problem of limited descriptive detail of complex interventions and the resulting potential for substantial heterogeneity among included interventions in systematic reviews has been consistently encountered in the literature (Grimshaw 2003; Ranji 2008; Shojania 2005; Walsh 2006).

Our focus on the median effects across studies represents another potential limitation. However, as outlined in the 'Methods' section, we chose this approach precisely to avoid spurious precision due to heterogeneity and clustering effects that could not be taken into account in many studies. This approach is becoming increasingly common in Cochrane Reviews of interventions to change practice (Grimshaw 2004; Jamtvedt 2006; O'Brien 2007) and has also been used in other evidence syntheses (Grimshaw 2004;Shojania 2004b; Steinman 2006; Walsh 2006). This method conveys the range of effects associated with the intervention of interest and also allows for analysis of factors associated with effect size.

Additional studies continue to appear and we plan to assess eligible new studies formally for inclusion in six months. At that time we will also include a study that had previously been excluded as a time series, but which we have since decided merits inclusion as a controlled clinical trial (Durieux 2000).

In summary, computer reminders delivered at the point of care have achieved variable improvements in target behaviours and processes of care. The small to modest median effects shown in our analysis may hide larger effects. However, the current literature does not suggest which features of the reminder systems, the systems with which they are delivered, or which target problems might consistently predict larger improvements.

AUTHORS' CONCLUSIONS

Implications for practice

On-screen computer reminders may become more prevalent as healthcare institutions advance in the use of computer technology. There appears to be a wide range of effects of the intervention, making it difficult to provide specific suggestions about how to maximize the benefits.

Implications for research

Although some studies have clearly shown substantial improvements in care from point of care computer reminders it is concerning that the majority of studies have shown fairly small improvements across a range of process types. This finding of small to modest improvements is not unique to computer reminders. As had been said before, there are no

Europe PMC Funders Author Manuscripts

'magic bullets' when it comes to changing provider behavior and improving care (Shojania 2005;Oxman 1995). However, given that the opportunity to deliver computer reminders at the point of care represents one of the major incentives to implementing sophisticated clinical information systems, future research will need to identify key factors (related to the target quality problem or the design of the reminder) that reliably predict larger improvements in care from these expensive technologies.

Acknowledgments

We would like to acknowledge the assistance of Naghmeh Mojaverian and Jun Ji for their assistance with data extraction on this review. We would also like to acknowledge the assistance of Kathleen McGovern in preparing the review for publication. We would also like to acknowledge the contributions of Richard Gordon, Jeremy Wyatt and Rachel Rowe on the protocol for this review. Finally, we would like to thank Pierre Durieux, Richard Shiffman, Tomas Pantoja and Michelle Fiander for their helpful comments on earlier versions of this review.

SOURCES OF SUPPORT

Internal sources

- Ottawa Hospital Research Institute, Canada.
- University of Ottawa, Canada.

External sources

- Canadian Institutes of Health Research, Canada.
- CIHR Institute of Health Services and Policy Research, Canada.
- CIHR Institute of Musculoskeletal Health and Arthritis, Canada.
- CIHR Institute of Gender and Health, Canada.
- CIHR Institute of Human Development, Child and Youth Health, Canada.
- CIHR Institute of Nutrition, Metabolism and Diabetes, Canada.
- CIHR Institute of Infection and Immunity, Canada.
- Canadian Foundation for Innovation, Canada.
- Government of Canada Research Chair in Patient Safety and Quality Improvement, Canada.
- UK National Institute for Health Research Cochrane Programme Grant scheme, UK.
- Chief Scientist Office of the Scottish Government Health Directorate, UK.

The Health Services Research Unit is funded by the Chief Scientist Office of the Scottish Government Health Directorate. The views expressed, however, are those of the authors.

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Bates 1999

Methods	RCT
Participants	Medical & surgical inpatient services, teaching hospital, Boston, USA (Brigham and Women's Hospital) 11,586 episodes of care
Interventions	Alerting providers to potentially redundant orders for laboratory tests

Outcomes	Process adherence (test ordering), resource use	
Notes	System for delivery of reminder: CPOE	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	Quote "randomization was performed using an internal identification number not available to providers." Unclear if allocation was concealed from investigators
Incomplete outcome data addressed? All outcomes	Unclear	Not specified in the text

Christakis 2001

Methods	Cluster-RCT	
Participants	Outpatient pediatric teaching clinic, Seattle, USA (University of Washington) 1339 episodes of care, 38 providers	
Interventions	Displaying evidence regarding the use and duration of antibiotics for otitis media in children	
Outcomes	Process adherence (prescribing)	
Notes	System for delivery of reminder: CPOE	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	Quote: "stratified randomization using an electronic random number generator"
Incomplete outcome data addressed? All outcomes	Yes	Authors report 92% and 74% complete follow-up for providers for 2 analyses

Dexter 2001

Methods	Cluster-RCT	
Participants	General medicine inpatient service, teaching hospital, Indianapolis, USA (Indiana University, Regenstrief Institute) 6371 patients, 8 provider teams	
Interventions	Notifying providers of hospitalised patients' eligibility for 4 preventive care measures	
Outcomes	Process adherence (prescribing, vaccination)	
Notes	System for delivery of reminder: CPOE	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	Quote "a blinded system of coin randomization"
Incomplete outcome data addressed? All outcomes	Unclear	Difficult to assess if all subjects were included

Eccles 2002a

Methods	Cluster-RCT
Participants	Ambulatory general practices, United Kingdom **a.** 2335 patients, 60 practices **b.** 2363 patients, 60 practices
Interventions	Decision support for management of outpatients with (a) angina or (b) asthma
Outcomes	Process adherence (documentation)
Notes	System for delivery of reminder: EMR Additional interventions delivered to intervention and control group: distribution of educational materials to providers

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	Not reported in text of study
Incomplete outcome data addressed? All outcomes	Unclear	Not reported

Filippi 2003

Methods	Cluster-RCT
Participants	Ambulatory general practices in Italy 15,343 patients, 300 providers
Interventions	Identifying diabetic patients who would benefit from antiplatelet agents for cardiovascular risk reduction
Outcomes	Process adherence (prescribing)
Notes	System for delivery of reminder: EMR Additional interventions delivered to intervention and control group: distribution of educational materials to providers

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	Not stated in text
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 74.4% calculated from paper for patients

Flottorp 2002

Methods	Cluster-RCT
Participants	Ambulatory general practices in Norway **a.** 9887 episodes of care, 57 practices **b.** 16,939 episodes of care, 56 practices

Interventions	Display of guidelines for appropriate use of antibiotics and laboratory tests in (a) women with suspected urinary tract infection or (b) patients with sore throat
Outcomes	Process adherence (prescribing, test ordering, other)
Notes	System for delivery of care: EMR Additional interventions delivered to intervention and control groups: educational materials for providers and patients, educational workshops for providers, financial incentives for providers

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	Quote "142 practices were randomised by computer"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 79.6% for practices calculated from paper

Frank 2004

Methods	CCT
Participants	Urban ambulatory practice (academic status not reported), Australia 10,507 patients
Interventions	Notifying providers of outpatients' eligibility for various processes of care (mostly preventive measures)
Outcomes	Process adherence (test ordering, documentation, vaccination)
Notes	System for delivery of care: EMR

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	Quote "All patients who attended were randomised by the terminal digit of their record number"
Incomplete outcome data addressed? All outcomes	Unclear	Data not presented for number of patients followed up

Hicks 2008

Methods	Cluster-RCT
Participants	Community and hospital-based academically-affiliated primary clinics, Boston, USA (Brigham and Women's Hospital) 1834 patients, 12 clinics
Interventions	Presenting guideline-based suggestions for management of patients with hypertension
Outcomes	Process adherence (guideline-adherent prescribing for hypertension treatment)
Notes	System for delivery of reminder: EMR with e-prescribing

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	No description of allocation concealment

Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 50% calculated from paper for patients

Judge 2006

Methods	Cluster-RCT
Participants	Academically-affiliated, long-term care facility, Toronto, Canada 3843 episodes of care, 7 wards
Interventions	Alerting providers to various potential adverse drug events (e.g. severe drug interactions, out-of-recommended-range doses for elderly patients)
Outcomes	Process adherence (prescribing)
Notes	System for delivery of reminder: CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	No description of allocation concealment
Incomplete outcome data addressed? All outcomes	Unclear	Unable to assess follow-up data

Kenealy 2005

Methods	Cluster-RCT
Participants	General practices, New Zealand outpatient 2814 patients, 33 practices
Interventions	Suggesting to providers that they screen patients over 50 years of age
Outcomes	Process adherence (test ordering)
Notes	System for delivery of reminder: EMR Additional interventions delivered to some participants in the intervention and control groups: distribution of educational materials to providers, educational outreach

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	Quote "An independent person used Excel to generate random numbers in blocks of 8 and place the names of intervention groups in sealed and consecutively numbered envelopes"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 94.4% calculated from paper for professionals

Kralj 2003

Methods	Cluster-CCT

Participants	Two community oncology outpatient practices, USA 2170 episodes of care, 2 practices
Interventions	Prompting providers to order erythropoietin for patients with haemoglobin < 120 g/dL
Outcomes	Process adherence (prescribing)
Notes	System for delivery of reminder: EMR with link to CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	No description, cluster trial
Incomplete outcome data addressed? All outcomes	Unclear	No description provided

Krall 2004

Methods	Cluster-RCT
Participants	Ambulatory Family and Internal Medicine practices, Oregon, USA (Kaiser Permanente Northwest) 1076 patients, 100 providers
Interventions	Notification of patients' eligibility to receive aspirin for cardiovascular risk reduction
Outcomes	Process adherence (prescribing)
Notes	System for delivery of reminder: EMR and CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	No description of allocation
Incomplete outcome data addressed? All outcomes	Yes	Authors report 100% follow up for professionals

Kucher 2005

Methods	CCT
Participants	Major teaching hospital, Boston, USA (Brigham and Women's Hospital) 2506 patients
Interventions	Identifying hospitalized patients at increased risk for developing venous thromboembolism
Outcomes	Process adherence (prescribing, other), clinical outcomes
Notes	System for delivery of reminder: CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	CCT, allocation based on medical record number
Incomplete outcome data addressed?	Yes	Follow-up rate of 94.2% calculated from paper for patients

All outcomes

McCowan 2001

Methods	Cluster-RCT	
Participants	Outpatient general practices, United Kingdom 477 patients, 46 practices	
Interventions	Decision support for management of outpatients with asthma	
Outcomes	Process adherence (other), clinical outcomes	
Notes	System for delivery of reminder: EMR	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	Quote "random number sequence"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 37.9% calculated for providers

Meigs 2003

Methods	Cluster-RCT	
Participants	Internal medicine ambulatory clinic, teaching hospital, Boston, USA (Massachusetts General Hospital) 598 patients, 2 provider teams	
Interventions	Display of recommended target goals of care, last known values of relevant lab tests (e. g. HbA1c, creatinine, lipids)	
Outcomes	Process adherence (test ordering), clinical outcomes, resource use	
Notes	System for delivery of reminder: EMR	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	Quote "A coin was tossed to select an intervention group and a control group"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 46.2% for providers and 37.5% for patients calculated from paper

Overhage 1996

Methods	Cluster-RCT
Participants	Inpatient internal medicine service, academic medical center, Indianapolis, USA (Regenstrief Institute) 1622 patients, 24 providers
Interventions	Suggesting orders for various preventive care measures in eligible patients
Outcomes	Process adherence (prescribing, test ordering, vaccination, other)

Notes	System for delivery of reminder: CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	No description of allocation concealment
Incomplete outcome data addressed? All outcomes	Unclear	Unclear reporting of total number of patients

Overhage 1997

Methods	Cluster-RCT
Participants	Medicine service, teaching hospital, Indianapolis, USA (Regenstrief Institute) 2181 patients, 6 services
Interventions	Prompting providers about "corollary orders"
Outcomes	Process adherence (test ordering), clinical outcomes, resource use
Notes	System for delivery of reminder: CPOE Additional interventions delivered to intervention and control groups: drug utilization review program

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	No description of allocation concealment
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 93.5% for professionals and 100% for patients calculated from paper

Peterson 2007

Methods	CCT
Participants	Academic medical center, Nashville, USA (Vanderbilt University) 2981 patients
Interventions	Providing medication decision support for drugs in the hospitalized elderly (avoiding certain drugs and modified dosing for others)
Outcomes	Process adherence (medication dosage and criteria)
Notes	System for delivery of reminder: CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	No description of allocation concealment
Incomplete outcome data addressed? All outcomes	Unclear	Information not provided

Rothschild 2007

Methods	Cluster-RCT
Participants	Academic medical center, Boston, USA (Brigham and Women's Hospital) 350 episodes of care, 453 providers
Interventions	Presentation of guidelines regarding indications for transfusion of red cells, platelets, and frozen plasma
Outcomes	Process adherence (prescribing), clinical outcomes
Notes	System for delivery of reminder: CPOE Additional interventions delivered to intervention and control groups: provider education (printed materials, workshops)

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	Quote "A computerized program generated the randomization scheme for each block"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 100% for both patients and providers calculated from paper

Roumie 2006

Methods	Cluster-RCT
Participants	2 hospitals, 8 ambulatory clinics, Nashville, USA (Vanderbilt University) 871 patients, 116 providers
Interventions	Alert in electronic medical record displaying recent blood pressure value and outlining national recommendations for hypertension treatment and blood pressure goals
Outcomes	Process adherence (prescribing), clinical outcomes
Notes	System for delivery of reminder: EMR Additional interventions delivered to intervention and control groups: provider education (printed materials delivered via e-mail)

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	Quote "randomization sequence was computer-generated"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 88% for providers and 77% for patients calculated from paper

Safran 1995a

Methods	Cluster-RCT
Participants	Academic primary care clinic, Boston, USA (Beth Israel Hospital) 349 patients, 2 teams
Interventions	Alerting providers to eligibility of HIV-positive patients for various recommended processes of care
Outcomes	Process adherence (other), process outcomes, clinical outcomes
Notes	System for delivery of reminder: EMR

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	Quote "by flipping a coin"
Incomplete outcome data addressed? All outcomes	Unclear	Follow-up rate of 51.3% for patients calculated from paper

Sequist 2005

Methods	Cluster-RCT
Participants	Outpatient primary clinics (academic and community) Boston area, USA (Brigham and Women's Hospital) 6243 patients, 20 clinics
Interventions	Displaying guidelines for recommended aspects of care for patients with diabetes and coronary artery disease
Outcomes	Process adherence (prescribing, other)
Notes	System for delivery of reminder: EMR Additional interventions delivered to intervention and control groups: paper reminders to providers

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	Not described in paper
Incomplete outcome data addressed? All outcomes	Unclear	Insufficient information to assess in paper

Tamblyn 2003

Methods	Cluster-RCT
Participants	Primary care practices in Quebec, Canada 12,560 encounters, 107 providers
Interventions	Alerting providers to various potential adverse drug events (e.g. based on drug-drug interactions, and drug-disease or drug-age contraindications)
Outcomes	Process adherence (prescribing)
Notes	System for delivery of reminder: CPOE

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	Not described in paper
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 100% for providers and 100% for patients calculated from paper

Tape 1993

Methods	Cluster-CCT
Participants	Internal medicine teaching clinic, Omaha, USA (University of Nebraska) 1809 patients, 2 clinics
Interventions	Drawing attention to deficiencies in preventive care measures for a given patient
Outcomes	Process adherence (test ordering, vaccination)
Notes	System for delivery of reminder: EMR Additional interventions delivered to intervention and control groups: provider education (conferences), paper reminders to providers

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	Alternate week randomisation
Incomplete outcome data addressed? All outcomes	Unclear	Insufficient information to assess in paper

Tierney 2003

Methods	Cluster-RCT
Participants	Academic primary care group practice, Indianapolis, USA (Regenstrief Institute) 378 encounters, 32 practice sessions
Interventions	Presenting guideline-based suggestions for management of heart failure and coronary artery disease
Outcomes	Process adherence (prescribing, vaccination), clinical outcome, resource use
Notes	System for delivery of reminder: CPOE Additional interventions delivered to intervention and control groups: provider (printed materials, workshops, outreach visits), use of local opinion leaders

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	Quote "We used the random number generator...", but unclear if procedure was followed for the whole sample
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 81% for patients calculated from paper

Tierney 2005

Methods	RCT
Participants	General medicine practice, teaching hospital, Indianapolis, USA (Regenstrief Institute) 363 episodes of care
Interventions	Presenting guideline-based suggestions for management of asthma and chronic obstructive pulmonary disease
Outcomes	Process adherence (prescribing, test ordering, vaccination), clinical outcome, resource use
Notes	System for delivery of reminder: CPOE

	Additional interventions delivered to intervention and control groups: provider education (printed materials and workshops)

Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	Quote "We randomized all half-day sessions to intervention or control status via a coin flip" but adjustment to allocation performed and whether the adjustment was concealed
Incomplete outcome data addressed? All outcomes	Unclear	Follow-up rate of 89.9% for patients calculated from paper

van Wyk 2008

Methods	Cluster-RCT
Participants	General practice clinics in the Netherlands 3955 patients, 24 clinics
Interventions	Automatic presentation of patient-specific recommendations related to screening and treatment of patients with dyslipidemia
Outcomes	Process adherence (screening, treating)
Notes	System for delivery of reminder: EMR

Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	Quote "Randomization was performed with a table of random numbers"
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 95% of practices calculated from paper.

Zanetti 2003

Methods	CCT
Participants	Cardiac surgery service at academic medical center, Boston, USA (Brigham and Women's Hospital) 449 operations
Interventions	Audible alarm on operating room computer with accompanying visual alert that patient should receive a second dose of antibiotic prophylaxis due to prolonged operative time
Outcomes	Process adherence (prescribing), clinical outcomes
Notes	System for delivery of reminder: CPOE

Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	No	Assignment based on case number
Incomplete outcome data addressed? All outcomes	Yes	Follow-up rate of 82% for patients calculated from paper

CPOE: Computerised provider order entry; EMR: electronic medical record; RCT: randomised controlled trial; CCT: Controlled clinical trial.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Aase 1999	Excluded topic
Ageno 1998	Not a provider reminder
Anaya 2004	Not a provider reminder
Andersen 2002	Not a provider reminder
Anderson 1976	Excluded topic
Anderson 2003	Not a provider reminder
Anonymous 2002	Not an on-screen computer reminder
Ansari 2003	Ineligible comparison or inappropriate control
Apkon 2005	Excluded topic
Aronsky 2001	Excluded topic
Ashe 2004	Not an on-screen computer reminder
Atherton-Naji 2001	Not a provider reminder
Bailey 2007	Not an on-screen computer reminder
Baird 1984	Not a provider reminder
Barnett 1983	Not an on-screen computer reminder
Baskerville 2001	Not a provider reminder
Bates 1997	No eligible outcomes
Beaulieu 2004	Not an on-screen computer reminder
Becker 1989	Not an on-screen computer reminder
Bekkering 2005	Excluded topic
Bennett 2003	Study design
Berkenstadt 2006	Excluded topic
Bindels 2000	Study design
Bindels 2003	Not an on-screen computer reminder
Bindels 2004	Study design
Bird 1990	Not an on-screen computer reminder
Bjorsness 2003	Not an on-screen computer reminder
Black 2002	Not a provider reminder
Boekeloo 1990	Not an on-screen computer reminder
Bogucki 2004	Study design
Bomba 2006	Not a provider reminder
Bonevski 1999	Not a provider reminder
Borlawsky 2005	Study design
Bosworth 2005	Data not interpretable
Bovbjerg 2000	Not a provider reminder
Brown 2003	Excluded topic
Brownbridge 1986	Study design
Buchsbaum 1993	Not an on-screen computer reminder

Study	Reason for exclusion
Bullard 2004	Not a provider reminder
Burack 1989	Not an on-screen computer reminder
Burack 2003	Not an on-screen computer reminder
Burton 1991	Not a provider reminder
Cabrero-Canosa 2004	Excluded topic
Calabrisi 2002	Study design
Cannon 2000	Not a provider reminder
Care Management 2002	Not a provider reminder
Casebeer 2003	Not a provider reminder
Cho 2003	Not a provider reminder
Christakis 2004	No eligible outcomes
Christensen 2004	Not an on-screen computer reminder
Clayton 2007	Not a provider reminder
Coe 1977	Not an on-screen computer reminder
Collins 2003	Not an on-screen computer reminder
Colombet 2004	Study design
Cooke 2001	Not a provider reminder
Cornia 2003	Not a provider reminder
Costanza 2000	Not a provider reminder
Coyle 2004	Not an on-screen computer reminder
Cramer 1999	Not a provider reminder
Crane 2006	Not an on-screen computer reminder
Creedon 1998	Not a provider reminder
Curry 2003	Data not interpretable
Daley 2004a	Not a provider reminder
Daley 2004b	Not an on-screen computer reminder
Daugaard 2002	Not a provider reminder
Davis 2005	Study design
Day 2006	Excluded topic
de Dombal 1994	Study design
de Fine Olivarius 2001	Not a provider reminder
Degia 2005	Not a provider reminder
Degli 1999	Not a provider reminder
del Mar 2006	Duplicate publication
Demakis 2000	Ineligible comparison or inappropriate control
Derose 2005	Not an on-screen computer reminder
Desbiens 2000	Not an on-screen computer reminder
Dexter 1998	Not an on-screen computer reminder
Dexter 2004	Ineligible comparison or inappropriate control

Study	Reason for exclusion
Dowie 2002	Not a provider reminder
East 1999	Not a provider reminder
Ebell 1995	Study design
Eccles 2000	Data not interpretable
Eccles 2001	Not an on-screen computer reminder
Eccles 2002	Not an on-screen computer reminder
Edmonson 2005	Not a provider reminder
Emery 2007	Excluded topic
Evans 1994	No eligible outcomes
Faresjo 2006	Not a provider reminder
Feeg 2005	Not a provider reminder
Feldstein 2006a	Not an on-screen computer reminder
Feldstein 2006b	Not an on-screen computer reminder
Fihn 1994	Not a provider reminder
Fiks 2007	Study design
Fischer 2003	Study design
Fitzmaurice 1996	Not a provider reminder
Fitzmaurice 2000	Not an on-screen computer reminder
Flanagan 1999a	Not an on-screen computer reminder
Flanagan 1999b	Study design
Flottorp 2003a	Not a provider reminder
Flottorp 2003b	Study design
Fordham 1990	Not a provider reminder
Frame 1994	Not an on-screen computer reminder
Frances 2001	Ineligible comparison or inappropriate control
Fransen 2004	Not a provider reminder
Fretheim 2003	Study design
Fretheim 2006a	Ineligible comparison or inappropriate control
Fretheim 2006b	Duplicate publication
Frolich 1997	Not an on-screen computer reminder
Galanter 2005	Study design
Garrett 2002	Not a provider reminder
German 1987	Not an on-screen computer reminder
Gill 2000	Not an on-screen computer reminder
Glasgow 1995	Not an on-screen computer reminder
Goff 2003	Not an on-screen computer reminder
Goldberg 2000	Study design
Goldberg 2002	Not an on-screen computer reminder
Goodey 2000	Not an on-screen computer reminder

Study	Reason for exclusion
Grimaud 1999	Not a provider reminder
Hales 1995	Not an on-screen computer reminder
Harpole 1997	Ineligible comparison or inappropriate control
Haruna 1998	Not a provider reminder
Hatcher 2005	Study design
Heidenreich 2005	Not an on-screen computer reminder
Heiman 2004	Not an on-screen computer reminder
Hetlevik 1998	No eligible outcomes
Hetlevik 1999	No eligible outcomes
Hetlevik 2000	Ineligible comparison or inappropriate control
Hickling 1989	Not a provider reminder
Hobbs 1996	Not a provider reminder
Hoch 2003	Not an on-screen computer reminder
Hoeper 1984	Not a provider reminder
Hogg 1990	Not an on-screen computer reminder
Holbrook 2002	Study design
Holbrook 2005	Data not interpretable
Hollingworth 1995	Excluded topic
Horng 2006	Not a provider reminder
Hsieh 2004	Study design
Javitt 2005	Not an on-screen computer reminder
Jenkins 2000	Study design
John 2008	Study design
Johnson 2004	Excluded topic
Johnson 2006	Not a provider reminder
Johnston 2004	Not a provider reminder
Junghans 2007	Not a provider reminder
Kailajärvi 2000	Study design
Kaplan 2000	Not a provider reminder
Karikoski 2003	Not a provider reminder
Katz 2004	Not an on-screen computer reminder
Keeffe 2005	No eligible outcomes
Kellett 1997	Not an on-screen computer reminder
Koop 2002	Not a provider reminder
Kuilboer 2006	Data not interpretable
Kuperman 1999	Not an on-screen computer reminder
Kuperman 2001	Study design
Lafata 2007	Ineligible comparison or inappropriate control
Laflamme 2005	Not a provider reminder

Study	Reason for exclusion
Landis 1992	Not an on-screen computer reminder
Lattimer 1998	Not a provider reminder
Lattimer 2000	Not a provider reminder
Lau 1998	Study design
LeBaron 2004	Not a provider reminder
Lemelin 2001	Not a provider reminder
Lesourd 2002	Not an on-screen computer reminder
Leung 2003	Not a provider reminder
Lewis 1996	Not an on-screen computer reminder
Lilford 1992	Not a provider reminder
Lin 2004	Not a provider reminder
Lipkus 1999	Not an on-screen computer reminder
Litzelman 1993	Not an on-screen computer reminder
Lobach 1997	Not an on-screen computer reminder
Lobach 1994	Not an on-screen computer reminder
Lobach 1996	Not a provider reminder
Love 2008	Data not interpretable
Lowensteyn 1998	Not an on-screen computer reminder
Lubitz 1995	Not a provider reminder
MacIntyre 2003	Not an on-screen computer reminder
MacLean 2004	Not an on-screen computer reminder
Margolis 1992	Data not interpretable
Margolis 2004	Not a provider reminder
Martens 2006	Data not interpretable
Martens 2007	Data not interpretable
Martin 2007	Not an on-screen computer reminder
Matheny 2007	Not an on-screen computer reminder
McAlister 2006	Not an on-screen computer reminder
McCartney 1997	Not an on-screen computer reminder
McDonald 1976	Not an on-screen computer reminder
McDonald 1980	Not an on-screen computer reminder
McDonald 1984	Not an on-screen computer reminder
McDonald 1992	Not an on-screen computer reminder
McDowell 1986	Not a provider reminder
McDowell 1989a	Not a provider reminder
McDowell 1989b	Not an on-screen computer reminder
McEwen 2006	Not an on-screen computer reminder
McGowan 1999	Excluded topic
McGowan 2000	Not a provider reminder

Study	Reason for exclusion
McGregor 2006	Not an on-screen computer reminder
McIsaac 2002	Not an on-screen computer reminder
McKinley 2001	Not an on-screen computer reminder
McPhee 1989	Not an on-screen computer reminder
McPhee 1991	Not an on-screen computer reminder
Medow 2001	Excluded topic
Mills 2006	Not a provider reminder
Montani 2000	Not a provider reminder
Montgomery 2000	Ineligible comparison or inappropriate control
Montori 2002	Not a provider reminder
Morisky 2002	Not a provider reminder
Murray 1999	Not an on-screen computer reminder
Murray 2004	Duplicate publication
Musser 2001	Not a provider reminder
Myers 2004	Not an on-screen computer reminder
Nguyen 2000	Not an on-screen computer reminder
Nilasena 1995	Not an on-screen computer reminder
Norman 2004	Not a provider reminder
Olivarius 2001	Not an on-screen computer reminder
Oppenheim 2002	Study design
Ornstein 1991	Not an on-screen computer reminder
Ornstein 2001	Not an on-screen computer reminder
Otero-Sabogal 2006	Not an on-screen computer reminder
Overhage 1995	Study design
Overhage 2001	Not a provider reminder
Oyen 2005	Study design
Palen 2006	Ineligible comparison or inappropriate control
Parry 2000	Duplicate publication
Patterson 1998	Not an on-screen computer reminder
Peck 1973	Not a provider reminder
Persell 2008	No eligible outcomes
Petrucci 1991	Excluded topic
Poller 1993	Not an on-screen computer reminder
Poller 1998	Not a provider reminder
Preston 2000	Not an on-screen computer reminder
Raebel 2005	Excluded topic
Raebel 2007a	Excluded topic
Raebel 2007b	Excluded topic
Ramnarayan 2003	Excluded topic

Study	Reason for exclusion
Rapley 2006	Not a provider reminder
Reeve 2008	Excluded topic
Rhodes 2006	Not an on-screen computer reminder
Rind 1991	Study design
Rind 1995	Study design
Robinson 2007	Not a provider reminder
Rodman 1984	Not a provider reminder
Rogers 1982	Not an on-screen computer reminder
Rogers 1984	Not an on-screen computer reminder
Rollman 2001	Not an on-screen computer reminder
Rollman 2002	Not an on-screen computer reminder
Rood 2005	Excluded topic
Rosenman 2003	Study design
Rosser 1991	Not an on-screen computer reminder
Rosser 1992	Not an on-screen computer reminder
Rotman 1995	Data not interpretable
Rotman 1996	No eligible outcomes
Roukema 2008	Excluded topic
Roumie 2004	Study design
Roumie 2007	Duplicate publication
Rubenstein 1995	Not an on-screen computer reminder
Ryff-de Leche 1919	Not a provider reminder
Sabnis 2003	Not an on-screen computer reminder
Safran 1993	Duplicate publication
Safran 1995b	Duplicate publication
Safran 1996	Duplicate publication
Saitz 2003	Not an on-screen computer reminder
Samore 2005	Not an on-screen computer reminder
Sanders 2000	Not an on-screen computer reminder
Scharer 2002	Not a provider reminder
Scheel 2002	Not an on-screen computer reminder
Scholes 2006	Not an on-screen computer reminder
Schriger 1997	Study design
Schriger 2001	Not an on-screen computer reminder
Schwartz 2005	Not a provider reminder
Schwid 1999	Excluded topic
Shandro 2002	Not a provider reminder
Shannon 2001	Not an on-screen computer reminder
Shapiro 1987	Not a provider reminder

Study	Reason for exclusion
Shea 1995	No eligible outcomes
Shojania 1998	No eligible outcomes
Shu 2001	Not an on-screen computer reminder
Sicotte 1998	Not a provider reminder
Simon 2000	Not an on-screen computer reminder
Simon 2006	Ineligible comparison or inappropriate control
Sittig 1990	Study design
Smith 2008	Not an on-screen computer reminder
Smithuis 1994	Non-English
Solomon 2001	Not a provider reminder
Sommers 1984	Not an on-screen computer reminder
Stair 1995	Not a provider reminder
Stamos 2001	Not an on-screen computer reminder
Steele 2003	Not a provider reminder
Stewart 2003	Study design
Stone 2005	Not a provider reminder
Subramanian 2004	Not an on-screen computer reminder
Séroussi 2004	Study design
Tai 1999	Not a provider reminder
Tamblyn 1997	Duplicate publication
Tang 1999	Study design
Taylor 2008	No eligible outcomes
Thomas 1983	Not an on-screen computer reminder
Thomas 2007	Not a provider reminder
Thompson 1999	Not a provider reminder
Tierney 1986	Not an on-screen computer reminder
Tierney 1987	No eligible outcomes
Tierney 1988	No eligible outcomes
Tierney 1990	No eligible outcomes
Tierney 1993	No eligible outcomes
Topal 2005	Study design
Topol 2007	Study design
Torgerson 1993	Not a provider reminder
Toth-Pal 2004	Study design
Tremaine 2001	Not a provider reminder
Trivedi 2003	Study design
Trivedi 2007	Not a provider reminder
Tung 2003	Study design
Turner 1989	Not an on-screen computer reminder

Study	Reason for exclusion
Vadher 1997a	Not an on-screen computer reminder
Vadher 1997b	Not a provider reminder
van den Besselaar 2007	Not an on-screen computer reminder
van Overbeeke 1996	Not a provider reminder
van Wyk 2003	Not a provider reminder
Verstappen 2007	Not an on-screen computer reminder
Veselý 2006	Excluded topic
Vinker 2002	Not an on-screen computer reminder
Vissers 1995	Not an on-screen computer reminder
Vissers 1996a	Not an on-screen computer reminder
Vissers 1996b	Not an on-screen computer reminder
Walton 1997	Study design
Wanger 1997	Study design
Warren 1999	Excluded topic
Weaver 2004	Study design
Weber 2008	Not an on-screen computer reminder
Weingarten 1989	Not an on-screen computer reminder
Weir 2003	Not an on-screen computer reminder
Wellingham 2003	Study design
White 1987	Not a provider reminder
White 1991	Not a provider reminder
Whitty 2004	Study design
Williams 1998	Not an on-screen computer reminder
Wolfenden 2005	Data not interpretable
Wright 2007	Not an on-screen computer reminder
Yarnall 1998	Not an on-screen computer reminder
Yealy 2005	Not an on-screen computer reminder
Young 1981	Not an on-screen computer reminder
Young 2003	Not a provider reminder
Ziemer 20056	Not an on-screen computer reminder
Zimmerman 2003	Not a provider reminder
Zwar 2002	Not an on-screen computer reminder

Characteristics of studies awaiting assessment *[ordered by study ID]*

Durieux 2000

Methods

Participants
Interventions
Outcomes
Notes

Plaza 2005

Methods
Participants
Interventions
Outcomes
Notes

Study published in Spanish - awaiting translation. Expected to be eligible for inclusion.

DATA AND ANALYSES

This review has no analyses.

HISTORY

Protocol first published: Issue 2, 1998

Review first published: Issue 3, 2009

Date	Event	Description
11 November 2009	Amended	Minor changes to figures

WHAT'S NEW

Last assessed as up-to-date: 10 January 2009.

Date	Event	Description
7 December 2010	Amended	Minor typo change to title

References to studies included in this review

Bates 1999 {published data only} . Bates DW, Kuperman GJ, Rittenberg E, Teich JM, Fiskio J, Ma'luf N, et al. A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests. American Journal of Medicine. 1999; 106:144–50. [PubMed: 10230742]

Christakis 2001 {published data only} . Christakis DA, Zimmerman FJ, Wright JA, Garrison MM, Rivara FP, Davis RL. A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. Pediatrics. 2001; 107:E15. [PubMed: 11158489]

Dexter 2001 {published data only} . Dexter PR, Perkins S, Overhage JM, Maharry K, Kohler RB, McDonald CJ. A computerized reminder system to increase the use of preventive care for hospitalized patients. New England Journal of Medicine. 2001; 345:965–70. [PubMed: 11575289]

Eccles 2002a {published data only} . Eccles MP, McColl E, Steen N, Rousseau N, Grimshaw J, Parkin D, et al. Effect of computerized evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomized controlled trial. BMJ. 2002; 325:941. [PubMed: 12399345]

Filippi 2003 {published data only} . Filippi A, Sabatini A, Badioli L, Samani F, Mazzaglia G, Catapano A, et al. Effects of an automated electronic reminder in changing the antiplatelet drug-prescribing behavior among Italian general practitioners in diabetic patients: an intervention trial. Diabetes Care. 2003; 26:1497–500. [PubMed: 12716811]

Flottorp 2002 {published data only} . Flottorp S, Oxman AD, Havelsrud K, Treweek S, Herrin J. Cluster randomised controlled trial of tailored interventions to improve the management of urinary tract infections in women and sore throat. BMJ. 2002; 325:367. [PubMed: 12183309]

Frank 2004 {published data only} . Frank O, Litt J, Beilby J. Opportunistic electronic reminders. Improving performance of preventive care in general practice. Australian Family Physician. 2004; 33:87–90. [PubMed: 14988972]

Hicks 2008 {published data only} . Hicks LS, Sequist TD, Ayanian JZ, Shaykevich S, Fairchild DG, Orav EJ, et al. Impact of computerized decision support on blood pressure management and control: a randomized controlled trial. Journal of General Internal Medicine. 2008; 23:429–41. [PubMed: 18373141]

Judge 2006 {published data only} . Judge J, Field TS, DeFlorio M, et al. Prescribers' responses to alerts during medication ordering in the long term care setting. Journal of the American Medical Informatics Association. 2006; 13:385–90. [PubMed: 16622171]

Kenealy 2005 {published data only} . Kenealy T, Arroll B, Petrie KJ. Patients and computers as reminders to screen for diabetes in family practice. Randomized-controlled trial. Journal of General Internal Medicine. 2005; 20:916–21. [PubMed: 16191138]

Kralj 2003 {published data only} . Kralj B, Iverson D, Hotz K, Ashbury FD. The impact of computerized clinical reminders on physician prescribing behavior: evidence from community oncology practice. American Journal of Medical Quality. 2003; 18:197–203. [PubMed: 14604272]

Krall 2004 {published data only} . Krall MA, Traunweiser K, Towery W. Effectiveness of an electronic medical record clinical quality alert prepared by off-line data analysis. Studies in Health Technology and Informatics. 2004; 107:135–9. [PubMed: 15360790]

Kucher 2005 {published data only} . Kucher N, Koo S, Quiroz R, Cooper JM, Paterno MD, Soukonnikov B, et al. Electronic alerts to prevent venous thromboembolism among hospitalized patients. New England Journal of Medicine. 2005; 352:969–77. [PubMed: 15758007]

McCowan 2001 {published data only} . McCowan C, Neville RG, Ricketts IW, Warner FC, Hoskins G, Thomas GE. Lessons from a randomized controlled trial designed to evaluate computer decision support software to improve the management of asthma. Medical Informatics and the Internet in Medicine. 2001; 26:191–201. [PubMed: 11706929]

Meigs 2003 {published data only} . Meigs JB, Cagliero E, Dubey A, Murphy-Sheehy P, Gildesgame C, Chueh H, et al. A controlled trial of web-based diabetes disease management: the MGH diabetes primary care improvement project. Diabetes Care. 2003; 26:750–7. [PubMed: 12610033]

Overhage 1996 {published data only} . Overhage JM, Tierney WM, McDonald CJ. Computer reminders to implement preventive care guidelines for hospitalized patients. Archives of Internal Medicine. 1996; 156:1551–6. [PubMed: 8687263]

Overhage 1997 {published data only} . Overhage JM, Tierney WM, Zhou XH, McDonald CJ. A randomized trial of "corollary orders" to prevent errors of omission. Journal of the American Medical Informatics Association. 1997; 4:364–75. [PubMed: 9292842]

Peterson 2007 {published data only} . Peterson JF, Rosenbaum BP, Waitman LR, Habermann R, Powers J, Harrell D, et al. Physicians' response to guided geriatric dosing: initial results from a randomized trial. Studies in Health Technology and Informatics. 2007; 129:1037–40. [PubMed: 17911873]

Rothschild 2007 {published data only} . Rothschild JM, McGurk S, Honour M, Lu L, McClendon AA, Srivastava P, et al. Assessment of education and computerized decision support interventions for improving transfusion practice. Transfusion. 2007; 47:228–39. [PubMed: 17302768]

Roumie 2006 {published data only} . Roumie CL, Elasy TA, Greevy R, Griffin MR, Liu X, Stone WJ, Wallston KA, et al. Improving blood pressure control through provider education, provider alerts, and patient education: a cluster randomized trial. Annals of Internal Medicine. 2006; 145:165–75. [PubMed: 16880458]

Safran 1995a {published data only} . Safran C, Rind DM, Davis RB, Sands DZ, Caraballo E, Rippel K, et al. A clinical trial of a knowledge-based medical record. Medinfo. 1995; 8 Pt 2:1076–80. [PubMed: 8591371]

Sequist 2005 {published data only} . Sequist TD, Gandhi TK, Karson AS, Fiskio JM, Bugbee D, Sperling M, et al. A randomized trial of electronic clinical reminders to improve quality of care for diabetes and coronary artery disease. Journal of the American Medical Informatics Association. 2005; 12:431–7. [PubMed: 15802479]

Tamblyn 2003 {published data only} . Tamblyn R, Huang A, Perreault R, Jacques A, Roy D, Hanley J, et al. The medical office of the 21st century (MOXXI): effectiveness of computerized decision-making support in reducing inappropriate prescribing in primary care. CMAJ. 2003; 169:549–56. [PubMed: 12975221]

Tape 1993 {published data only} . Tape TG, Campbell JR. Computerized medical records and preventive health care: success depends on many factors. American Journal of Medicine. 1993; 94:619–25. [PubMed: 8506888]

Tierney 2003 {published data only} . Tierney WM, Overhage JM, Murray MD, Harris LE, Zhou XH, Eckert GJ, et al. Effects of computerized guidelines for managing heart disease in primary care. Journal of General Internal Medicine. 2003; 18:967–76. [PubMed: 14687254]

Tierney 2005 {published data only} . Tierney WM, Overhage JM, Murray MD, Harris LE, Zhou XH, Eckert GJ, et al. Can computer-generated evidence-based care suggestions enhance evidence-based management of asthma and chronic obstructive pulmonary disease? A randomized, controlled trial. Health Services Research. 2005; 40:477–97. [PubMed: 15762903]

van Wyk 2008 {published data only} . van Wyk JT, van Wijk MA, Sturkenboom MC, Mosseveld M, Moorman PW, van der Lei J. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. Circulation. 2008; 117:371–8. [PubMed: 18172036]

Zanetti 2003 {published data only} . Zanetti G, Flanagan HL, Cohn LH, Giardina R, Platt R. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. Infection Control and Hospital Epidemiology. 2003; 24(1):13–6. [PubMed: 12558230]

References to studies excluded from this review

Aase 1999 {published data only} . Aase O. Clinical experience with a decision support computer program using Bayes theorem to diagnose chest pain patients. Cardiology. 1999; 92(2):128–34. [PubMed: 10702656]

Ageno 1998 {published data only} . Ageno W, Turpie AG. A randomized comparison of a computer-based dosing program with a manual system to monitor oral anticoagulant therapy. Thrombosis Research. 1998; 91(5):237–40. [PubMed: 9755836]

Anaya 2004 {published data only} . Anaya HD, Yano EM, Asch SM. Early adoption of human immunodeficiency virus quality improvement in Veterans Affairs medical centers: use of

organizational surveys to measure readiness to change and adapt interventions to local priorities. American Journal of Medical Quality. 2004; 19(4):137–44. [PubMed: 15368778]

Andersen 2002 {published data only} . Andersen SK, Nohr C, Vingtoft S, Bernstein K, Rasmussen MB. A comparative study of EPR projects in Denmark. Studies in Health Technology & Informatics. 2002; 90:226–31. [PubMed: 15460692]

Anderson 1976 {published data only} . Anderson G, Llerena C, Davidson D, Taylor TR. Practical application of computer-assisted decision-making in an antenatal clinic - a feasibility study. Methods of Information in Medicine. 1976; 15(4):224–9. [PubMed: 792631]

Anderson 2003 {published data only} . Anderson RM, Musch DC, Nwankwo RB, Wolf FM, Gillard ML, Oh MS, 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. Ethnicity & Disease. 2003; 13(1):149. [PubMed: 12723026]

Anonymous 2002 {published data only} . Anonymous. Simple physician-prompting intervention drastically improves outcomes in CHD. Formulary. 2002; 37(4):209. author(s).

Ansari 2003 {published data only} . Ansari M, Shlipak MG, Heidenreich PA, van Ostaeyen D, Pohl EC, Browner WS, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. Circulation. 2003; 107(22):2799–804. [PubMed: 12756157]

Apkon 2005 {published data only} . Apkon M, Mattera JA, Lin Z, Herrin J, Bradley EH, Carbone M, et al. A randomized outpatient trial of a decision-support information technology tool. Archives of Internal Medicine. 2005; 165(20):2388–94. [PubMed: 16287768]

Aronsky 2001 {published data only} . Aronsky D, Chan KJ, Haug PJ. Evaluation of a computerized diagnostic decision support system for patients with pneumonia: study design considerations. Journal of the American Medical Informatics Association. 2001; 8(5):473–85. [PubMed: 11522768]

Ashe 2004 {published data only} . Ashe M, Khan K, Guy P, Kruse K, Hughes K, O'Brien P, et al. Wristwatch - distal radial fracture as a marker for osteoporosis investigation: a controlled trial of patient education and a physician alerting system. Journal of Hand Therapy. 2004; 17(3):324–8. [PubMed: 15273672]

Atherton-Naji 2001 {published data only} . Atherton-Naji A, Hamilton R, Riddle W, Naji S. Improving adherence to antidepressant drug treatment in primary care: a feasibility study for a randomized controlled trial of educational intervention. Primary Care Psychiatry. 2001; 7(2):61.

Bailey 2007 {published data only} . Bailey TC, Noirot LA, Blickensderfer A, Rachmiel E, Schaiff R, Kessels A, et al. An intervention to improve secondary prevention of coronary heart disease. Archives of Internal Medicine. 2007; 167(6):586–90. [PubMed: 17389290]

Baird 1984 {published data only} . Baird TK, Broekemeier RL, Anderson MW. Effectiveness of a computer-supported refill reminder system. American Journal of Hospital Pharmacy. 1984; 41(11):2395–7. [PubMed: 6507445]

Barnett 1983 {published data only} . Barnett GO, Winickoff RN, Morgan MM, Zielstorff RD. A computer-based monitoring system for follow-up of elevated blood pressure. Medical Care. 1983; 21(4):400–9. [PubMed: 6341724]

Baskerville 2001 {published data only} . Baskerville NB, Hogg W, Lemelin J. Process evaluation of a tailored multifaceted approach to changing family physician practice patterns improving preventive care. Journal of Family Practice. 2001; 50(3):W242. [PubMed: 11252222]

Bates 1997 {published data only} . Bates DW, Kuperman GJ, Jha A, Teich JM, Orav EJ, Ma'luf N, et al. Does the computerized display of charges affect inpatient ancillary test utilization? Archives of Internal Medicine. 1997; 157(21):2501–8. [PubMed: 9385303]

Beaulieu 2004 {published data only} . Beaulieu MD, Brophy J, Jacques A, Blais R, Battista R, Lebeau R. Drug treatment of stable angina pectoris and mass dissemination of therapeutic guidelines: a randomized controlled trial. QJM. 2004; 97(1):21–31. [PubMed: 14702508]

Becker 1989 {published data only} . Becker DM, Gomez EB, Kaiser DL, Yoshihasi A, Hodge RH Jr. Improving preventive care at a medical clinic: how can the patient help? American Journal of Preventive Medicine. 1989; 5(6):353–9. [PubMed: 2597431]

Bekkering 2005 {published data only} . Bekkering GE, van Tulder MW, Hendriks EJ, Koopmanschap MA, Knol DL, Bouter LM, et al. Implementation of clinical guidelines on physical therapy for patients with low back pain: randomized trial comparing patient outcomes after a standard and active implementation strategy. Physical Therapy. 2005; 85(6):544–55. [PubMed: 15921475]

Bennett 2003 {published data only} . Bennett JW, Glasziou PP, Sim I. Review: Computerised reminders and feedback can improve provider medication management. Evidence Based Medicine. 2003; 8(6):190.

Berkenstadt 2006 {published data only} . Berkenstadt H, Yusim Y, Ziv A, Ezri T, Perel A. An assessment of a point-of-care information system for the anesthesia provider in simulated malignant hyperthermia crisis. Anesthesia & Analgesia. 2006; 102(2):530–2. [PubMed: 16428555]

Bindels 2000 {published data only} . Bindels R, de Clercq PA, Winkens RA, Hasman A. A test ordering system with automated reminders for primary care based on practice guidelines. International Journal of Medical Informatics. 2000; 58-59:219–33. [PubMed: 10978923]

Bindels 2003 {published data only} . Bindels R, Hasman A, Kester AD, Talmon JL, De Clercq PA, Winkens RA. The efficacy of an automated feedback system for general practitioners. Informatics in Primary Care. 2003; 11(2):69–74.

Bindels 2004 {published data only} . Bindels R, Hasman A, van Wersch JW, Talmon J, Winkens RA. Evaluation of an automated test ordering and feedback system for general practitioners in daily practice. International Journal of Medical Informatics. 2004; 73(9-10):705–12. [PubMed: 15325327]

Bird 1990 {published data only} . Bird JA, McPhee SJ, Jenkins C, Fordham D. Three strategies to promote cancer screening. How feasible is wide-scale implementation? Medical Care. 1990; 28(11):1005–12. [PubMed: 2250488]

Bjorsness 2003 {published data only} . Bjorsness DK, Pellett KM, Unruh J, Snipes DR, Hannula SL, McDowall JM, et al. Increasing pneumococcal immunizations among people with diabetes using patient reminders. Diabetes Care. 2003; 26(6):1943–5. [PubMed: 12766144]

Black 2002 {published data only} . Black ME, Yamada J, Mann V. A systematic literature review of the effectiveness of community-based strategies to increase cervical cancer screening. Canadian Journal of Public Health. 2002; 93(5):386–93. [PubMed: 12353463]

Boekeloo 1990 {published data only} . Boekeloo BO, Becker DM, Levine DM, Belitsos PC, Pearson TA. Strategies for increasing house staff management of cholesterol with inpatients. American Journal of Preventive Medicine. 1990; 6(Suppl 2):51–9. [PubMed: 2383413]

Bogucki 2004 {published data only} . Bogucki B, Jacobs BR, Hingle J, Clinical Informatics Outcomes Research Group. Computerized reminders reduce the use of medications during shortages. Journal of the American Medical Informatics Association. 2004; 11(4):278–80. [PubMed: 15064285]

Bomba 2006 {published data only} . Bomba D, Land T. The feasibility of implementing an electronic prescribing decision support system: a case study of an Australian public hospital. Australian Health Review. 2006; 30(3):380–8. [PubMed: 16879097]

Bonevski 1999 {published data only} . Bonevski B, Sanson-Fisher RW, Campbell E, Carruthers A, Reid ALA, Ireland M. Randomized controlled trial of a computer strategy to increase general practitioner preventive care. Preventive Medicine. 1999; 29(6):478–86. [PubMed: 10600428]

Borlawsky 2005 {published data only} . Borlawsky T, Li J, Jalan S, Stern E, Williams R, Lussier YA. Partitioning knowledge bases between advanced notification and clinical decision support systems. Proceedings of the AMIA Annual Symposium. 2005:901.

Bosworth 2005 {published data only} . Bosworth HB, Olsen MK, Goldstein MK, Orr M, Dudley T, McCant F, et al. The veterans' study to improve the control of hypertension (V-STITCH): design and methodology. Contemporary Clinical Trials. 2005; 26(2):155–68. [PubMed: 15837438]

Bovbjerg 2000 {published data only} . Bovbjerg VE, Olchanski V, Zimberg SE, Green JS, Rossiter LF. Internet-based monitoring and benchmarking in ambulatory surgery centers. Joint Commission Journal on Quality Improvement. 2000; 26(8):450–65. [PubMed: 10934636]

Brown 2003 {published data only} . Brown PJ, Warmington V, Laurence M, Prevost AT. Randomised crossover trial comparing the performance of Clinical Terms Version 3 and Read Codes 5 byte set coding schemes in general practice. BMJ. 2003; 326(7399):1127. [PubMed: 12763986]

Brownbridge 1986 {published data only} . Brownbridge G, Evans A, Fitter M, Platts M. An interactive computerized protocol for the management of hypertension: effects on the general practitioner's clinical behaviour. Journal of the Royal College of General Practitioners. 1986; 36(286):198–202. [PubMed: 3746762]

Buchsbaum 1993 {published data only} . Buchsbaum DG, Buchanan RG, Lawton MJ, Elswick RK Jr, Schnoll SH. A program of screening and prompting improves short-term physician counseling of dependent and nondependent harmful drinkers. Archives of Internal Medicine. 1993; 153(13): 1573–7. [PubMed: 8323420]

Bullard 2004 {published data only} . Bullard MJ, Meurer DP, Colman I, Holroyd BR, Rowe BH. Supporting clinical practice at the bedside using wireless technology. Academic Emergency Medicine. 2004; 11(11):1186–92. [PubMed: 15528583]

Burack 1989 {published data only} . Burack RC, Gimotty PA, Stengle W, Eckert D, Warbasse L, Moncrease A. Detroit's avoidable mortality project: breast cancer control for inner-city women. Public Health Reports. 1989; 104(6):527–35. [PubMed: 2511584]

Burack 2003 {published data only} . Burack RC, Gimotty PA, Simon. The effect of adding Pap smear information to a mammography reminder system in an HMO: results of randomized controlled trial. Preventive Medicine. 2003; 36(5):547–54. [PubMed: 12689799]

Burton 1991 {published data only} . Burton ME, Ash CL, Hill DP Jr, Handy T, Shepherd MD, Vasko MR. A controlled trial of the cost benefit of computerized bayesian aminoglycoside administration. Clinical Pharmacology and Therapeutics. 1991; 49(6):685–94. [PubMed: 1905602]

Cabrero-Canosa 2004 {published data only} . Cabrero-Canosa M, Hernandez-Pereira E, Moret-Bonillo V. Intelligent diagnosis of sleep apnea syndrome. IEEE Engineering in Medicine and Biology Magazine. 2004; 23(2):72–81. [PubMed: 15264473]

Calabrisi 2002 {published data only} . Calabrisi RR, Czarnecki T, Blank C. The impact of clinical reminders and alerts on health screenings. The VA Pittsburgh Healthcare System achieves notable results by enhancing an automated clinical reminder system within its CPR - and has the data to prove it. Health Management Technology. 2002; 23(12):32–4. [PubMed: 12467262]

Cannon 2000 {published data only} . Cannon DS, Allen SN. A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline. Journal of the American Medical Informatics Association. 2000; 7(2):196–203. [PubMed: 10730603]

Care Management 2002 {published data only} . Anonymous. Certified case manager news. Tailored interventions yield greater results. Care Management. 2002; 8(5):42.

Casebeer 2003 {published data only} . Casebeer LL, Strasser SM, Spettell CM, Wall TC, Weissman N, Ray MN, et al. Designing tailored web-based instruction to improve practicing physicians' preventive practices. Journal of Medical Internet Research. 2003; 5(3):e20. [PubMed: 14517111]

Cho 2003 {published data only} . Cho L, Kottke-Marchant K, Lincoff AM, Roffi M, Reginelli JP, Kaldus T, et al. Correlation of point-of-care ecarin clotting time versus activated clotting time with bivalirudin concentrations. American Journal of Cardiology. 2003; 91(9):1110–3. [PubMed: 12714157]

Christakis 2004 {published data only} . Christakis DA, Wright JA. Can continuity of care be improved? Results from a randomized pilot study. Ambulatory Pediatrics. 2004; 4(4):336–9. [PubMed: 15264940]

Christensen 2004 {published data only} . Christensen MB, Christensen B, Mortensen JT, Olesen F. Intervention among frequent attenders of the out-of-hours service: a stratified cluster randomized controlled trial. Scandinavian Journal of Primary Health Care. 2004; 22(3):180–6. [PubMed: 15370796]

Clayton 2007 {published data only} . Clayton JM, Butow PN, Tattersall MH, Devine RJ, Simpson JM, Aggarwal G, et al. Randomized controlled trial of a prompt list to help advanced cancer

patients and their caregivers to ask questions about prognosis and end-of-life-care. Journal of Clinical Oncology. 2007; 25(6):715–23. [PubMed: 17308275]

Coe 1977 {published data only} . Coe FL, Norton E, Oparil S, Tatar A, Pullman TN. Treatment of hypertension by computer and physician - a prospective controlled study. Journal of Chronic Diseases. 1977; 30(2):81–92. [PubMed: 838839]

Collins 2003 {published data only} . Collins PW, Bolton-Maggs P, Stephenson D, Jenkins B, Loran C, Winter M. Pilot study of an internet-based electronic patient treatment record and communication system for haemophilia. Haemophilia. 2003; 9(3):285–91.Advoy.com [PubMed: 12694519]

Colombet 2004 {published data only} . Colombet I, Bura-Rivière A, Chatila R, Chatellier G, Durieux P, PHRC-OAT study group. Personalized versus non-personalized computerized decision support system to increase therapeutic quality control of oral anticoagulant therapy: an alternating time series analysis. BMC Health Services Research. 2004; 4(1):27. [PubMed: 15456515]

Cooke 2001 {published data only} . Cooke M, Mattick RP, Walsh RA. Differential uptake of a smoking cessation programme disseminated to doctors and midwives in antenatal clinics. Addiction. 2001; 96(3):495–505. [PubMed: 11255588]

Cornia 2003 {published data only} . Cornia PB, Amory JK, Fraser S, Saint S, Lipsky BA. Computer-based order entry decreases duration of indwelling urinary catheterization in hospitalized patients. American Journal of Medicine. 2003; 114(5):404–7. [PubMed: 12714131]

Costanza 2000 {published data only} . Costanza ME, Stoddard AM, Luckmann R, White MJ, Spitz Avrunin J, Clemow L. Promoting mammography: results of a randomized trial of telephone counseling and a medical practice intervention. American Journal of Preventive Medicine. 2000; 19(1):39–46. [PubMed: 10865162]

Coyle 2004 {published data only} . Coyle CM, Currie BP. Improving the rates of inpatient pneumococcal vaccination: impact of standing orders versus computerized reminders to physicians. Infection Control & Hospital Epidemiology. 2004; 25(11):904–7. [PubMed: 15566021]

Cramer 1999 {published data only} . Cramer JA, Rosenheck R. Enhancing medication compliance for people with serious mental illness. Journal of Nervous & Mental Disease. 1999; 187(1):53–5. [PubMed: 9952254]

Crane 2006 {published data only} . Crane LA, Deas A, Mokrohisky ST, Ehrsam G, Jones RH, Dellavalle R, et al. A randomized intervention study of sun protection promotion in well-child care. Preventive Medicine. 2006; 42(3):162–70. [PubMed: 16376977]

Creedon 1998 {published data only} . Creedon MA, Malone TB, Dutra LA, Perse RM. Human factors engineering approach to gerontechnology: development of an electronic medication compliance device. Studies in Health Technology & Informatics. 1998; 48:288–95. [PubMed: 10186531]

Curry 2003 {published data only} . Curry SJ, Hollis J, Bush T, Polen M, Ludman EJ, Grothaus L, et al. A randomized trial of a family-based smoking prevention intervention in managed care. Preventive Medicine. 2003; 37(6 Pt 1):617–26. [PubMed: 14636795]

Daley 2004a {published data only} . Daley MF, Barrow J, Pearson K, Crane LA, Gao D, Stevenson JM, et al. Identification and recall of children with chronic medical conditions for influenza vaccination. Pediatrics. 2004; 113(1 Pt 1):26–33.

Daley 2004b {published data only} . Daley MF, Steiner JF, Kempe A, Beaty BL, Pearson KA, Jones JS, et al. Quality improvement in immunization delivery following an unsuccessful immunization recall. Ambulatory Pediatrics. 2004; 4(3):217. [PubMed: 15153053]

Daugaard 2002 {published data only} . Daugaard S. Comment on “The implementation of guidelines and computerised forms improves the completeness of cancer pathology reporting. The CROPS project: a randomised controlled trial in pathology” by Branston and colleagues. European Journal of Cancer. 2002; 38(6):743–4. [PubMed: 11937305]

Davis 2005 {published data only} . Davis RL. Computerized physician order entry systems: the coming of age for outpatient medicine. Public Library of Science Medicine. 2005; 2(9):e290. [PubMed: 16173835]

Day 2006 {published data only} . Day PF, Duggal MS, Kiefte B, Balmer RC, Roberts GJ. The role for "reminders" in dental traumatology: 4. The use of a computer database for recording dento-alveolar trauma in comparison to unstructured and structured paper-based methods. Dental Traumatology. 2006; 22(5):265–74. [PubMed: 16942557]

de Dombal 1994 {published data only} . de Dombal FT. Computer-aided decision support: in praise of level playing fields. Methods of Information in Medicine. 1994; 33(2):161–3. [PubMed: 8057941]

de Fine Olivarius 2001 {published data only} . de Fine Olivarius N, Beck-Nielsen H, Andreasen AH, Horder M, Pedersen PA. Randomized controlled trial of structured, individualized treatment of type 2 diabetes mellitus. The project of Diabetes Care in General Practice. Danish. Ugeskrift for Laeger. 2001; 163(44):6134–9.

Degia 2005 {published data only} . Degia A, Meadows R, Johnsen S, Hindmarch I, Boyle J. Development of a portable psychometric testing device for use in the field: an alcohol investigation. Perceptual and Motor Skills. 2005; 101(2):383–92. [PubMed: 16383068]

Degli 1999 {published data only} . Degli EE, Berto P, Buda S, Di Nardo AM, Sturani A. The Pandora Project: results of the pilot study. American Journal of Hypertension. 1999; 12(8 Pt 1): 790–6. [PubMed: 10480472]

del Mar 2006 {published data only} . del Mar C. Improving prescribing practices in primary care. A randomised trial and economic analysis of a multicomponent intervention showed small, but important, gains. Public Library of Science Medicine. 2006; 3(6):e229. [PubMed: 16729845]

Demakis 2000 {published data only} . Demakis JG, Beauchamp C, Cull WL, Denwood R, Eisen SA, Lofgren R, et al. Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders. JAMA. 2000; 284(11):1411–6. [PubMed: 10989404]

Derose 2005 {published data only} . Derose SF, Dudl JR, Benson VM, Contreras R, Nakahiro RK, Ziel FH. Point-of-service reminders for prescribing cardiovascular medications. American Journal of Managed Care. 2005; 11(5):298–304. [PubMed: 15898218]

Desbiens 2000 {published data only} . Desbiens NA, Wu AW. Pain and suffering in seriously ill hospitalized patients. Journal of the American Geriatrics Society. 2000; 48(Suppl 5):S183–6. [PubMed: 10809473]

Dexter 1998 {published data only} . Dexter PR, Wolinsky FD, Gramelspacher GP, Zhou XH, Eckert GJ, Waisburd M, et al. Effectiveness of computer-generated reminders for increasing discussions about advance directives and completion of advance directive forms: a randomized, controlled trial. Annals of Internal Medicine. 1998; 128(2):102–10. [PubMed: 9441569]

Dexter 2004 {published data only} . Dexter PR. Automated standing orders to nurses increase influenza and pneumococcal vaccination rates among inpatients compared with reminders to physicians. Evidence-based Healthcare and Public Health. 2005; 9(3):211–2.Dexter PR, Perkins SM, Maharry KS, Jones K, McDonald CJ. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. JAMA. 2004; 292(19):2366–71. [PubMed: 15547164]

Dowie 2002 {published data only} . Dowie J. The role of patients' meta-preferences in the design and evaluation of decision support systems. Health Expectations. 2002; 5(1):16–27. [PubMed: 11915844]

East 1999 {published data only} . East TD, Heermann LK, Bradshaw RL, Lugo A, Sailors RM, Ershler L, et al. Efficacy of computerized decision support for mechanical ventilation: results of a prospective multi-center randomized trial. Proceedings of the AMIA Symposium. 1999:251–5.

Ebell 1995 {published data only} . Ebell MH. Computers in the examination room. Journal of Family Practice. 1995; 41(3):293–4. [PubMed: 7650510]

Eccles 2000 {published data only} . Eccles MP, Grimshaw J, Steen N, Parkin D, Purves I, McColl E, et al. The design and analysis of a randomized controlled trial to evaluate computerized decision support in primary care: the COGENT study. Family Practice. 2000; 17(2):180–6. [PubMed: 10758083]

Eccles 2001 {published data only} . Eccles MP, Steen N, Grimshaw J, Thomas L, McNamee P, Soutter J, et al. Effect of audit and feedback, and reminder messages on primary-care radiology referrals: a randomised trial. Lancet. 2001; 357(9266):1406–9. [PubMed: 11356439]

Eccles 2002 {published data only} . Eccles MP, Hawthorne G, Whitty P, Steen N, Vanoli A, Grimshaw J, et al. A randomised controlled trial of a patient based Diabetes Recall and Management System: the DREAM trial: a study protocol [ISRCTN32042030]. BMC Health Services Research. 2002; 2(1):5. [PubMed: 11914161]

Edmonson 2005 {published data only} . Edmonson SR, Esquivel A, Mokkarala P, Johnson CW, Phelps CL. Using technology to teach technology: design and evaluation of bilingual online physician education about electronic medical records. Proceedings of the AMIA Annual Symposium. 2005:946.

Emery 2007 {published data only} . Emery J, Morris H, Goodchild R, Fanshawe T, Prevost AT, Bobrow M, et al. The GRAIDS Trial: a cluster randomised controlled trial of computer decision support for the management of familial cancer risk in primary care. British Journal of Cancer. 2007; 97(4):486–93. [PubMed: 17700548]

Evans 1994 {published data only} . Evans RS, Classen DC, Pestotnik SL, Lundsgaarde HP, Burke JP. Improving empiric antibiotic selection using computer decision support. Archives of Internal Medicine. 1994; 154(8):878–84. [PubMed: 8154950]

Faresjo 2006 {published data only} . Faresjo A, Grodzinsky E, Johansson S, Wallander MA, Foldevi M. Patients with irritable bowel syndrome in Swedish primary care. European Journal of General Practice. 2006; 12(2):88–90. [PubMed: 16945886]

Feeg 2005 {published data only} . Feeg VD, Bashatah A, Langley C. Development and testing of a CD-ROM based tutorial for nursing students: getting ready for HIPAA. Journal of Nursing Education. 2005; 44(8):381–6. [PubMed: 16130345]

Feldstein 2006a {published data only} . Feldstein AC, Smith DH, Perrin N, Yang X, Rix M, Raebel MA, et al. Improved therapeutic monitoring with several interventions: a randomized trial. Archives of Internal Medicine. 2006; 166(17):1848–54. [PubMed: 17000941]

Feldstein 2006b {published data only} . Feldstein A, Elmer PJ, Smith DH, Herson M, Orwoll E, Chen C, et al. Electronic medical record reminder improves osteoporosis management after a fracture: a randomized, controlled trial. Journal of the American Geriatrics Society. 2006; 54(3): 450–7. [PubMed: 16551312]

Fihn 1994 {published data only} . Fihn SD, McDonell MB, Vermes D, Henikoff JG, Martin DC, Callahan CM, et al. A computerized intervention to improve timing of outpatient follow-up: a multicenter randomized trial in patients treated with warfarin. National Consortium of Anticoagulation Clinics. Journal of General Internal Medicine. 1994; 9(3):131–9. [PubMed: 8195911]

Fiks 2007 {published data only} . Fiks AG, Grundmeier RW, Biggs LM, Localio AR, Alessandrini EA. Impact of clinical alerts within an electronic health record on routine childhood immunization in an urban pediatric population. Pediatrics. 2007; 120(4):707–14. [PubMed: 17908756]

Fischer 2003 {published data only} . Fischer MA, Solomon DH, Teich JM, Avorn J. Conversion from intravenous to oral medications: assessment of a computerized intervention for hospitalized patients. Archives of Internal Medicine. 2003; 163(21):2585–9. [PubMed: 14638558]

Fitzmaurice 1996 {published data only} . Fitzmaurice DA, Hobbs FD, Murray ET, Bradley CP, Holder R. Evaluation of computerized decision support for oral anticoagulation management based in primary care. British Journal of General Practice. 1996; 46(410):533–5. [PubMed: 8917873]

Fitzmaurice 2000 {published data only} . Fitzmaurice DA, Hobbs FD, Murray ET, Holder RL, Allan TF, Rose PE. Oral anticoagulation management in primary care with the use of computerized decision support and near-patient testing: a randomized, controlled trial. Archives of Internal Medicine. 2000; 160(15):2343–8. [PubMed: 10927732]

Flanagan 1999a {published data only} . Flanagan JR, Doebbeling BN, Dawson J, Beekmann S. Randomized study of online vaccine reminders in adult primary care. Proceedings of the AMIA Symposium. 1999:755–9.

Flanagan 1999b {published data only} . Flanagan JR, Walker KP. Tracking vaccine compliance in a primary care setting: online history, reminders, order entry, and charting. Proceedings of the AMIA Symposium. 1999:760–4.

Flottorp 2003a {published data only} . Flottorp S, Oxman AD. Identifying barriers and tailoring interventions to improve the management of urinary tract infections and sore throat: a pragmatic study using qualitative methods. BMC Health Services Research. 2003; 3(1):3. [PubMed: 12622873]

Flottorp 2003b {published data only} . Flottorp S, Håvelsrud K, Oxman AD. Process evaluation of a cluster randomized trial of tailored interventions to implement guidelines in primary care - why is it so hard to change practice? Family Practice. 2003; 20(3):333–9. [PubMed: 12738704]

Fordham 1990 {published data only} . Fordham D, McPhee SJ, Bird JA, Rodnick JE, Detmer WM. The Cancer Prevention Reminder System. MD Computing. 1990; 7(5):289–95. [PubMed: 2243544]

Frame 1994 {published data only} . Frame PS, Zimmer JG, Werth PL, Hall WJ, Eberly SW. Computer-based vs manual health maintenance tracking. A controlled trial. Archives of Family Medicine. 1994; 3(7):581–8. [PubMed: 7921293]

Frances 2001 {published data only} . Frances CD, Alperin P, Alder JS, Grady D. Does a fixed physician reminder system improve the care of patients with coronary artery disease? A randomized controlled trial. Western Journal of Medicine. 2001; 175(3):165–6. [PubMed: 11527840]

Fransen 2004 {published data only} . Fransen J, Twisk JW, Creemers MC, van Riel PL. Design and analysis of a randomized controlled trial testing the effects of clinical decision support on the management of rheumatoid arthritis. Arthritis and Rheumatism. 2004; 51(1):124–7. [PubMed: 14872465]

Fretheim 2003 {published data only} . Fretheim A, Oxman AD, Treweek S, Bjørndal A. Rational Prescribing in Primary Care (RaPP-trial). A randomised trial of a tailored intervention to improve prescribing of antihypertensive and cholesterol-lowering drugs in general practice [ISRCTN48751230]. BMC Health Services Research. 2003; 3(1):5. [PubMed: 12657163]

Fretheim 2006a {published data only} . Fretheim A, Aaserud M, Oxman AD. Rational prescribing in primary care (RaPP): economic evaluation of an intervention to improve professional practice. Public Library of Science. 2006; 3(6):e216.

Fretheim 2006b {published data only} . Fretheim A, Oxman AD, Håvelsrud K, Treweek S, Kristoffersen DT, Bjørndal A. Rational prescribing in primary care (RaPP): a cluster randomized trial of a tailored intervention. Public Library of Science Medicine. 2006; 3(6):e134. [PubMed: 16737346]

Frolich 1997 {published data only} . Frolich A. Combined reports on serum calcium and discriminant functions increase the diagnostic rate of hypercalcaemia. Scandinavian Journal of Clinical & Laboratory Investigation. 1997; 57(8):725–9. [PubMed: 9458496]

Galanter 2005 {published data only} . Galanter WL, Didomenico RJ, Polikaitis A. A trial of automated decision support alerts for contraindicated medications using computerized physician order entry. Journal of the American Medical Informatics Association. 2005; 12(3):269–74. [PubMed: 15684124]

Garrett 2002 {published data only} . Garrett NY, Yasnoff WA. Disseminating public health practice guidelines in electronic medical record systems. Journal of Public Health Management & Practice. 2002; 8(3):1–10. [PubMed: 15156619]

German 1987 {published data only} . German PS, Shapiro S, Skinner EA, Von Korff M, Klein LE, Turner RW, et al. Detection and management of mental health problems of older patients by primary care providers. JAMA. 1987; 257(4):489–93. [PubMed: 3540329]

Gill 2000 {published data only} . Gill JM, Saldarriaga AM. The impact of a computerized physician reminder and a mailed patient reminder on influenza immunizations for older patients. Delaware Medical Journal. 2000; 72(10):425–30. [PubMed: 11085020]

Glasgow 1995 {published data only} . Glasgow RE, Toobert DJ, Hampson SE, Noell JW. A brief office-based intervention to facilitate diabetes dietary self-management. Health Education Research. 1995; 10(4):467–78. [PubMed: 10159676]

Goff 2003 {published data only} . Goff DC Jr, Gu L, Cantley LK, Sheedy DJ, Cohen SJ. Quality of care for secondary prevention for patients with coronary heart disease: results of the Hastening the Effective Application of Research through Technology (HEART) trial. American Heart Journal. 2003; 146(6):1045–51. [PubMed: 14660997]

Goldberg 2000 {published data only} . Goldberg HI, Neighbor WE, Cheadle AD, Ramsey SD, Diehr P, Gore E. A controlled time-series trial of clinical reminders: using computerized firm systems to make quality improvement research a routine part of mainstream practice. Health Services Research. 2000; 34(7):1519–34. [PubMed: 10737451]

Goldberg 2002 {published data only} . Goldberg HI, Neighbor WE, Hirsch IB, Cheadle AD, Ramsey SD, Gore E. Evidence-based management: using serial firm trials to improve diabetes care quality. Joint Commission Journal on Quality Improvement. 2002; 28(4):155–66. [PubMed: 11942259]

Goodey 2000 {published data only} . Goodey RD, Brickley MR, Hill CM, Shepherd JP. A controlled trial of three referral methods for patients with third molars. British Dental Journal. 2000; 189(10):556–60. [PubMed: 11128259]

Grimaud 1999 {published data only} . Grimaud J, Amato MP, Confavreux C. Design of a European multicenter study dedicated to the evaluation of the EDMUS system: EVALUED. European Database for Multiple Sclerosis. EVALUation of the EDMUS system. Multiple Sclerosis. 1999; 5(4):234–8. [PubMed: 10467381]

Hales 1995 {published data only} . Hales JW, Gardner RM, Jacobson JT. Factors impacting the success of computerized preadmission screening. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1995:728–32.

Harpole 1997 {published data only} . Harpole LH, Khorasani R, Fiskio J, Kuperman GJ, Bates DW. Automated evidence-based critiquing of orders for abdominal radiographs: impact on utilization and appropriateness. Journal of the American Medical Informatics Association. 1997; 4(6):511–21. [PubMed: 9391938]

Haruna 1998 {published data only} . Haruna M, Kumon K, Yahagi N, Watanabe Y, Ishida Y, Kobayashi N, et al. Blood volume measurement at the bedside using ICG pulse spectrophotometry. Anesthesiology. 1998; 89(6):1322–8. [PubMed: 9856705]

Hatcher 2005 {published data only} . Hatcher M, Heetebry I, Tabriziani H. Mini medical record application: annual register for flu shot vaccinations. Journal of Medical Systems. 2005; 29(3): 233–9. [PubMed: 16050078]

Heidenreich 2005 {published data only} . Heidenreich PA, Chacko M, Goldstein MK, Atwood JE. ACE inhibitor reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction. American Journal of Medicine. 2005; 118(9):1034–7. [PubMed: 16164891]

Heiman 2004 {published data only} . Heiman H, Bates DW, Fairchild D, Shaykevich S, Lehmann LS. Improving completion of advance directives in the primary care setting: a randomized controlled trial. American Journal of Medicine. 2004; 117(5):318–24. [PubMed: 15336581]

Hetlevik 1998 {published data only} . Hetlevik I, Holmen J, Krüger O, Kristensen P, Iversen H. Implementing clinical guidelines in the treatment of hypertension in general practice. Blood Pressure. 1998; 7(5-6):270–6. [PubMed: 10321438]

Hetlevik 1999 {published data only} . Hetlevik I, Holmen J, Krüger O. Implementing clinical guidelines in the treatment of hypertension in general practice. Evaluation of patient outcome related to implementation of a computer-based clinical decision support system. Scandinavian Journal of Primary Health Care. 1999; 17(1):35–40. [PubMed: 10229991]

Hetlevik 2000 {published data only} . Hetlevid I, Holmen J, Kruger O, Kristensen P, Iversen H, Furuseth K. Implementing clinical guidelines in the treatment of diabetes mellitus in general practice. Evaluation of effort, process, and patient outcome related to implementation of a computer-based decision support system. International Journal of Technology Assessment in Health Care. 2000; 16(1):210–27. [PubMed: 10815366]

Hickling 1989 {published data only} . Hickling K, Begg E, Moore ML. A prospective randomised trial comparing individualised pharmacokinetic dosage prediction for aminoglycosides with prediction based on estimated creatinine clearance in critically ill patients. Intensive Care Medicine. 1989; 15(4):233–7. [PubMed: 2745867]

Hobbs 1996 {published data only} . Hobbs FD, Delaney BC, Carson A, Kenkre JE. A prospective controlled trial of computerized decision support for lipid management in primary care. Family Practice. 1996; 13(2):133–7. [PubMed: 8732323]

Hoch 2003 {published data only} . Hoch I, Heymann AD, Kurman I, Valinsky LJ, Chodick G, Shalev V. Countrywide computer alerts to community physicians improve potassium testing in patients receiving diuretics. Journal of the American Medical Informatics Association. 2003; 10(6):541–6. [PubMed: 12925546]

Hoeper 1984 {published data only} . Hoeper EW, Nycz GR, Kessler LG, Burke JD Jr, Pierce WE. The usefulness of screening for mental illness. Lancet. 1984; 1(8367):33–5. [PubMed: 6140351]

Hogg 1990 {published data only} . Hogg W, Hogg W. The role of computers in preventive medicine in a rural family practice. Canadian Medical Association Journal. 1990; 143(1):33–7. [PubMed: 2357679]

Holbrook 2002 {published data only} . Holbrook A. Rule-based computerized reminders increased ordering of preventive services in an inpatient setting. ACP Journal Club. 2002; 136(2):74. [PubMed: 11874299]

Holbrook 2005 {published data only} . Holbrook A, Keshavjee K, Lee H, Bernstein B, Chan D, Thabane L, et al. Individualized electronic decision support and reminders can improve diabetes care in the community. Proceedings of the AMIA Annual Symposium. 2005:982.

Hollingworth 1995 {published data only} . Hollingworth GR, Bernstein RM, Viner GS, Remington JS, Wood WE. Prompting for cost-effective test ordering: a randomized controlled trial. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1995:635–9.

Horng 2006 {published data only} . Horng MS. Performance feedback can improve diabetes care provided by residents: Commentary. Journal of Clinical Outcomes Management. 2006; 13(5): 266–7.

Hsieh 2004 {published data only} . Hsieh TC, Kuperman GJ, Jaggi T, Hojnowski-Diaz P, Fiskio J, Williams DH, et al. Characteristics and consequences of drug allergy alert overrides in a computerized physician order entry system [see comment]. Journal of the American Medical Informatics Association. 2004; 11(6):482–91. [PubMed: 15298998]

Javitt 2005 {published data only} . Javitt JC, Steinberg G, Locke T, Couch JB, Jacques J, Juster I, et al. Using a claims data-based sentinel system to improve compliance with clinical guidelines: results of a randomized prospective study. American Journal of Managed Care. 2005; 11(2):93–102. [PubMed: 15726857]

Jenkins 2000 {published data only} . Jenkins RG, Ornstein SM. Preventive services in the primary care practices of the Practice Partner Research Network. Topics in Health Information Management. 2000; 20(3):80–4. [PubMed: 10747438]

John 2008 {published data only} . John SK, George S, Howell RD, Primrose JN, Fozard JB. Validation of the lower gastrointestinal electronic referral protocol. British Journal of Surgery. 2008; 95(4):506–14. [PubMed: 18196552]

Johnson 2004 {published data only} . Johnson ED, Pancoast PE, Mitchell JA, Shyu CR. Design and evaluation of a personal digital assistant-based alerting service for clinicians. Journal of the Medical Library Association. 2004; 92(4):438–44. [PubMed: 15494759]

Johnson 2006 {published data only} . Johnson DW, Craig W, Brant R, Mitton C, Svenson L, Klassen TP. A cluster randomized controlled trial comparing three methods of disseminating practice guidelines for children with croup [ISRCTN73394937]. Implementation Science. 2006; 1:10. [PubMed: 16722541]

Johnston 2004 {published data only} . Johnston JM, Leung GM, Tin KY, Ho LM, Lam W, Fielding R. Evaluation of a handheld clinical decision support tool for evidence-based learning and practice in medical undergraduates. Medical Education. 2004; 38(6):628–37. [PubMed: 15189259]

Junghans 2007 {published data only} . Junghans CF. Effect of patient-specific ratings vs conventional guidelines on investigation decisions in angina. Appropriateness of Referral and Investigation in Angina (ARIA) Trial. 2007; 167(2):195–202.

Kailajärvi 2000 {published data only} . Kailajärvi M, Takala T, Grönroos P, Tryding N, Viikari J, Irjala K, et al. Reminders of drug effects on laboratory test results. Clinical Chemistry. 2000; 46(9):1395–400. [PubMed: 10973871]

Kaplan 2000 {published data only} . Kaplan CP, Bastani R, Belin TR, Marcus A, Nasseri K, Hu MY. Improving follow-up after an abnormal pap smear: results from a quasi-experimental intervention study. Journal of Womens Health & Gender-Based Medicine. 2000; 9(7):779–90.

Karikoski 2003 {published data only} . Karikoski A, Ilanne-Parikka P, Murtomaa H. Oral health promotion among adults with diabetes in Finland. Community Dentistry and Oral Epidemiology. 2003; 31(6):447–53. [PubMed: 14986912]

Katz 2004 {published data only} . Katz DA, Muehlenbruch DR, Brown RL, Fiore MC, Baker TB, AHRO Smoking Cessation Guideline Study Group. Effectiveness of implementing the agency for healthcare research and quality smoking cessation clinical practice guideline: a randomized, controlled trial. Journal of the National Cancer Institute. 2004; 96:594–603. [PubMed: 15100337]

Keeffe 2005 {published data only} . Keeffe B, Subramanian U, Tierney WM, Udris E, Willems J, McDonell M, et al. Provider response to computer-based care suggestions for chronic heart failure. Medical Care. 2005; 43(5):461–5. [PubMed: 15838410]

Kellett 1997 {published data only} . Kellett J. The impact of a bedside decision support computer program (DSCP) on coronary care. Irish Medical Journal. 1997; 90(6):240. [PubMed: 9611930]

Koop 2002 {published data only} . Koop A, Mösges R. The use of handheld computers in clinical trials. Controlled Clinical Trials. 2002; 23(5):469–80. [PubMed: 12392861]

Kuilboer 2006 {published data only} . Kuilboer MM, van Wijk MA, Mosseveld M, van der Does E, de Jongste JC, Overbeek SE, et al. Computed critiquing integrated into daily clinical practice affects physicians' behavior - a randomized clinical trial with AsthmaCritic. Methods of Information in Medicine. 2006; 45(4):447–54. [PubMed: 16964364]

Kuperman 1999 {published data only} . Kuperman GJ, Teich JM, Tanasijevic MJ, Ma'Luf N, Rittenberg E, Jha A, et al. Improving response to critical laboratory results with automation: results of a randomized controlled trial. Journal of the American Medical Informatics Association. 1999; 6(6):512–22. [PubMed: 10579608]

Kuperman 2001 {published data only} . Kuperman GJ, Teich JM, Gandhi TK, Bates DW. Patient safety and computerized medication ordering at Brigham and Women's Hospital. Joint Commission Journal on Quality Improvement. 2001; 27(10):509–21. [PubMed: 11593885]

Lafata 2007 {published data only} . Lafata JE, Kolk D, Peterson EL, McCarthy BD, Weiss TW, Chen YT, et al. Improving osteoporosis screening: results from a randomized cluster trial. Journal of General Internal Medicine. 2007; 22(3):346–51. [PubMed: 17356966]

Laflamme 2005 {published data only} . Laflamme MR, Dexter PR, Graham MF, Hui SL, McDonald CJ. Efficiency, comprehensiveness and cost-effectiveness when comparing dictation and electronic templates for operative reports. Proceedings of the AMIA Annual Symposium. 2005:425–9.

Landis 1992 {published data only} . Landis SE, Hulkower SD, Pierson S. Enhancing adherence with mammography through patient letters and physician prompts. A pilot study. North Carolina Medical Journal. 1992; 53(11):575–8. [PubMed: 1436150]

Lattimer 1998 {published data only} . Lattimer V, George S, Thompson F, Thomas E, Mullee M, Turnbull J, et al. Safety and effectiveness of nurse telephone consultation in out of hours primary care: randomised controlled trial. The South Wiltshire Out of Hours Project (SWOOP) Group. BMJ. 1998; 317(7165):1054–9. [PubMed: 9774295]

Lattimer 2000 {published data only} . Lattimer V, Sassi F, George S, Moore M, Turnbull J, Mullee M, et al. Cost analysis of nurse telephone consultation in out of hours primary care: evidence from a randomised controlled trial. BMJ. 2000; 320(7241):1053–7. [PubMed: 10764368]

Lau 1998 {published data only} . Lau F, Penn A, Wilson D, Noseworthy T, Vincent D, Doze S. The diffusion of an evidence-based disease guidance system for managing stroke. International Journal of Medical Informatics. 1998; 51(2-3):107–16. [PubMed: 9794327]

LeBaron 2004 {published data only} . LeBaron CW, Starnes DM, Rask KJ. The impact of reminder-recall interventions on low vaccination coverage in an inner-city population. Archives of Pediatrics & Adolescent Medicine. 2004; 158(3):255–61. [PubMed: 14993085]

Lemelin 2001 {published data only} . Lemelin J, Hogg W, Baskerville N. Evidence to action: a tailored multifaceted approach to changing family physician practice patterns and improving preventive care. CMAJ. 2001; 164(6):757–63. [PubMed: 11276541]

Lesourd 2002 {published data only} . Lesourd F, Avril C, Boujennah A, Parinaud J. A computerized decision support system for ovarian stimulation by gonadotropins. Fertility and Sterility. 2002; 77(3):456–60. [PubMed: 11872193]

Leung 2003 {published data only} . Leung GM, Johnston JM, Tin KY, Wong IO, Ho LM, Lam WW, et al. Randomised controlled trial of clinical decision support tools to improve learning of evidence based medicine in medical students. BMJ. 2003; 327(7423):1090. [PubMed: 14604933]

Lewis 1996 {published data only} . Lewis G, Sharp D, Bartholomew J, Pelosi AJ. Computerized assessment of common mental disorders in primary care: effect on clinical outcome. Family Practice. 1996; 13(2):120–6. [PubMed: 8732321]

Lilford 1992 {published data only} . Lilford RJ, Kelly M, Baines A, Cameron S, Cave M, Guthrie K, et al. Effect of using protocols on medical care: randomised trial of three methods of taking an antenatal history. BMJ. 1992; 305(6863):1181. [PubMed: 1467719]

Lin 2004 {published data only} . Lin HH, Beck CL, Bloom MJ. On the use of multivariable piecewise-linear models for predicting human response to anesthesia. IEEE Transactions on Biomedical Engineering. 2004; 51(11):1876–87. [PubMed: 15536890]

Lipkus 1999 {published data only} . Lipkus IM, Yna PR, Rimer BK. Using tailored interventions to enhance smoking cessation among African-Americans at a community health center. Nicotine & Tobacco Research. 1999; 1(1):77–85. [PubMed: 11072391]

Litzelman 1993 {published data only} . Litzelman DK, Dittus RS, Miller ME, Tierney WM. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. Journal of General Internal Medicine. 1993; 8(6):311–7. [PubMed: 8320575]

Lobach 1997 {published data only} . Lobach DF, Hammond WE. Computerized decision support based on a clinical practice guideline improves compliance with care standards. American Journal of Medicine. 1997; 102(1):89–98. [PubMed: 9209205]

Lobach 1994 {published data only} . Lobach DF, Hammond WE. Development and evaluation of a Computer-Assisted Management Protocol (CAMP): improved compliance with care guidelines for diabetes mellitus. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1994:787–91.

Lobach 1996 {published data only} . Lobach DF. Electronically distributed, computer-generated, individualized feedback enhances the use of a computerized practice guideline. Proceedings of the AMIA Annual Fall Symposium. 1996:493–7.

Love 2008 {published data only} . Love TE, Cebul RD, Einstadter D, Jain AK, Miller H, Harris CM, et al. Electronic medical record-assisted design of a cluster-randomized trial to improve diabetes care and outcomes. Journal of General Internal Medicine. 2008; 23(4):383–91. [PubMed: 18373134]

Lowensteyn 1998 {published data only} . Lowensteyn I, Joseph L, Levinton C, Abrahamowicz M, Steinert Y, Grover S. Can computerized risk profiles help patients improve their coronary risk? The results of the coronary health assessment study (CHAS). Preventive Medicine. 1998; 27(5): 730–7. [PubMed: 9808805]

Lubitz 1995 {published data only} . Lubitz RM, Litzelman DK, Dittus RS, Tierney WM. Is obesity a barrier to physician screening for cervical cancer? American Journal of Medicine. 1995; 98(5): 491–6. [PubMed: 7733129]

MacIntyre 2003 {published data only} . MacIntyre CR, Kainer MA, Brown GV. A randomised, clinical trial comparing the effectiveness of hospital and community-based reminder systems for increasing uptake of influenza and pneumococcal vaccine in hospitalised patients aged 65 years and over. Gerontology. 2003; 49(1):33–40. [PubMed: 12457048]

MacLean 2004 {published data only} . MacLean CD, Littenberg B, Gagnon M, Reardon M, Turner PD, Jordan C. The Vermont Diabetes Information System (VDIS): study design and subject recruitment for a cluster randomized trial of a decision support system in a regional sample of primary care practices. Clinical Trials. 2004; 1(6):532–44. [PubMed: 16279294]

Margolis 1992 {published data only} . Margolis CZ, Warshawsky SS, Goldman L, Dagan O, Wirtschafter D, Pliskin JS. Computerized algorithms and pediatricians' management of common problems in a community clinic. Academic Medicine. 1992; 67(4):282–4. [PubMed: 1558607]

Margolis 2004 {published data only} . Margolis PA, Lannon CM, Stuart JM, Fried BJ, Keyes-Elstein L, Moore DE Jr. Practice based education to improve delivery systems for prevention in primary care: randomised trial. BMJ. 2004; 328(7436):388. [PubMed: 14766718]

Martens 2006 {published data only} . Martens JD, van der Aa A, Panis B, van der Weijden T, Winkens RA, Severens JL. Design and evaluation of a computer reminder system to improve prescribing behaviour of GPs. Studies in Health Technology & Informatics. 2006; 124:617–23. [PubMed: 17108585]

Martens 2007 {published data only} . Martens JD, van der Weijden T, Severens JL, de Clercq PA, de Bruijn DP, Kester AD, et al. The effect of computer reminders on GPs' prescribing behaviour: A cluster-randomised trial. International Journal of Medical Informatics. 2007; 76(Suppl 3):S403–16. [PubMed: 17569575]

Martin 2007 {published data only} . Martin WE, Miller SC, Welch LC, Burrill J. Improving access to hospice: the Physician Feedback and Reminders to Improve Access to Hospice (PFRIAH) study. Medicine and Health, Rhode Island. 2007; 90(12):388–90.

Matheny 2007 {published data only} . Matheny ME, Gandhi TK, Orav EJ, Ladak-Merchant Z, Bates DW, Kuperman GJ, et al. Impact of an automated test results management system on patients' satisfaction about test result communication. Archives of Internal Medicine. 2007; 167(20):2233–9. [PubMed: 17998497]

McAlister 2006 {published data only} . McAlister FM, Fradette M, Graham M, Majumdar SR, Ghali WA, Williams R, et al. A randomized trial to assess the impact of opinion leader endorsed evidence summaries on the use of secondary prevention strategies in patients with coronary artery disease: the ESP-CAD trial protocol [NCT00175240]. Implementation Science. 2006; 6(1):11. [PubMed: 16722548]

McCartney 1997 {published data only} . McCartney P, Macdowall W, Thorogood M. A randomised controlled trial of feedback to general practitioners of their prophylactic aspirin prescribing. BMJ. 1997; 315(7099):35–6. [PubMed: 9233326]

McDonald 1976 {published data only} . McDonald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. Annals of Internal Medicine. 1976; 84(2):162–7. [PubMed: 1252043]

McDonald 1980 {published data only} . McDonald CJ, WIlson GA, McCabe GP. Physician response to computer reminders. JAMA. 1980; 244(14):1579–81. [PubMed: 7420656]

McDonald 1984 {published data only} . McDonald CJ, Hui SL, Smith DM, Tierney WM, Cohen SJ, Weinberger M, et al. Reminders to physicians from an introspective computer medical record. A two-year randomized trial. Annals of Internal Medicine. 1984; 100(1):130–8. [PubMed: 6691639]

McDonald 1992 {published data only} . McDonald CJ, Hui SL, Tierney WM. Effects of computer reminders for influenza vaccination on morbidity during influenza epidemics. MD Computing. 1992; 9(5):304–12. [PubMed: 1522792]

McDowell 1986 {published data only} . McDowell I, Newell C, Rosser W. Comparison of three methods of recalling patients for influenza vaccination. CMAJ. 1986; 135(9):991–7. [PubMed: 3093045]

McDowell 1989a {published data only} . McDowell I, Newell C, Rosser W. Computerized reminders to encourage cervical screening in family practice. Journal of Family Practice. 1989; 28(4):420–4. [PubMed: 2495337]

McDowell 1989b {published data only} . McDowell I, Newell C, Rosser W. A randomized trial of computerized reminders for blood pressure screening in primary care. Medical Care. 1989; 273(3297-305):297–305. [PubMed: 2494397]

McEwen 2006 {published data only} . McEwen A, West R, Preston A. Triggering anti-smoking advice by GPs: mode of action of an intervention stimulating smoking cessation advice by GPs. Patient Education and Counseling. 2006; 62(1):89–94. [PubMed: 16023821]

McGowan 1999 {published data only} . McGowan JJ, Winstead-Fry P. Problem Knowledge Couplers: reengineering evidence-based medicine through interdisciplinary development, decision support, and research. Bulletin of the Medical Library Association. 1999; 87(4):462–70. [PubMed: 10550032]

McGowan 2000 {published data only} . McGowan JJ, Richwine M. Electronic information access in support of clinical decision making: a comparative study of the impact on rural health care outcomes. Proceedings of the AMIA Symposium. 2000:565–9.

McGregor 2006 {published data only} . McGregor JC, Weekes E, Forrest GN, Standiford HC, Perencevich EN, Furuno JP, et al. Impact of a computerized clinical decision support system on reducing inappropriate antimicrobial use: a randomized controlled trial. Journal of the American Medical Informatics Association. 2006; 13(4):378–84. [PubMed: 16622162]

McIsaac 2002 {published data only} . McIsaac WJ, Goel V, To T, Permaul JA, Low DE. Effect on antibiotic prescribing of repeated clinical prompts to use a sore throat score: lessons from a failed community intervention study. Journal of Family Practice. 2002; 51(4):339–44. [PubMed: 11978257]

McKinley 2001 {published data only} . McKinley BA, Moore FA, Sailors RM, Cocanour CS, Marquez A, Wright RK, et al. Computerized decision support for mechanical ventilation of trauma induced ARDS: results of a randomized clinical trial. Journal of Trauma. 2001; 50(3): 415–24. [PubMed: 11265020]

McPhee 1989 {published data only} . McPhee SJ, Bird JA, Jenkins CN, Fordham D. Promoting cancer screening. A randomized, controlled trial of three interventions. Archives of Internal Medicine. 1989; 149(8):1866–72. [PubMed: 2764657]

McPhee 1991 {published data only} . McPhee SJ, Bird JA, Fordham D, Rodnick JE, Osborn EH. Promoting cancer prevention activities by primary care physicians. Results of a randomized, controlled trial. JAMA. 1991; 266(4):538–44. [PubMed: 2061981]

Medow 2001 {published data only} . Medow MA, Wilt TJ, Dysken S, Hillson SD, Woods S, Borowsky SJ. Effect of written and computerized decision support aids for the U.S. Agency for Health Care Policy and Research depression guidelines on the evaluation of hypothetical clinical scenarios. Medical Decision Making. 21(5):344–56. 201. [PubMed: 11575484]

Mills 2006 {published data only} . Mills PD, Neily J, Mims E, Burkhardt ME, Bagian J. Improving the bar-coded medication administration system at the Department of Veterans Affairs. American Journal of Health-System Pharmacy. 2006; 63(15):1442–7. [PubMed: 16849710]

Montani 2000 {published data only} . Montani S, Bellazzi R. Exploiting multi-modal reasoning for knowledge management and decision support: an evaluation study. Proceedings of the AMIA Symposium. 2000:585–9.

Montgomery 2000 {published data only} . Montgomery AA, Fahey T, Peters TJ, MacIntosh C, Sharp DJ. Evaluation of computer based clinical decision support system and risk chart for management of hypertension in primary care: randomised controlled trial. BMJ. 2000; 320(7236):686–90. [PubMed: 10710578]

Montori 2002 {published data only} . Montori VM, Dinneen SF, Gorman CA, Zimmerman BR, Rizza RA, Bjornsen SS, et al. The impact of planned care and a diabetes electronic management system on community-based diabetes care: the Mayo Health System Diabetes Translation Project. Diabetes Care. 2002; 25(11):1952–7. [PubMed: 12401738]

Morisky 2002 {published data only} . Morisky DE, Lees NB, Sharif BA, Liu KY, Ward HJ. Reducing disparities in hypertension control: a community-based hypertension control project (CHIP) for an ethnically diverse population. Health Promotion Practice. 2002; 3(2):264–75.

Murray 1999 {published data only} . Murray MD, Loos B, Tu W, Eckert GJ, Zhou XH, Tierney WM. Work patterns of ambulatory care pharmacists with access to electronic guideline-based treatment suggestions. American Journal of Health-System Pharmacy. 1999; 56(3):225–32. [PubMed: 10030506]

Murray 2004 {published data only} . Murray MD, Harris LE, Overhage JM, Zhou XH, Eckert GJ, Smith FE, et al. Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial. Pharmacotherapy. 2004; 24(3):324–37. [PubMed: 15040645]

Musser 2001 {published data only} . Musser, DB. The effect of a Technology-Linking Care (TLC) intervention on HIV/AIDS patients' therapeutic drug regimen adherence. Univ. of Missouri; Saint Louis, USA: 2001.

Myers 2004 {published data only} . Myers RE, Turner B, Weinberg D, Hyslop T, Hauck WW, Brigham T, et al. Impact of a physician-oriented intervention on follow-up in colorectal cancer screening. Preventive Medicine. 2004; 38(4):375–81. [PubMed: 15020170]

Nguyen 2000 {published data only} . Nguyen BH, Nguyen KP, McPhee SJ, Nguyen AT, Tran DQ, Jenkins CN. Promoting cancer prevention activities among Vietnamese physicians in California. Journal of Cancer Education. 2000; 15(2):82–5. [PubMed: 10879896]

Nilasena 1995 {published data only} . Nilasena DS, Lincoln MJ. A computer-generated reminder system improves physician compliance with diabetes preventive care guidelines. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1995:640–5.

Norman 2004 {published data only} . Norman C. CATCH-IT report: evaluation of an internet-based smoking cessation program: lessons learned from a pilot study. Journal of Medical Internet Research. 2004; 6(4):e47. [PubMed: 15631971]

Olivarius 2001 {published data only} . Olivarius NF, Beck-Nielsen H, Andreasen AH, Hørder M, Pedersen PA. Randomised controlled trial of structured personal care of type 2 diabetes mellitus. BMJ. 2001; 323(7319):970–5. [PubMed: 11679387]

Oppenheim 2002 {published data only} . Oppenheim MI, Vidal C, Velasco FT, Boyer AG, Cooper MR, Hayes JG, et al. Impact of a computerized alert during physician order entry on medication dosing in patients with renal impairment. Proceedings of the AMIA Annual Symposium. 2002:577–81.

Ornstein 1991 {published data only} . Ornstein SM, Garr DR, Jenkins RG, Rust PF, Arnon A. Computer-generated physician and patient reminders. Tools to improve population adherence to selected preventive services. Journal of Family Practice. 1991; 32(1):82–90. [PubMed: 1985140]

Ornstein 2001 {published data only} . Ornstein SM. Translating research into practice using electronic medical records the PPRNet-TRIP project: primary and secondary prevention of coronary heart disease and stroke. Topics in Health Information Management. 2001; 22(2):52–8. [PubMed: 11761792]

Otero-Sabogal 2006 {published data only} . Otero-Sabogal RO, Owens D, Canchola J, Tabnak F. Improving rescreening in community clinics: does a system approach work? Journal of Community Health. 2006; 31(6):497–519. [PubMed: 17186643]

Overhage 1995 {published data only} . Overhage JM, Mamlin B, Warvel J, Warvel J, Tierney W, McDonald CJ. A tool for provider interaction during patient care: G-CARE. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1995:178–82.

Overhage 2001 {published data only} . Overhage JM, Perkins S, Tierney WM, McDonald CJ. Controlled trial of direct physician order entry: effects on physicians' time utilization in ambulatory primary care internal medicine practices. Journal of the American Medical Informatics Association. 2001; 8(4):361–71. [PubMed: 11418543]

Oyen 2005 {published data only} . Oyen LJ, Nishimura RA, Ou NN, Armon JJ, Zhou M. Effectiveness of a computerized system for intravenous heparin administration: using information technology to improve patient care and patient safety. American Heart Hospital Journal. 2005; 3(2):75–81. [PubMed: 15860993]

Palen 2006 {published data only} . Palen TE, Raebel M, Lyons E, Magid DM. Evaluation of laboratory monitoring alerts within a computerized physician order entry system for medication orders. American Journal of Managed Care. 2006; 12(7):389–95. [PubMed: 16834525]

Parry 2000 {published data only} . Parry D, Fitzmaurice D, Raftery J. Anticoagulation management in primary care: a trial-based economic evaluation. British Journal of Haematology. 2000; 111(2):530. [PubMed: 11122095]

Patterson 1998 {published data only} . Patterson R. A computerized reminder for prophylaxis of deep vein thrombosis in surgical patients. Proceedings of the AMIA Annual Symposium. 1998:573–6.

Peck 1973 {published data only} . Peck CC, Sheiner LB, Martin CM, Combs DT, Melmon KL. Computer-assisted digoxin therapy. New England Journal of Medicine. 1973; 289(9):441–6. [PubMed: 4763409]

Persell 2008 {published data only} . Persell SD, Denecke-Dattalo TA, Dunham DP, Baker DW. Patient-directed intervention versus clinician reminders alone to improve aspirin use in diabetes:

a cluster randomized trial. Joint Commission Journal on Quality & Patient Safety. 2008; 34(2): 98–105. [PubMed: 18351194]

Petrucci 1991 {published data only} . Petrucci K, Petrucci P, Canfield K, McCormick KA, Kjerulff K, Parks P. Evaluation of UNIS: Urological Nursing Information Systems. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1991:43–7.

Poller 1993 {published data only} . Poller L, Wright D, Rowlands M. Prospective comparative study of computer programs used for management of warfarin. Journal of Clinical Pathology. 1993; 46(4):299–303. [PubMed: 8496384]

Poller 1998 {published data only} . Poller L, Shiach CR, MacCallum PK, Johansen AM, Münster AM, Magalhães A, et al. Multicentre randomised study of computerised anticoagulant dosage. European Concerted Action on Anticoagulation. Lancet. 1998; 352(9139):1505–9. [PubMed: 9820298]

Preston 2000 {published data only} . Preston JA, Scinto JD, Grady JM, Schulz AF, Petrillo MK. The effect of a multifaceted physician office-based intervention on older women's mammography use. Journal of the American Geriatrics Society. 2000; 48(1):1–7. [PubMed: 10642013]

Raebel 2005 {published data only} . Raebel MA, Lyons EE, Chester EA, Bodily MA, Kelleher JA, Long CL, et al. Improving laboratory monitoring at initiation of drug therapy in ambulatory care: a randomized trial. Archives of Internal Medicine. 2005; 165(20):2395–401. [PubMed: 16287769]

Raebel 2007a {published data only} . Raebel MA, Carroll NM, Kelleher JA, Chester EA, Berga S, Magid DJ. Randomized trial to improve prescribing safety during pregnancy. Journal of the American Medical Informatics Association. 2007; 14(4):440–50. [PubMed: 17460126]

Raebel 2007b {published data only} . Raebel MA, Charles J, Dugan J, Carroll NM, Korner EJ, Brand DW, et al. Randomized trial to improve prescribing safety in ambulatory elderly patients. Journal of the American Geriatrics Society. 2007; 55(7):977–85. [PubMed: 17608868]

Ramnarayan 2003 {published data only} . Ramnarayan P, Kapoor RR, Coren M, Nanduri V, Tomlinson AL, Taylor PM, et al. Measuring the impact of diagnostic decision support on the quality of clinical decision making: development of a reliable and valid composite score. Journal of the American Medical Informatics Association. 2003; 10(6):563–72. [PubMed: 12925549]

Rapley 2006 {published data only} . Rapley T, May C, Heaven B, Murtagh M, Graham R, Kaner EF, et al. Doctor-patient interaction in a randomised controlled trial of decision-support tools. Social Science & Medicine. 2006; 62(9):2267–78. [PubMed: 16290918]

Reeve 2008 {published data only} . Reeve JF, Tenni PC, Peterson GM. An electronic prompt in dispensing software to promote clinical interventions by community pharmacists: a randomized controlled trial. British Journal of Pharmacology. 2008; 65(3):377–85.

Rhodes 2006 {published data only} . Rhodes KV, Drum M, Anliker E, Frankel RM, Howes DS, Levinson W. Lowering the threshold for discussions of domestic violence: a randomized controlled trial of computer screening. Archives of Internal Medicine. 2006; 166(10):1107–14. [PubMed: 16717173]

Rind 1991 {published data only} . Rind DM, Safran C, Phillips RS, Slack WV, Calkins DR, Delbanco TL, et al. The effect of computer-based reminders on the management of hospitalized patients with worsening renal function. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1991:28–32.

Rind 1995 {published data only} . Rind DM, Davis R, Safran C. Designing studies of computer-based alerts and reminders. M.D. Computing: Computers in Medical Practice. 1995; 12(2):122–6. [PubMed: 7700124]

Robinson 2007 {published data only} . Robinson CA, Cocohoba J, MacDougall C, John MD, Guglielmo BJ. Discordance between ambulatory care clinic and community pharmacy medication databases for HIV-positive patients. Journal of the American Pharmacists Association. 2007; 47(5):613–5. [PubMed: 17848351]

Rodman 1984 {published data only} . Rodman JH, Jelliffe RW, Kolb E, Tuey DB, de Guzman MF, Wagers PW, et al. Clinical studies with computer-assisted initial lidocaine therapy. Archives of Internal Medicine. 1984; 144(4):703–9. [PubMed: 6712366]

Rogers 1982 {published data only} . Rogers JL, Haring OM, Wortman PM, Watson RA, Goetz JP. Medical information systems: assessing impact in the areas of hypertension, obesity and renal disease. Medical Care. 1982; 20(1):63–74. [PubMed: 7078276]

Rogers 1984 {published data only} . Rogers JL, Haring OM, Goetz JP. Changes in patient attitudes following the implementation of a medical information system. Quality Review Bulletin. 1984; 10(3):65–74. [PubMed: 6427724]

Rollman 2001 {published data only} . Rollman BL, Hanusa BH, Gilbert T, Lowe HJ, Kapoor WN, Schulberg HC. The electronic medical record. A randomized trial of its impact on primary care physicians' initial management of major depression. Archives of Internal Medicine. 2001; 161(2):189–97. [PubMed: 11176732]

Rollman 2002 {published data only} . Rollman BL, Hanusa BH, Lowe HJ, Gilbert T, Kapoor WN, Schulberg HC. A randomized trial using computerized decision support to improve treatment of major depression in primary care. Journal of General Internal Medicine. 2002; 17(7):493–503. [PubMed: 12133139]

Rood 2005 {published data only} . Rood E, Bosman RJ, van der Spoel JI, Taylor P, Zandstra DF. Use of a computerized guideline for glucose regulation in the intensive care unit improved both guideline adherence and glucose regulation. Journal of the American Medical Informatics Association. 2005; 12(2):172–80. [PubMed: 15561795]

Rosenman 2003 {published data only} . Rosenman M, Wang J, Dexter P, Overhage JM. Computerized reminders for syphilis screening in an urban emergency department. Proceedings of the AMIA Annual Symposium. 2003:987.

Rosser 1991 {published data only} . Rosser WW, McDowell I, Newell C. Use of reminders for preventive procedures in family medicine. Canadian Medical Association Journal. 1991; 145(7): 807–14. [PubMed: 1913409]

Rosser 1992 {published data only} . Rosser WW, Hutchison BG, McDowell I, Newell C. Use of reminders to increase compliance with tetanus booster vaccination. Canadian Medical Association Journal. 1992; 146(6):911–7. [PubMed: 1544078]

Rotman 1995 {published data only} . Rotman BL, Sullivan AN, McDonald T, DeSmedt P, Goodnature D, Higgins M, et al. A randomized evaluation of a computer-based physician's workstation: design considerations and baseline results. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1995:693–7.

Rotman 1996 {published data only} . Rotman BL, Sullivan AN, McDonald TW, Brown BW, DeSmedt P, Goodnature D, et al. A randomized controlled trial of a computer-based physician workstation in an outpatient setting: implementation barriers to outcome evaluation [see comment]. Journal of the American Medical Informatics Association. 1996; 3(5):340–8. [PubMed: 8880681]

Roukema 2008 {published data only} . Roukema J, Steyerberg EW, van der Lei J, Moll HA. Randomized trial of a clinical decision support system: impact on the management of children with fever without apparent source. Journal of the American Medical Informatics Association. 2008; 15(1):107–13. [PubMed: 17947627]

Roumie 2004 {published data only} . Roumie CL, Grogan EL, Falbe W, Awad J, Speroff T, Dittus RS, et al. A three-part intervention to change the use of hormone replacement therapy in response to new evidence [see comment]. Annals of Internal Medicine. 2004; 141(2):118–25. [PubMed: 15262667]

Roumie 2007 {published data only} . Roumie CL, Elasy TA, Wallston KA, Pratt S, Greevy RA, Liu X, et al. Clinical inertia: a common barrier to changing provider prescribing behavior. Joint Commission Journal on Quality and Patient Safety. 2007; 33(5):277–85. [PubMed: 17503683]

Rubenstein 1995 {published data only} . Rubenstein LV, McCoy JM, Cope DW, Barrett PA, Hirsch SH, Messer KS, et al. Improving patient quality of life with feedback to physicians about functional status. Journal of General Internal Medicine. 1995; 10(11):607–14. [PubMed: 8583263]

Ryff-de Leche 1919 {published data only} . Ryff-de Leche A, Engler H, Nutzi E, Berger M, Berger W. Clinical application of two computerized diabetes management systems: comparison with the log-book method. Diabetes Research. 1919; 3:97–105.

Sabnis 2003 {published data only} . Sabnis SS, Pomeranz AJ, Amateau MM. The effect of education, feedback, and provider prompts on the rate of missed vaccine opportunities in a community health center. Clinical Pediatrics. 2003; 41(2):147–51. [PubMed: 12659388]

Safran 1993 {published data only} . Safran C, Rind DM, Davis RM, Currier J, Ives D, Sands DZ, et al. An electronic medical record that helps care for patients with HIV infection. Proceedings of the Annual Symposium on Computer Applications in Medical Care. 1993:224–8.

Safran 1995b {published data only} . Safran C, Rind DM, Davis RB, Ives D, Sands DZ, Currier J, et al. Guidelines for management of HIV infection with computer-based patient's record. Lancet. 1995; 346(8971):341–6. [PubMed: 7623532]

Safran 1996 {published data only} . Safran C, Rind DM, Davis RB, Ives D, Sands DZ, Currier J, et al. Effects of a knowledge-based electronic patient record in adherence to practice guidelines. MD Computing. 1996; 13(1):55–63. [PubMed: 11407412]

Saitz 2003 {published data only} . Saitz R, Horton NJ, Sullivan LM, Moskowitz MA, Samet JH. Addressing alcohol problems in primary care: a cluster randomized, controlled trial of a systems intervention. The screening and intervention in primary care (SIP) study. Annals of Internal Medicine. 2003; 138(5):372–82. [PubMed: 12614089]

Samore 2005 {published data only} . Samore MH, Bateman K, Alder SC, Hannah E, Donnelly S, Stoddard GJ, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. JAMA. 2005; 294(18):2305–14. [PubMed: 16278358]

Sanders 2000 {published data only} . Sanders GD, Nease RF Jr, Owens DK. Design and pilot evaluation of a system to develop computer-based site-specific practice guidelines from decision models. Medical Decision Making. 2000; 20(2):145–59. [PubMed: 10772353]

Scharer 2002 {published data only} . Scharer LO, Hartweg V, Valerius G, Graf M, Hoern M, Biedermann C, et al. Life charts on a palmtop computer: first results of a feasibility study with an electronic diary for bipolar patients. Bipolar Disorders. 2002; 4(Suppl 1):107–8. [PubMed: 12479693]

Scheel 2002 {published data only} . Scheel IB, Hagen KB, Herrin J, Oxman AD. A randomized controlled trial of two strategies to implement active sick leave for patients with low back pain. Spine. 2002; 27(6):561–6. [PubMed: 11884902]

Scholes 2006 {published data only} . Scholes D, Grothaus L, McClure J, Reid R, Fishman P, Sisk C, et al. A randomized trial of strategies to increase chlamydia screening in young women. Preventive Medicine. 2006; 43(4):343–50. [PubMed: 16782182]

Schriger 1997 {published data only} . Schriger DL, Baraff LJ, Rogers WH, Cretin S. Implementation of clinical guidelines using a computer charting system. Effect on the initial care of health care workers exposed to body fluids. JAMA. 1997; 278(19):1585–90. [PubMed: 9370504]

Schriger 2001 {published data only} . Schriger DL, Gibbons PS, Langone CA, Lee S, Altshuler LL. Enabling the diagnosis of occult psychiatric illness in the emergency department: a randomized, controlled trial of the computerized, self-administered PRIME-MD diagnostic system. Annals of Emergency Medicine. 2001; 37(2):132–40. [PubMed: 11174229]

Schwartz 2005 {published data only} . Schwartz MD, Tercyak KP, Peshkin BN, Valdimarsdottir H. Can a computer-based system be used to educate women on genetic testing for breast cancer susceptibility? Nature Clinical Practice. Oncology. 2005; 2(1):24–5.

Schwid 1999 {published data only} . Schwid HA, Rooke GA, Ross BK, Sivarajan M. Use of a computerized advanced cardiac life support simulator improves retention of advanced cardiac life support guidelines better than a textbook review. Critical Care Medicine. 1999; 27(4):821–4. [PubMed: 10321676]

Shandro 2002 {published data only} . Shandro MT, Pick ME, Gruninger A, Ryan EA. Diabetes care: interventions in the community. Diabetes Care. 2002; 25(5):941–2. [PubMed: 11978703]

Shannon 2001 {published data only} . Shannon KC, Sinacore JM, Bennett SG, Joshi AM, Sherin KM, Deitrich A. Improving delivery of preventive health care with the comprehensive annotated reminder tool (CART). Journal of Family Practice. 2001; 50(9):767–71. [PubMed: 11674909]

Shapiro 1987 {published data only} . Shapiro S, German PS, Skinner EA, VonKorff M, Turner RW, Klein LE. An experiment to change detection and management of mental morbidity in primary care. Medical Care. 1987; 25(4):327–39. [PubMed: 3320595]

Shea 1995 {published data only} . Shea S, Sideli RV, DuMouchel W, Pulver G, Arons RR, Clayton PD. Computer-generated informational messages directed to physicians: effect on length of hospital stay. Journal of the American Medical Informatics Association. 1995; 2(1):58–64. [PubMed: 7895137]

Shojania 1998 {published data only} . Shojania KG, Yokoe D, Platt R, Fiskio J, Ma'luf N, Bates DW. Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial [see comment]. Journal of the American Medical Informatics Association. 1998; 5(6):554–62. [PubMed: 9824802]

Shu 2001 {published data only} . Shu K, Boyle D, Spurr C, Horsky J, Heiman H, O'Connor P, et al. Comparison of time spent writing orders on paper with computerized physician order entry. Studies in Health Technology and Informatics. 2001; 84(Pt 2):1207–11. [PubMed: 11604922]

Sicotte 1998 {published data only} . Sicotte C, Denis JL, Lehoux P. The computer based patient record: a strategic issue in process innovation. Journal of Medical Systems. 1998; 22(6):431–43. [PubMed: 9871877]

Simon 2000 {published data only} . Simon GE, VonKorff M, Rutter C, Wagner E. Randomised trial of monitoring, feedback, and management of care by telephone to improve treatment of depression in primary care [see comments]. BMJ. 2000; 320(7234):550–4. [PubMed: 10688563]

Simon 2006 {published data only} . Simon SR, Smith DH, Feldstein AC, Perrin N, Yang X, Zhou Y, et al. Computerized prescribing alerts and group academic detailing to reduce the use of potentially inappropriate medications in older people. Journal of the American Geriatrics Society. 2006; 54(6):963–8. [PubMed: 16776793]

Sittig 1990 {published data only} . Sittig DF, Gardner RM, Morris AH, Wallace CJ. Clinical evaluation of computer-based respiratory care algorithms. International Journal of Clinical Monitoring & Computing. 1990; 7(3):177–85. [PubMed: 2250128]

Smith 2008 {published data only} . Smith SA, Shah ND, Bryant SC, Christianson TJ, Bjornsen SS, Giesler PD, et al. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. Mayo Clinic Proceedings. 2008; Vol. 83(issue 7):747–57. [PubMed: 18613991]

Smithuis 1994 {published data only} . Smithuis LOMJ, Geldrop WJ van, Lucassen PLBJ. Beperking van het laboratorium–onderzoek door een probleemgeorienteerd aanvraagformulier. Huisarts en Wetenschap. 1994; 37(11):464–6.

Solomon 2001 {published data only} . Solomon DH, Van Houten L, Glynn RJ, Baden L, Curtis K, Schrager H, et al. Academic detailing to improve use of broad-spectrum antibiotics at an academic medical center. Archives of Internal Medicine. 2001; 161(15):1897–902. [PubMed: 11493132]

Sommers 1984 {published data only} . Sommers LS, Sholtz R, Shepherd RM, Starkweather DB. Physician involvement in quality assurance. Medical Care. 1984; 22(12):1115–38. [PubMed: 6513620]

Stair 1995 {published data only} . Stair TO, Howell JM. Effect on medical education of computerized physician order entry. Academic Medicine. 1995; 70(6):543. [PubMed: 7786378]

Stamos 2001 {published data only} . Stamos TD, Shaltoni H, Girard SA, Parrillo JE, Calvin JE. Effectiveness of chart prompts to improve physician compliance with the National Cholesterol Education Program guidelines. American Journal of Cardiology. 2001; 88(12):1420–3. [PubMed: 11741565]

Steele 2003 {published data only} . Steele A, Garrett N, Davidson A, Jatko M, Eisert S, Lyons P. Encoded guidelines for targeted latent tuberculosis screening using an electronic medical record. Proceedings of the AMIA Annual Symposium. 2003:1017.

Stewart 2003 {published data only} . Stewart K, Loftus S, DeLisle S. Prescription of amiodarone through a computerized template that includes both decision support and executive functions improves the monitoring for toxicities. Proceedings of the AMIA Annual Symposium. 2003:1020.

Stone 2005 {published data only} . Stone RA, Mor MK, Lave JF, Hough LJ, Fine MJ. Implementation of an inpatient management and discharge strategy for patients with community-acquired pneumonia. American Journal of Managed Care. 2005; 11(8):491–9. [PubMed: 16095435]

Subramanian 2004 {published data only} . Subramanian U, Fihn SD, Weinberger M, Plue L, Smith FE, Udris EM, et al. A controlled trial of including symptom data in computer-based care suggestions for managing patients with chronic heart failure. American Journal of Medicine. 2004; 116(6):375–84. [PubMed: 15006586]

Séroussi 2004 {published data only} . Séroussi B, Bouaud. Reminder-based or on-demand decision support systems: a preliminary study in primary care with the management of hypertension. Studies in Health Technology & Informatics. 2004; 101:142–6. [PubMed: 15537217]

Tai 1999 {published data only} . Tai SS, Nazareth I, Donegan C, Haines A. Evaluation of general practice computer templates. Lessons from a pilot randomised controlled trial. Methods of Information in Medicine. 1999; 38(3):177–81. [PubMed: 10522120]

Tamblyn 1997 {published data only} . Tamblyn RM, Jacques A, Laprise R, Huang A, Perreault R. The office of the future project: the integration of new technology into the office practice. Academic detailing through the super highway. Quebec Research Group on Medication Use in the Elderly. Clinical Performance and Quality Health Care. 1997; 5(2):104–8. [PubMed: 10167210]

Tang 1999 {published data only} . Tang PC, LaRosa MP, Newcomb C, Gorden SM. Measuring the effects of reminders for outpatient influenza immunizations at the point of clinical opportunity. Journal of the American Medical Informatics Association. 1999; 6(2):115–21. [PubMed: 10094064]

Taylor 2008 {published data only} . Taylor B, Dinh M, Kwok R, Dinh D, Chu M, Tang E. Electronic interface for emergency department management of asthma: a randomized control trial of clinician performance. Emergency Medicine Australasia: EMA. 2008; 20(1):38–44. [PubMed: 18062784]

Thomas 1983 {published data only} . Thomas JC, Moore A, Qualls PE. The effect on cost of medical care for patients treated with an automated clinical audit system. Journal of Medical Systems. 1983; 7(3):307–13. [PubMed: 6619687]

Thomas 2007 {published data only} . Thomas KG, Thomas MR, Stroebel RJ, McDonald FS, Hanson GJ, Naessens JM, et al. Use of a registry-generated audit, feedback, and patient reminder intervention in an internal medicine resident clinic - a randomized trial. Journal of General Internal Medicine. 2007; 22(12):1740–4. [PubMed: 17973175]

Thompson 1999 {published data only} . Thompson F, George S, Lattimer V, Smith H, Moore M, Turnbull J, et al. Overnight calls in primary care: randomised controlled trial of management using nurse telephone consultation. BMJ. 1999; 319(7222):1408. [PubMed: 10574857]

Tierney 1986 {published data only} . Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. Medical Care. 1986; 24(8):659–66. [PubMed: 3736141]

Tierney 1987 {published data only} . Tierney WM, McDonald CJ, Martin DK, Rogers MP. Computerized display of past test results. Effect on outpatient testing. Annals of Internal Medicine. 1987; 107(4):569–74. [PubMed: 3631792]

Tierney 1988 {published data only} . Tierney WM, McDonald CJ, Hui SL, Martin DK. Computer predictions of abnormal test results. Effects on outpatient testing. JAMA. 1988; 259(8):1194–8. [PubMed: 3339821]

Tierney 1990 {published data only} . Tierney WM, Miller ME, McDonald CJ. The effect on test ordering of informing physicians of the charges for outpatient diagnostic tests. New England Journal of Medicine. 1990; 322(21):1499–504. [PubMed: 2186274]

Tierney 1993 {published data only} . Tierney WM, Miller ME, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. JAMA. 1993; 269(3):379–83. [PubMed: 8418345]

Topal 2005 {published data only} . Topal J, Conklin S, Camp K, Morris V, Balcezak T, Herbert P. Prevention of nosocomial catheter-associated urinary tract infections through computerized

feedback to physicians and a nurse-directed protocol. American Journal of Medical Quality. 2005; 20(3):121–6. [PubMed: 15951517]

Topol 2007 {published data only} . Topol P, Porat N, Zelker R, Ingber A, Zlotogorski A, Brezis M. Quality improvement program to assure the delivery of pathology test results: a systemic intervention in a large general hospital. Dermatology Nursing/Dermatology Nurses' Association. 2007; 19(3):253–7. [PubMed: 17626503]

Torgerson 1993 {published data only} . Torgerson DJ, Garton MJ, Donaldson C, Russell IT, Reid DM. Recruitment methods for screening programmes: trial of an improved method within a regional osteoporosis study. BMJ. 1993; 307(6896):99. [PubMed: 8343737]

Toth-Pal 2004 {published data only} . Toth-Pal E, Nilsson GH, Furhoff AK. Clinical effect of computer generated physician reminders in health screening in primary health care - a controlled clinical trial of preventive services among the elderly. International Journal of Medical Informatics. 2004; 73(9-10):695–703. [PubMed: 15325326]

Tremaine 2001 {published data only} . Tremaine WJ, Sandborn WJ, Loftus EV, Kenan ML, Petterson TM, Zinsmeister AR, et al. A prospective cohort study of practice guidelines in inflammatory bowel disease. American Journal of Gastroenterology. 2001; 96(8):2401–6. [PubMed: 11513181]

Trivedi 2003 {published data only} . Trivedi MH. Remission of depression and the Texas Medication Algorithm Project. Managed Care Interface. 2003; (Suppl B):9–13. [PubMed: 12647607]

Trivedi 2007 {published data only} . Trivedi MH, Rush AJ, Gaynes BN, Stewart JW, Wisniewski SR, Warden D. Maximizing the adequacy of medication treatment in controlled trials and clinical practice: STAR (*)D measurement-based care. Neuropsychopharmacology. 2007; 32(12):2479–89. [PubMed: 17406651]

Tung 2003 {published data only} . Tung Y, Duffy LC, Gyamfi JO, Wojtaszczyk F, Dozier A, Tempfer T, et al. Improvements in immunization compliance using a computerized tracking system for inner city clinics. Clinical Pediatrics. 2003; 42(7):603–11. [PubMed: 14552519]

Turner 1989 {published data only} . Turner BJ, Day SC, Borenstein B. A controlled trial to improve delivery of preventive care: physician or patient reminders? Journal of General Internal Medicine. 1989; 4(5):403–9. [PubMed: 2677271]

Vadher 1997a {published data only} . Vadher BD, Patterson DL, Leaning M. Comparison of oral anticoagulant control by a nurse-practitioner using a computer decision-support system with that by clinicians. Clinical and Laboratory Haematology. 1997; 19(3):203–7. [PubMed: 9352146]

Vadher 1997b {published data only} . Vadher B, Patterson DL, Leaning M. Evaluation of a decision support system for initiation and control of oral anticoagulation in a randomised trial. BMJ. 1997; 314(7089):1252–6. [PubMed: 9154031]

van den Besselaar 2007 {published data only} . van den Besselaar AM, Hoekstra MM, van der Meer FJ. Quality control of CoaguChek test strips in the Netherlands. Thrombosis and Haemostasis. 2007; 97(2):323–4. [PubMed: 17264967]

van Overbeeke 1996 {published data only} . van Overbeeke JJ, Westerhof HP. The Dutch "Benefit-II" project: do physicians benefit from using an electronic medical dossier? International Journal of Bio-Medical Computing. 1996; 42(1-2):91–6. [PubMed: 8880273]

van Wyk 2003 {published data only} . van Wyk JT, van Wijk MA, Moorman PW, Mosseveld M, van der Lei J. Cholgate - a randomized controlled trial comparing the effect of automated and on-demand decision support on the management of cardiovascular disease factors in primary care. Proceedings of the AMIA Annual Symposium. 2003:1040.

Verstappen 2007 {published data only} . Verstappen SM, Jacobs JW, van der Veen MJ, Heurkens AH, Schenk Y, ter Borg EJ, et al. Intensive treatment with methotrexate in early rheumatoid arthritis: aiming for remission. Computer Assisted Management in Early Rheumatoid Arthritis (CAMERA, an open-label strategy trial). Annals of the Rheumatic Diseases. 2007; 66(11):1443–9. [PubMed: 17519278]

Veselý 2006 {published data only} . Veselý A, Zvárová J, Peleska J, Buchtela D, Anger Z. Medical guidelines presentation and comparing with Electronic Health Record. International Journal of Medical Informatics. 2006; 75(3-4):240–5. [PubMed: 16165396]

Vinker 2002 {published data only} . Vinker S, Nakar S, Rosenberg E, Kitai E. The role of family physicians in increasing annual fecal occult blood test screening coverage: a prospective intervention study. The Israel Medical Association Journal. 2002; 4(6):424–5. [PubMed: 12073414]

Vissers 1995 {published data only} . Vissers MC, Hasman A, van der Linden CJ. Protocol processing system (ProtoVIEW) to support residents at the emergency ward. Computer Methods and Programs in Biomedicine. 1995; 48(1-2):53–8. [PubMed: 8846712]

Vissers 1996a {published data only} . Vissers MC, Biert J, van der Linden CJ, Hasman A. Effects of a supportive protocol processing system (ProtoVIEW) on clinical behaviour of residents in the accident and emergency department. Computer Methods and Programs in Biomedicine. 1996; 49(2):177–84. [PubMed: 8735024]

Vissers 1996b {published data only} . Vissers MC, Hasman A, van der Linden CJ. Impact of a protocol processing system (ProtoVIEW) on clinical behaviour of residents and treatment. International Journal of Bio-medical Computing. 1996; 42(1-2):143–50. [PubMed: 8880281]

Walton 1997 {published data only} . Walton RT, Gierl C, Yudkin P, Mistry H, Vessey MP, Fox J. Evaluation of computer support for prescribing (CAPSULE) using simulated cases. BMJ. 1997; 315(7111):791–5. [PubMed: 9345174]

Wanger 1997 {published data only} . Wanger P, Martin L. Management of ocular hypertension and open angle glaucoma: clinical practice and computer-assisted decision-making. Acta Ophthalmologica Scandinavica. 1997; 75(6):700–4. [PubMed: 9527335]

Warren 1999 {published data only} . Warren JR, Posey B, Thornton T, Parang P. Can computer autoacquisition of medical information meet the needs of the future? A feasibility study in direct computation of the fine grained electronic medical record. Proceedings of the AMIA Annual Symposium. 1999:445–9.

Weaver 2004 {published data only} . Weaver FM, Goldstein B, Hammond M. Improving respiratory vaccination rates in veterans with spinal cord injury/disorders: lessons learned. SCI Nursing: A Publication of the American Association of Spinal Cord Injury Nurses. 2004; 21(3): 143–8.

Weber 2008 {published data only} . Weber V, White A, McIlvried R. An electronic medical record (EMR)-based intervention to reduce polypharmacy and falls in an ambulatory rural elderly population. Journal of General Internal Medicine. 2008; 23(4):399–404. [PubMed: 18373136]

Weingarten 1989 {published data only} . Weingarten MA, Bazel D, Shannon HS. Computerized protocol for preventive medicine: a controlled self-audit in family practice. Family Practice. 1989; 6(2):120–4. [PubMed: 2744295]

Weir 2003 {published data only} . Weir CJ, Lees KR, MacWalter RS, Muir KW, Wallesch CW, McLelland EV, et al. Cluster-randomized, controlled trial of computer-based decision support for selecting long-term anti-thrombotic therapy after acute ischaemic stroke. QJM. 2003; 96(2):143–53. [PubMed: 12589012]

Wellingham 2003 {published data only} . Wellingham J, Tracey J, Rea H, Gribben B, Chronic Care Management Programme. The development and implementation of the Chronic Care Management Programme in Counties Manukau. New Zealand Medical Journal. 2003; 116(1169):U327. [PubMed: 12601404]

White 1987 {published data only} . White RH, Hong R, Venook AP, Daschbach MM, Murray W, Mungall DR, et al. Initiation of warfarin therapy: comparison of physician dosing with computer-assisted dosing. Journal of General Internal Medicine. 1987; 2(3):141–8. [PubMed: 3295148]

White 1991 {published data only} . White RH, Mungall D. Outpatient management of warfarin therapy: comparison of computer-predicted dosage adjustment to skilled professional care. Therapeutic Drug Monitoring. 1991; 13(1):46–50. [PubMed: 2057991]

Whitty 2004 {published data only} . Whitty P, Eccles MP, Hawthorne G, Steen N, Vanoli A, Grimshaw JM, et al. Improving diabetes services: lessons from the DREAM trial. Practical Diabetes International. 2004; 21(9):323–8.

Williams 1998 {published data only} . Williams RB, Boles M, Johnson RE. A patient-initiated system for preventive health care. A randomized trial in community-based primary care practices [see comment]. Archives of Family Medicine. 1998; 7(4):338–45. [PubMed: 9682687]

Wolfenden 2005 {published data only} . Wolfenden L, Wiggers J, Knight J, Campbell E, Spigelman A, Kerridge R, et al. Increasing smoking cessation care in a preoperative clinic: a randomized controlled trial. Preventive Medicine. 2005; 41(1):284–90. [PubMed: 15917023]

Wright 2007 {published data only} . Wright J, Bibby J, Eastham J, Harrison S, McGeorge M, Patterson C, et al. Multifaceted implementation of strok eprevention guidelines in primary care: cluster-randomised evaluation of clinical and cost effectiveness. Quality & Safety in Health Care. 2007; 16(1):51–9. [PubMed: 17301206]

Yarnall 1998 {published data only} . Yarnall KS, Rimer BK, Hynes D, Watson G, Lyna PR, Woods-Powell CT, et al. Computerized prompts for cancer screening in a community health center. Journal of the American Board of Family Practice. 1998; 11(2):96–104. [PubMed: 9542701]

Yealy 2005 {published data only} . Yealy DM, Auble TE, Stone RA, Lave JR, Meehan TP, Graff LG, et al. Effect of increasing the intensity of implementing pneumonia guidelines: a randomized, controlled trial. Annals of Internal Medicine. 2005; 143(12):881–94. [PubMed: 16365469]

Young 1981 {published data only} . Young DW. Improving the consistency with which investigations are requested. Medical Informatics. 1981; 6(1):13–7. [PubMed: 6971975]

Young 2003 {published data only} . Young JM, Ward JE. Randomised trial of intensive academic detailing to promote opportunistic recruitment of women to cervical screening by general practitioners. Australian & New Zealand Journal of Public Health. 2003; 27(3):273–81. [PubMed: 14705281]

Ziemer 20056 {published data only} . Ziemer DC, Doyle JP, Barnes CS, Branch WT Jr, Cook CB, El-Kebbi IM, et al. An intervention to overcome clinical inertia and improve diabetes mellitus control in a primary care setting: Improving Primary Care of African Americans with Diabetes (IPCAAD) 8. Archives of Internal Medicine. 2006; 166(5):507–13. [PubMed: 16534036]

Zimmerman 2003 {published data only} . Zimmerman RK, Nowalk MP, Raymund M, Tabbarah M, Hall DG, Wahrenberger JT, et al. Tailored interventions to increase influenza vaccination in neighborhood health centers serving the disadvantaged. American Journal of Public Health. 2003; 93(10):1699–705. [PubMed: 14534225]

Zwar 2002 {published data only} . Zwar N, Henderson J, Britt H, McGeechan K, Yeo G. Influencing antibiotic prescribing by prescriber feedback and management guidelines: a 5-year follow-up. Family Practice. 2002; 19(1):12–7. [PubMed: 11818344]

References to studies awaiting assessment

Durieux 2000 {published data only} . Durieux P, Nizard R, Ravaud P, Mounier N, Lepage E. A clinical decision support system for prevention of venous thromboembolism: effect on physician behaviour. JAMA. 2000; 283:2816–21. [PubMed: 10838650]

Plaza 2005 {published data only} . Plaza V, Cobos A, Ignacio-García JM, Molina J, Bergoñón S, García-Alonso F, et al. Cost-effectiveness of an intervention based on the Global Initiative for Asthma (GINA) recommendations using a computerized clinical decision support system: a physicians randomized trial [Coste–efectividad de una intervención basada en las recomendaciones de la Global INitiative for Asthma (GINA), mediante un sistema informatizado de apoyo a la decisión clínica: un ensayo con aleatorización de médicos]. Medicina Clínica. 2005; 124(6):201–6. [PubMed: 15737299]

Additional references

Ansari 2003 . Ansari M, Shlipak MG, Heidenreich PA, Van Ostaeyen D, Pohl EC, Browner WS, et al. Improving guideline adherence: a randomized trial evaluating strategies to increase beta-blocker use in heart failure. Circulation. 2003; 107:2799–804. [PubMed: 12756157]

Campbell 2000 . Campbell M, Grimshaw J, Steen N. Sample size calculations for cluster randomized trials. Changing Professional Practice in Europe Group (EU BIOMED II Concerted Action). Journal of Health Services Research & Policy. 2000; 5:12–6. [PubMed: 10787581]

Dexheimer 2008 . Dexheimer JW, Talbot TR, Sanders DL, Rosenbloom ST, Aronsky D. Prompting clinicians about preventive care measures: a systematic review of randomized controlled trials. Journal of the American Medical Informatics Association. 2008; 15:311–20. [PubMed: 18308989]

Dexter 2004 . Dexter PR, Perkins SM, Maharry KS, Jones K, McDonald CJ. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. JAMA. 2004; 292:2366–71. [PubMed: 15547164]

EPOC 2008 . Cochrane Effective Practice and Organisation of Care Group. [accessed 25 July 2008] EPOC-specific resources for review authors. The Cochrane Collaboration, 2008. http://www.epoc.cochrane.org/en/handsearchers.htmlhttp://www.epoc.cochrane.org/en/handsearchers.htmlAvailable from

Garg 2005 . Garg AX, Adhikari NK, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. JAMA. 2005; 293:1223–38. [PubMed: 15755945]

Gordon 1998 . Gordon RB, Grimshaw JM, Eccles MP, Rowe RE, Wyatt JC. On-screen computer reminders: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews. 1998; (Issue 2) [DOI: 10.1002/14651858.CD001096].

Grimshaw 2003 . Grimshaw J, McAuley LM, Bero LA, Grilli R, Oxman AD, Ramsay C, et al. Systematic reviews of the effectiveness of quality improvement strategies and programmes. Quality and Safety in Health Care. 2003; 12:298–303. [PubMed: 12897365]

Grimshaw 2004 . Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, et al. Effectiveness and efficiency of guideline dissemination and implementation strategies. Health Technology Assessment. 2004; 8:iii–iv. 1–72. [PubMed: 14960256]

Hunt 1998 . Hunt DL, Haynes RB, Hanna SE, Smith K. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. JAMA. 1998; 280:1339–46. [PubMed: 9794315]

Jamtvedt 2006 . Jamtvedt G, Young JM, Kristoffersen DT, O'Brien MA, Oxman AD. Does telling people what they have been doing change what they do? A systematic review of the effects of audit and feedback. Quality and Safety in Health Care. 2006; 15:433–6. [PubMed: 17142594]

Kawamoto 2005 . Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. BMJ. 2005; 330:765. [PubMed: 15767266]

Mason 1999 . Mason J, Wood J, Freemantle N. Designing evaluations of interventions to change professional practice. Journal of Health Services Research and Policy. 1999; 4:106–11. [PubMed: 10387402]

McGlynn 2003 . McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of health care delivered to adults in the United States. New England Journal of Medicine. 2003; 348:2635–45. [PubMed: 12826639]

O'Brien 2007 . O'Brien MA, Rogers S, Jamtvedt G, Oxman AD, Odgaard-Jensen J, Kristoffersen DT, et al. Educational outreach visits: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews. 2007; (Issue 4) [DOI: 10.1002/14651858.CD004577.pub2].

Oxman 1995 . Oxman AD, Thomson MA, Davis DA, Haynes RB. No magic bullets: a systematic review of 102 trials of interventions to improve professional practice. Canadian Medical Association Journal. 1995; 153:1423–31. [PubMed: 7585368]

Quality of Health Care 2001 . Committee on Quality of Health Care in America IoM. Crossing the quality chasm: a new health system for the 21st century; Washington, D.C.. National Academy Press; 2001.

Ranji 2008 . Ranji SR, Steinman MA, Shojania KG, Gonzales R. Interventions to reduce unnecessary antibiotic prescribing: a systematic review and quantitative analysis. Medical Care. 2008; 46(8):847–62. [PubMed: 18665065]

Schuster 1998 . Schuster MA, McGlynn EA, Brook RH. How good is the quality of health care in the United States. Milbank Quarterly. 1998; 76:517–63. 509. [PubMed: 9879302]

Shojania 2004a . Shojania, KG.; McDonald, KM.; Wachter, RM.; Owens, DK. Closing the quality gap: a critical analysis of quality improvement strategies. Vol. Vol. 1: Series Overview and Methodology. Agency for Healthcare Research and Quality; Rockville, MD: Aug. 2004 [: AHRQ Publication NO. 04–0051–1]

Shojania 2004b . Shojania, KG.; Ranji, S.; Shaw, LK., et al. Closing the quality gap: a critical analysis of quality improvement strategies. Vol. Vol. 2: Diabetes Mellitus Care. Agency for Healthcare Research and Quality; Rockville, MD: Sep. 2004 [: AHRQ Publication No. 04–0051–2]

Shojania 2005 . Shojania KG, Grimshaw JM. Evidence-based quality improvement: the state of the science. Health Affairs (Millwood). 2005; 24:138–50.

Shojania 2006 . Shojania KG, Ranji SR, McDonald KM, Grimshaw JM, Sundaram V, Rushakoff RJ, et al. Effects of quality improvement strategies for type 2 diabetes on glycemic control: a meta-regression analysis. JAMA. 2006; 296:427–40. [PubMed: 16868301]

Steinman 2006 . Steinman MA, Ranji SR, Shojania KG, Gonzales R. Improving antibiotic selection: a systematic review and quantitative analysis of quality improvement strategies. Medical Care. 2006; 44:617–28. [PubMed: 16799356]

Walsh 2006 . Walsh JM, McDonald KM, Shojania KG, Sundaram V, Nayak S, Lewis R, et al. Quality improvement strategies for hypertension management: a systematic review. Medical Care. 2006; 44:646–57. [PubMed: 16799359]

Zanetti 2003 . Zanetti G, Flanagan HL Jr, Cohn LH, Giardina R, Platt R. Improvement of intraoperative antibiotic prophylaxis in prolonged cardiac surgery by automated alerts in the operating room. Infection Control and Hospital Epidemiology. 2003; 24:13–6. [PubMed: 12558230]

* Indicates the major publication for the study

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

PLAIN LANGUAGE SUMMARY

On screen point of care computer reminders to improve care and health

It is known that doctors do not always provide the care that is recommended or according to the latest research. Many strategies have been tried in an attempt to reduce this gap between what is recommended and what is done. A potentially low cost way to do this could be to use computer systems that remind physicians about important information while they make decisions. For example, a doctor could be ordering antibiotics for a child with an ear infection. At that point, the computer the doctor is working on displays a pop up window with a reminder about the evidence for the best dose and length of time the antibiotics should be prescribed.

This review found 28 studies that evaluated the effects of different on-screen computer reminders. The studies tested reminders to prescribe specific medications, to warn about drug interactions, to provide vaccinations, or to order tests. The review found small to moderate benefits. The reminders improved physician practices by a median of 4%. In eight of the studies, patients' health improved by a median of 3%.

Although some studies showed larger benefits than these median effects, no specific reminders or features of how they worked were consistently associated with these larger benefits. More research is needed to identify what types of reminders work and when.

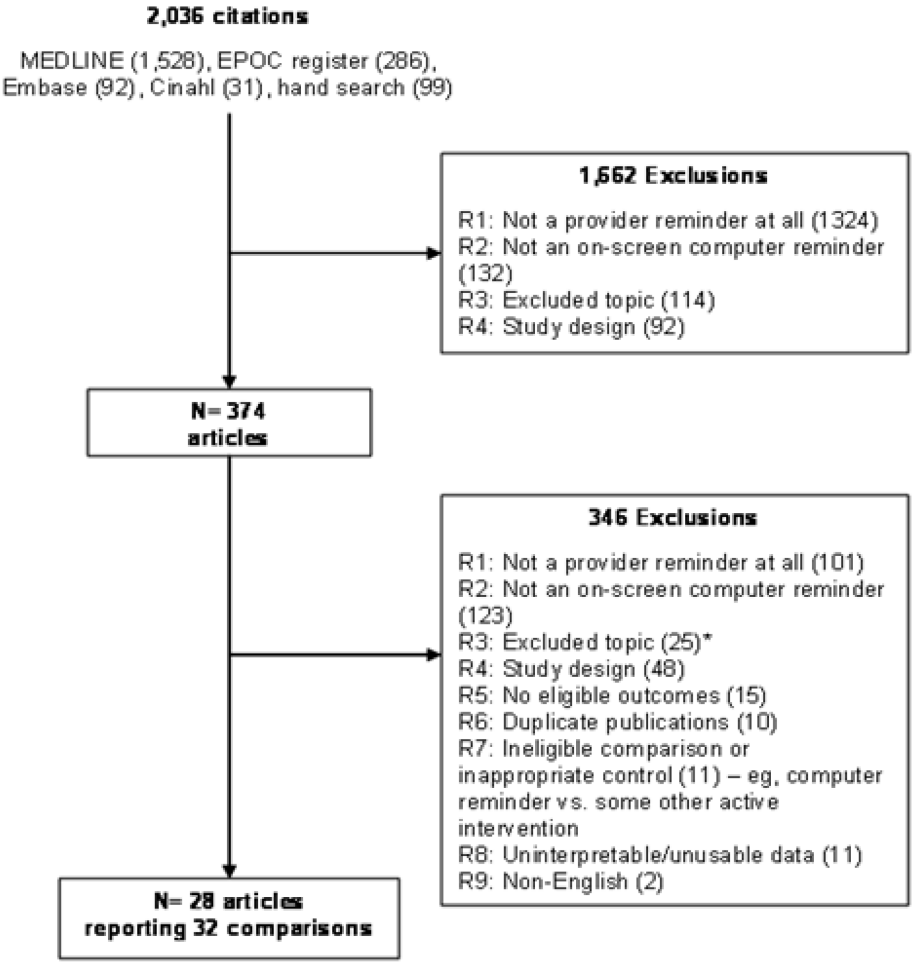
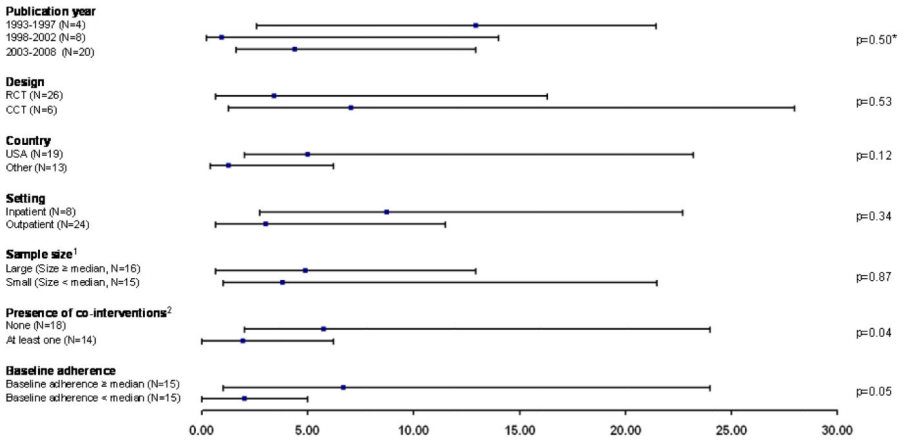


Figure 1.
Results of literature search and application of eligibility criteria



* Kruskall-Wallis test

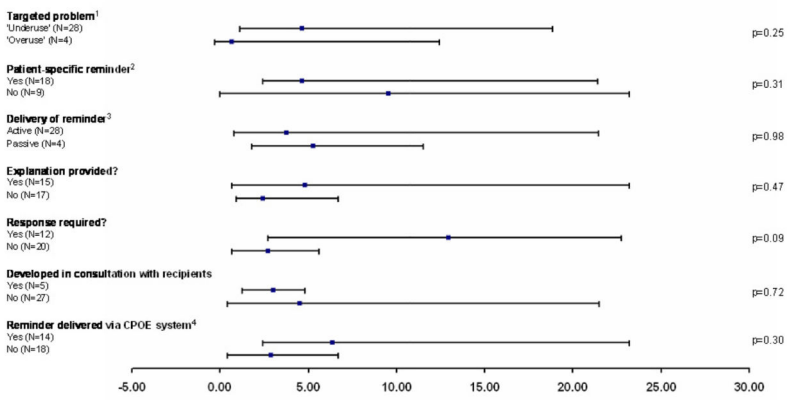
[1] Results for sample size used raw numbers of patients, without adjusting for cluster effects. Adjusting for clustering did not alter the results, nor did using the number of clusters instead of the number of patients. The total number of comparisons for the sample size analysis is 31, because 1 study did not report number of patients.

[2] Result compares the effect sizes of comparisons involving computer reminders alone versus usual care (i.e. no co-interventions) and reminders plus one or more other quality improvement interventions versus those other interventions alone.

Figure 2.

Median effects for process adherence by study feature

Europe PMC Funders Author Manuscripts



[1]Underuse' refers to targeting quality improvements that correspond to increasing the percentage of patients who receive a target process of care (e.g. increasing the percentage of patients receiving the influenza vaccine). 'Overuse' refers to targeting improvements that correspond to reductions in the percentage of patients receiving inappropriate care (e.g. reducing the percentage of patients who receive antibiotics for viral upper respiratory tract infections).

[2] Reminders with no patient specific information were those triggered on the basis of demographic triggers (e.g. age) or the intent to order a medication or investigation irrespective of any features of the patient involved (e.g. a reminder triggered by any order for heparin or any request for a certain radiologic investigation), as opposed to patient-specific laboratory results (e.g. a reminder related to the patient's serum creatinine) or combinations of medications or laboratory values exhibited by the patient. The sample size is reduced due to inability to accurately assess the presence or absence of the feature

[3] Active reminders were those that appeared automatically when triggering conditions were met, as opposed to passive reminders, where, for instance, users might be presented with the option to click on a link to receive decision support related to their current task. In some informatics context, this distinction is referred to as "push" vs. "pull".

[4] CPOE – computerized order entry system, reminders systems without CPOE were typically electronic medical record systems.

Figure 3.
Median effects for process adherence by reminder feature

Europe PMC Funders Author Manuscripts

Table 1

Median improvements in process adherence across included studies

Dichotomous outcomes (number of intervention vs. control comparisons)	Median absolute improvement (Interquartile range)	
	Using median outcome from each study	Using best outcome from each study
All process outcomes (N = 32)	4.2% (0.8% to 18.8%)	5.6% (2.0% to 19.2%)
Prescription of medications (N = 21)	3.30% (0.5% to 10.6%)	6.2% (3.0% to 28.0%)
Prescription of recommended vaccines (N = 6)	3.8% (0.5% to 6.6%)	4.8% (0.5% to 7.8%)
Test ordering (N = 13)	3.8% (0.4% to 16.30%)	9.6% (0.6% to 24.0%)
Elements of recommended documentation (N = 3)	0.0% (−1.0% to 1.3%)	2.0% (2.0% to 4.0%)
Other process outcomes (N = 7)	1.0% (0.8% to 8.5%)	4.0% (0.8% to 8.5%)

The Table shows average improvements (expressed as the median and interquartile range) across included comparisons for different types of process outcomes. All process outcomes were defined so that higher values always represent an improvement. For example, data from a study aimed at reducing the percentage of patients receiving inappropriate medications would be captured as the complementary percentage of patients receiving appropriate medications, so that an increase in process adherence would represent an improvement.

Most studies reported multiple endpoints but did not specify a primary outcome. For the main analyses, we used the median improvement from each study (that is the median change in adherence to a target guideline or process of care across all such changes reported for the study) as the single representative outcome for that study. We then calculated the median improvements across all included studies for different types of process measures, as shown in the middle column of the table. The column to the far right presents the same results when we used the best improvement from each study as its representative outcome.