Effect of point-of-care computer reminders on physician behaviour: a systematic review

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Abstract

Background: The opportunity to improve care using computer reminders is one of the main incentives for implementing sophisticated clinical information systems. We conducted a systematic review to quantify the expected magnitude of improvements in processes of care from computer reminders delivered to clinicians during their routine activities.

Methods: We searched the MEDLINE, Embase and CINAHL databases (to July 2008) and scanned the bibliographies of retrieved articles. We included studies in our review if they used a randomized or quasi-randomized design to evaluate improvements in processes or outcomes of care from computer reminders delivered to physicians during routine electronic ordering or charting activities.

Results: Among the 28 trials (reporting 32 comparisons) included in our study, we found that computer reminders improved adherence to processes of care by a median of 4.2% (interquartile range [IQR] 0.8%–18.8%). Using the best outcome from each study, we found that the median improvement was 5.6% (IQR 2.0%–19.2%). A minority of studies reported larger effects; however, no study characteristic or reminder feature significantly predicted the magnitude of effect except in one institution, where a well-developed, “homedgrown” clinical information system achieved larger improvements than in all other studies (median 16.8% [IQR 8.7%–26.0%] v. 3.0% [IQR 0.5%–11.5%]; p = 0.04). A trend toward larger improvements was seen for reminders that required users to enter a response (median 12.9% [IQR 2.7%–22.8%] v. 2.7% [IQR 0.6%–5.6%]; p = 0.09).

Interpretation: Computer reminders produced much smaller improvements than those generally expected from the implementation of computerized order entry and electronic medical record systems. Further research is required to identify features of reminder systems consistently associated with clinically worthwhile improvements.

Computerized systems for entering orders and electronic medical records represent two of the most widely recommended improvements in health care.1 These systems offer the opportunity to improve practice by delivering reminders to clinicians at the point of care. Such reminders range from simple prescribing alerts to more sophisticated support for decision-making.

Previous reviews have classified all computer reminders together, including computer-generated paper reminders and email alerts sent to providers, along with reminders generated at the point of care.2-4 They have also typically reported the proportion of studies with results that were on balance “positive.”2-4 We conducted a systematic review to quantify the expected magnitude of improvements in processes of care from computer reminders delivered to physicians during their routine electronic ordering or charting activities.

Methods

Data sources

We searched the MEDLINE database (1950 to July 2008) using relevant Medical Subject Headings and combinations of text words such as “computer” or “electronic” with terms such as “reminder,” “prompt,” “alert” and “support.” A methodologic filter identified all potential clinical trials. We similarly searched the Embase and CINAHL databases (both to July 2008). We also retrieved all articles that mentioned computers, reminder systems or decision support from the Cochrane Effective Practice and Organisation of Care registry (www.epoc.cochrane.org/welcome), which covers multiple bibliographic databases. Finally, we scanned reference lists of all included studies and review articles. For non-English-language articles, we screened English translations of titles and abstracts, pursuing a full-text translation as needed to determine inclusion or exclusion of the study.

Study selection

Eligible studies evaluated the effects of computer reminders on processes or outcomes of care using a randomized or quasi-randomized controlled design (allocation on the basis of an arbitrary but not truly random process, such as even or odd

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Outcomes

We focused primarily on improvements in processes of care rather than on clinical outcomes, because we wished to determine the degree to which computer reminders achieved their main goal, namely changing provider behaviour. The degree to which such changes ultimately improve patient outcomes will vary depending on the strength of the relation between targeted processes and clinical outcomes. Consequently, if computer reminders do not improve patient outcomes, this may reflect inadequate connections between the targeted processes and outcomes of care rather than a failure to change physician behaviour. Nonetheless, we did capture clinical outcomes, including intermediate outcomes such as control of blood pressure. We excluded outcomes primarily related to resource use, such as length of hospital stay.

We standardized all outcomes so that increases always corresponded to improvements in care. For instance, if a study reported the proportion of patients who received inappropriate medications, we would record the complementary proportion of patients who received appropriate care.

Data extraction

For any given article, two of three investigators (K.S., A.J. or A.M.) independently screened the citation for inclusion. They abstracted the following data from included articles: clinical setting, number of participants, methodologic details, characteristics of the computer reminder, the presence of cointerventions, and the results for eligible outcomes. Discrepancies between the two reviewers were resolved by discussion, involving the third reviewer if necessary to achieve consensus.

Statistical analysis

We anticipated that many studies would assign intervention status at the provider level but would not account for “cluster effects” when analyzing patient-level data.\textsuperscript{5,7} Correcting for clustering effects can sometimes be achieved by estimating the intraclass correlation coefficients, especially if the primary studies all report the same outcome and a minority provide relevant data upon which to base imputations.\textsuperscript{8} In this case, however, few studies contained the necessary data, and studies tended to report multiple outcomes, which required an additional assumption that correlations within clusters do not vary across different outcomes.

To preserve the goal of quantifying the effects of computer reminders without resorting to numerous assumptions and conveying a misleading degree of precision, we focused on the median and interquartile range (IQR) for improvements reported by eligible studies. This method, first used in a large review of strategies for implementing guidelines,\textsuperscript{9} has since been applied in Cochrane reviews of interventions to improve practice\textsuperscript{10−14} and other systematic reviews of quality improvement interventions.\textsuperscript{15−18}

Quantifying the median improvement involves two distinct uses of “median.” First, to handle multiple outcomes within individual studies, we identified the median improvement across each study’s eligible outcomes. If a study reported 10 adherence-related outcomes, we calculated the median absolute difference in adherence between the intervention and control groups. With each study represented by its median outcome, we then calculated the median effect and IQR across all included studies. For the purposes of sensitivity analyses, we repeated this calculation using the best outcome from each study.

The median and IQR convey the magnitudes of improvement achieved in the majority of studies. This method avoids skewing by a few outlying studies with highly positive results and 95% confidence intervals inappropriately narrowed by ignoring important clustering effects. It also permits nonparametric analyses of potential associations between study features and effect size in order to examine subgroups of studies.
with larger or smaller magnitudes of effect. For instance, we looked for associations between magnitude of effect and study size, markers of methodologic quality, features of the study context (e.g., ambulatory v. inpatient) and characteristics of the reminders (e.g., requiring users to enter a response before continuing with their work). We performed all such comparisons using a nonparametric Mann–Whitney rank-sum test.

**Results**

Of 2036 citations identified, we excluded 1662 at the initial stage of screening and an additional 374 after review of the full-text articles. A total of 28 articles (reporting 32 comparisons) met all of our inclusion criteria (Figure 1). The full review has recently been published in The Cochrane Library. Of the 32 comparisons, 19 were in the United States and 8 occurred in inpatient settings (Table 1, located at the end of the article). Only six comparisons involved a quasi-randomized design, typically allocating intervention status on the basis of even or odd provider identification numbers. Twenty-six comparisons allocated intervention status to providers or provider groups (cluster trials); 12 of these comparisons accounted for clustering effects in the analysis. Seventeen trials reported a power calculation that included a target effect size. Twelve trials reported a target improvement in adherence to processes of care; 10 of these trials specified an absolute increase of at least 10% (Table 1).

Figure 2 displays the median improvements in adherence to

| Study                          | Median (IQR), % |
|-------------------------------|-----------------|
| Bates et al., 1999           | 24.0            |
| Christakis et al., 2001      | 23.2 (12.5 to 34.0) |
| Dexter et al., 2001         | 4.7 (3.3 to 6.3) |
| Eccles et al., 2002         | 0.0 (-3.0 to 1.0) |
| Eccles et al., 2002         | -1 (-2 to 0)    |
| Filippi et al., 2003        | 6.2             |
| Flottorp et al., 2002       | 0.9 (0.4 to 5.1) |
| Flottorp et al., 2002       | 0.4 (-1.2 to 3.0) |
| Frank et al., 2004          | 0.6 (-0.1 to 1.3) |
| Hicks et al., 2008          | 2.0             |
| Judge et al., 2006          | 3.0             |
| Kenealy et al., 2005        | -0.2            |
| Kenealy et al., 2005        | 16.3            |
| Kralj et al., 2003          | 30.1            |
| Krall et al., 2004          | 28.5            |
| Kucher et al., 2005         | 9.6 (8.5 to 10.6) |
| McCowan et al., 2001        | 1.0 (-2.0 to 4.0) |
| Meigs et al., 2003          | 3.8 (2.6 to 3.8) |
| Overhage et al., 1996       | 0.6 (-0.3 to 5.8) |
| Overhage et al., 1997       | 21.4 (18.8 to 24.4) |
| Peterson et al., 2007       | -1.0            |
| Rothschild et al., 2007     | 7.9             |
| Roumie et al., 2006         | -0.3 (-3.9 to 0.3) |
| Safran et al., 1995         | 21.5 (21.0 to 22.0) |
| Sequist et al., 2005        | 5.0             |
| Tamblyn et al., 2003        | 2.4 (0.9 to 3.9) |
| Tape et al., 1993           | 2.8 (1.6 to 4.8) |
| Tierney et al., 2003        | -0.5 (-4.0 to 6.0) |
| Tierney et al., 2005        | 0.0 (-2.0 to 0.0) |
| Van Wyk et al., 2008        | 34.7 (29.8 to 39.5) |
| Van Wyk et al., 2008        | 6.7 (3.8 to 9.6)  |
| Zanetti et al., 2003        | 28.0            |

**Figure 2:** Median absolute improvements in adherence to processes of care between intervention and control groups in each study. Each study is represented by the median and interquartile range for its reported outcomes; studies with single data points reported only one eligible outcome.
We found no significant correlation between effect size and absolute improvement of 2.5% (IQ R 1.3%–4.2%). For blood outcomes, patients in the intervention groups experienced a median reduction in systolic blood pressure of 1.0 mm Hg (IQ R 0.8 mm Hg reduction to 1.0 mm Hg increase) and a median improvement in adherence associated with computer reminders was 4.2% (IQ R 0.8%–18.8%). Prescribing behaviours improved by a median of 3.3% (IQ R 0.5%–10.6% [21 trials]), adherence to target vaccinations by 3.8% (IQ R 0.5%–6.6% [6 trials]) and test-ordering behaviours by 3.8% (IQ R 0.4%–16.3% [13 trials]). Table 2 also shows the results obtained when we used the best outcome from each study instead of the median improvement.

Across eight comparisons that reported dichotomous clinical outcomes (e.g., achievement of target treatment goals), patients in the intervention groups experienced a median absolute improvement of 2.5% (IQ R 1.3%–4.2%). For blood pressure control, the single most commonly reported outcome, patients in the intervention groups experienced a median reduction in systolic blood pressure of 1.0 mm Hg (IQ R 2.5 mm Hg reduction to 2.0 mm Hg increase) and a median reduction in diastolic blood pressure of 0.2 mm Hg (IQ R 0.8 mm Hg reduction to 1.0 mm Hg increase).

**Study features and effect size**

We found no significant correlation between effect size and the following study features: publication year, country (United States v. other), study design (randomized v. quasi-randomized) or sample size (whether calculated on the basis of patients or providers) (Figure 3). We considered that studies with high adherence rates in control groups (a marker for baseline adherence) might achieve smaller improvements in care, because they had smaller opportunities for improvement. Surprisingly, studies with control-group adherence rates that were higher than the median across all studies showed larger effect sizes (Figure 3). When we analyzed the potential impact of baseline adherence in various other ways (e.g., focusing on the highest and lowest quartiles of baseline adherence), we found no evidence that small improvements reflected high baseline quality of care.

We observed a trend toward larger improvements with inpatient interventions than with outpatient interventions (median 8.7% [IQ R 2.7%–22.7%] v. 3.0% [IQ R 0.6%–11.5%]; p = 0.34). All inpatient interventions occurred at two institutions that had well-developed, “homegrown” computerized systems for order entry by providers. Moreover, the recipients of computer reminders from these institutions consisted primarily of physician trainees.

Our grouping of studies on the basis of track records in clinical informatics did not result in significant differences, except that the studies from Brigham and Women’s Hospital in Boston, USA, reported a median improvement of 16.8% (IQ R 8.7%–26.0%), compared with 3.0% (IQ R 0.5%–11.5%) for studies from the other institutions (p = 0.04).

**Features of computer reminders and effect size**

We analyzed a number of reminder characteristics to look for associations with effect size (Figure 4). Only the requirement for providers to enter a response to the reminder showed a trend toward larger improvements (median 12.9% [IQ R 2.7%–22.7%] v. 2.7% [IQ R 0.6%–5.6%] for no response required; p = 0.09). No trends toward larger effect sizes existed based on the type of targeted problem (underuse v. overuse of a targeted process of care), inclusion of patient-specific information, provision of an explanation for the alert, inclusion of a specific recommendation with the alert, development of the reminder by the study authors, or the type of system used to deliver the reminder (CPOE [computerized provider order entry] v. electronic medical records).

Reminders that were “pushed” onto users (i.e., users automatically received the reminder) did not achieve larger effects than reminders that required users to perform some action to receive them (i.e., users had to “pull” the reminders); only 4 of the 32 comparisons involved “pull” reminders. A three-armed cluster randomized controlled trial of reminders for screening and treatment of hyperlipidemiat directly compared these two modes of delivering reminders. Patients cared for at practices randomly assigned to deliver automatic alerts were more likely to undergo testing for hyperlipidemia and receive treatment than were patients at clinics where reminders were delivered to clinicians only “on demand.”

**Sensitivity analyses**

We re-analyzed the potential predictors of effect size (study features and characteristics of reminders) using a variety of choices for the representative outcome from each study, including the outcome with the middle value (rather than a calculated median) and the best outcome (the outcome associated with the largest improvement in adherence to the process). None of these analyses substantially altered the main findings.

**Interpretation**

Across the 32 comparisons, computer reminders achieved small to modest improvements in care, with a median improvement of 4.2% (IQ R 0.8%–18.8%). Even using the best out-

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**Table 2: Improvements in adherence to processes of care across the 28 studies (32 comparisons) included in the review**

| Process of care (no. of comparisons) | Median absolute improvement, % (IQ R) |
|--------------------------------------|--------------------------------------|
|                                      | Using median outcome from each study | Using best outcome from each study |
| All (32)                             | 4.2 (0.8 to 18.8)                    | 5.6 (2.0 to 19.2)                  |
| Prescription of medications (21)     | 3.3 (0.5 to 10.6)                    | 6.2 (3.0 to 28.0)                  |
| Prescription of recommended vaccines (6) | 3.8 (0.5 to 6.6)                    | 4.8 (0.5 to 7.8)                  |
| Ordering of tests (13)               | 3.8 (0.4 to 16.3)                    | 9.6 (0.6 to 24.0)                  |
| Recommended elements of clinical documentation (3) | 0.0 (–1.0 to 1.3)  | 2.0 (2.0 to 4.0)                  |
| Other (7)                            | 1.0 (0.8 to 8.5)                     | 4.0 (0.8 to 8.5)                  |

Note: IQ R = interquartile range.
come from each trial, the median improvement was only 5.6% (IQR 2.0%–19.2%). These changes fall below the thresholds for clinically significant improvements specified in most trials, and they are certainly smaller than the improvements generally expected from computerized order entry and electronic medical record systems. Interestingly, these improvements are also no larger than those observed for paper-based reminders.\(^5,48\)

With the upper quartile of reported improvements beginning at an almost 20% increase in adherence to processes of care, some studies in our review clearly did show larger effects. However, we were unable to identify any study characteristic or reminder feature that predicted larger effect sizes, except for a statistically significant increase in magnitude of effect seen in studies involving a well-developed, homegrown computer order entry system at Brigham and Women’s Hospital.\(^26,31,37,40,46\) A trend toward larger effects was also seen for reminders that required users to enter a response in order to proceed; however, 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 this institution reflects the design of reminders requiring user responses, other features of the computer system or perhaps institutional culture.

Included studies often provided limited descriptions of key features of the reminders and the systems through which they were delivered. We attempted to overcome this problem by abstracting basic features, such as whether user responses were required and whether the reminder displayed a justification for its content. But heterogeneity within even these apparently straightforward categories could mask important differences in effect. Important differences in effect may also reflect characteristics that we found difficult to operationalize (e.g., the “complexity” of the reminder) or that were inadequately reported. This problem of limited descriptive detail of complex interventions and the resulting potential for heterogeneity among included interventions in systematic reviews has been consistently encountered in the quality-improvement literature.\(^49,50\)

Conventional meta-analyses estimate mean effects and 95% confidence intervals by calculating weighted averages across study results. The individual weights derive from study precision such that larger studies contribute greater weight to the meta-analytic result. However, more than half of the studies included in our review reported spuriously high precision,
and most of the studies did not report the data required to adjust for this problem. For example, of the 26 clustered trials, only 9 provided a single value for the intra-cluster correlation coefficient, and only 3 reported values for all outcomes. Because we could not accurately weight studies based on precision, we focused on the median and interquartile range for study effects, a method that has found increasing application in systematic reviews of interventions for quality improvement.9,13−15,17,18,51

The main potential drawback of this method is that we assigned equal weight to all of the studies. However, for our results to have substantially misrepresented the true impacts of computer reminders, the minority of studies with large magnitudes of effect would also have to be the larger studies (and thus deserving of greater weight in a meta-analysis). Not only is this unlikely in general, we specifically showed that study size bore no relation to effect size, using various definitions of study and effect size.

**Conclusion**

Computer reminders typically increased adherence to target processes of care by amounts below thresholds for clinically significant improvements. A minority of studies showed more substantial improvements, consistent with the expectations of those who advocate widespread adoption of computerized order entry and electronic medical record systems. However, until further research identifies study design and reminder features that reliably predict clinically worthwhile improvements in care, implementing these expensive technologies will constitute an expensive exercise in trial and error.

This article has been peer reviewed.

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**Contributors:** Kaveh Shojania and Jeremy Grimshaw conceived the study. All of the authors contributed to refinements of the study design and to the analysis and interpretation of the data. Kaveh Shojania drafted the initial

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**Table 1:**

| Reminder feature (no. of comparisons) | Median (IQR), % |
|--------------------------------------|----------------|
| **Targeted problem***                |                |
| Underuse (n = 28)                    | 4.6 (1.1 to 18.8) |
| Overuse (n = 4)                      | 0.6 (–0.3 to 12.4) |
| **Type of reminder†**                |                |
| Specific (n = 18)                    | 4.6 (2.4 to 21.4) |
| Generic (n = 9)                      | 9.6 (0.0 to 23.2) |
| **Mode of delivery‡**                |                |
| Active (n = 28)                      | 3.8 (0.8 to 21.4) |
| Passive (n = 4)                      | 5.2 (1.8 to 11.5) |
| **Explanation provided**             |                |
| Yes (n = 15)                         | 4.8 (0.6 to 23.2) |
| No (n = 17)                          | 2.4 (0.9 to 6.7) |
| **Response required**                |                |
| Yes (n = 12)                         | 12.9 (2.7 to 22.8) |
| No (n = 20)                          | 2.7 (0.6 to 5.6) |
| **Developed in consultation with recipients** |          |
| Yes (n = 5)                          | 3.0 (1.2 to 4.8) |
| No (n = 27)                          | 4.5 (0.4 to 21.5) |
| **Delivered via CPOE system§**       |                |
| Yes (n = 14)                         | 6.4 (2.4 to 23.2) |
| No (n = 18)                          | 2.9 (0.4 to 6.7) |

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**Figure 4:** Median effects for adherence to processes of care by reminder feature. *Underuse = targeting improvements to increase the percentage of patients who receive targeted process of care (e.g., increasing the percentage of patients receiving the influenza vaccine); overuse = targeting improvements to reduce the percentage of patients receiving inappropriate care (e.g., reducing the percentage of patients who receive antibiotics for viral upper respiratory tract infections). †Reminders with no patient-specific information were those triggered on the basis of demographic characteristics (e.g., age) or the intent to order a medication or investigation irrespective of any features of the patient involved or patient-specific laboratory results. The sample size is reduced because of the inability to accurately assess the presence or absence of the feature. ‡Active delivery refers to reminders 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. §CPOE = computerized order entry system; reminder systems without CPOE were typically electronic medical record systems.
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Table 1: Description of 28 studies (32 comparisons) included in a systematic review of the effects of point-of-care computer reminders on physician behaviour (part 1 of 3)

| Study          | Study design (sample size) | Setting                                         | Intervention                                                                 | Additional interventions in intervention and control groups | Study groups balanced at baseline | Follow-up complete for ≥ 80% of providers and patients | Effect size used in power calculation |
|----------------|----------------------------|------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------|----------------------------------------------------------|--------------------------------------|
| Bates et al., 1999 | RCT (7090 patients)        | Inpatient medical and surgical services at teaching hospital in United States | CPOE-based alert to clinicians regarding potentially redundant orders for laboratory tests | None                                                        | Yes                                       | Yes                                                      | Yes                                  | NR                                   |
| Christakis et al., 2001 | Cluster RCT (1339 episodes of care, 38 providers) | Outpatient pediatric teaching clinic in United States | CPOE-based display of evidence for use and duration of antibiotics for otitis media | None                                                        | No                                             | No for providers; not clear for patients               | NR                                   |
| Dexter et al., 2001 | Cluster RCT (6371 patients, 8 provider teams) | General medicine inpatient service at teaching hospital in United States | CPOE-based note to providers of inpatients' eligibility for 4 preventive care measures | None                                                        | NR*                                           | Not clear                                               | NR                                   |
| Eccles et al., 2002 | Cluster RCT (2335 patients, 60 practices) | Ambulatory general practices in United Kingdom | Decision support for management of outpatients with angina                   | Distribution of educational materials to providers           | Yes                                           | NR                                                      | 10% absolute improvement in adherence to guideline for care |
| Eccles et al., 2002 | Cluster RCT (2363 patients, 60 practices) | Ambulatory general practices, United Kingdom | Decision support for management of outpatients with asthma                   | Distribution of educational materials to providers           | Yes                                           | NR                                                      | 10% absolute improvement in adherence to guideline for care |
| Filipp et al., 2003 | Cluster RCT (15 343 patients, 300 providers) | Ambulatory general practices in Italy          | Alert to clinicians to diabetic patients who would benefit from antiplatelet agents to reduce risk of cardiovascular disease | Distribution of educational materials to providers           | Yes                                           | Yes                                                     | 10% absolute improvement in prescription rates |
| Flottorp et al., 2002 | Cluster RCT (9887 episodes of care, 57 practices) | Ambulatory general practices in Norway          | Display of guidelines for appropriate use of antibiotics and laboratory tests in women with suspected urinary tract infection | Educational materials for providers and patients, educational workshops for providers, financial incentives for providers | Yes                                           | No for providers; NR for patients                    | 15% absolute improvement in recommended processes of care |
| Flottorp et al., 2002 | Cluster RCT (16 939 episodes of care, 56 practices) | Ambulatory general practices in Norway          | Display of guidelines for appropriate use of antibiotics and laboratory tests for patients with sore throat | Educational materials for providers and patients, educational workshops for providers, financial incentives for providers | Yes                                           | No for providers; NR for patients                    | 15% absolute improvement in recommended processes of care |
| Frank et al., 2004 | quasi-RCT (10507 patients) | Urban ambulatory practice (academic status not reported) in Australia | Note to providers of outpatients' eligibility for various preventive care measures | None                                                        | Yes                                           | NR                                                      | NR                                   |
| Hicks et al., 2008 | Cluster RCT (1834 patients, 12 clinics) | Community- and hospital-based primary care clinics affiliated with teaching hospital in United States | Display of guideline-based suggestions for management of patients with hypertension | None                                                        | No†                                           | No                                                     | 10% absolute improvement in blood pressure control and rates of adherence to guideline |
| Judge et al., 2006 | Cluster RCT (3843 episodes of care, 7 wards) | Long-term care facility affiliated with teaching hospital in Canada | Alert to providers to various potential adverse drug events (e.g., severe drug interactions, out-of-recommended range doses for elderly patients) | None                                                        | NR                                           | NR                                                      | NR                                   |
### Table 1: Description of 28 studies (32 comparisons) included in a systematic review of the effects of point-of-care computer reminders on physician behaviour (part 2 of 3)

| Study | Study design (sample size) | Setting | Intervention | Additional interventions in intervention and control groups | Study groups balanced at baseline | Follow-up complete for ≥ 80% of providers and patients | Effect size used in power calculation |
|-------|---------------------------|---------|--------------|-----------------------------------------------------------|----------------------------------|-----------------------------------------------|-------------------------------------|
| Kenealy et al., 2005 | Cluster RCT (2814 patients, 33 practices) | Outpatient general practices in New Zealand | Note to providers suggesting that they screen patients over 50 years of age for diabetes | Distribution of educational materials to providers, educational outreach | Yes | Yes | 15% absolute improvement in screening eligible patients for diabetes |
| Kenealy et al., 2005 | Cluster RCT (2814 patients, 33 practices) | Outpatient general practices in New Zealand | Note to providers suggesting that they screen patients over 50 years of age for diabetes | None | Yes | Yes | 15% absolute improvement in screening eligible patients for diabetes |
| Kralj et al., 2003 | Cluster quasi-RCT (2170 episodes of care, 2 practices) | Two community-based outpatient oncology practices in United States | Prompt for providers to order erythrocyte in patients with hemoglobin level < 120 g/dL | None | No† | NR | NR |
| Krall et al., 2004 | Cluster RCT (1076 patients, 100 providers) | Ambulatory family and internal medicine practices in United States | Note to providers of patients’ eligibility to receive ASA to reduce risk of cardiovascular disease | None | No | Yes for providers; not clear for patients | NR |
| Kucher et al., 2005 | Quasi-RCT (2506 patients) | Major teaching hospital in United States | Alert to clinicians to inpatients at increased risk of venous thromboembolism | None | Yes | Yes | 50% reduction in odds of developing venous thromboembolism |
| McCowan et al., 2001 | Cluster RCT (477 patients, 46 practices) | Outpatient general practices in United Kingdom | Decision support for management of outpatients with asthma | None | Yes | No | 7% absolute reduction in asthma exacerbation rates |
| Meigs et al., 2003 | Cluster RCT (598 patients, 2 provider teams) | Internal medicine ambulatory clinic at teaching hospital in United States | Display of recommended target goals of care, last known values of relevant lab tests (e.g., Hba1c, creatinine, lipids) | None | Yes | No | 0.5%–1.0% reduction in serum hemoglobin A1c |
| Overhage et al., 1996 | Cluster RCT (1622 patients, 24 providers) | Inpatient internal medicine service at academic medical center in United States | Note to providers suggesting orders for various preventive care measures for eligible patients | None | Yes | Yes | NR |
| Overhage et al., 1997 | Cluster RCT (2181 patients, 6 services) | Medicine service at teaching hospital in United States | Prompt for providers about “corollary orders” | Drug utilization review program | Yes | NR | NR |
| Peterson et al., 1997 | quasi-RCT (2981 patients) | Academic medical centre in United States | Decision support for drug therapy in elderly inpatients (to avoid certain drugs and modify dosing of others) | None | Yes | NR | NR |
| Rothschild et al., 2007 | Cluster RCT (350 episodes of care, 453 providers) | Academic medical centre in United States | Display of guidelines regarding indications for transfusion of red blood cells, platelets and frozen plasma | Provider education (printed materials, workshops) | Yes | Yes | NR |
| Roumie et al., 2006 | Cluster RCT (871 patients, 116 providers) | 8 ambulatory clinics and 2 hospitals in United States | Alert in electronic medical record displaying recent blood pressure value and outlining national recommendations for hypertension treatment and blood pressure goals | Provider education (printed materials delivered via email) | Yes | Yes for providers; no for patients | 1.8 increase in odds of achieving target blood pressure |
### Table 1: Description of 28 studies (32 comparisons) included in a systematic review of the effects of point-of-care computer reminders on physician behaviour (part 3 of 3)

| Study | Study design (sample size) | Setting | Intervention | Additional interventions in intervention and control groups | Study groups balanced at baseline | Follow-up complete for ≥ 80% of providers and patients | Effect size used in power calculation |
|-------|-----------------------------|---------|--------------|------------------------------------------------------------|----------------------------------|------------------------------------------------------|--------------------------------------|
| Safran et al., "1993 | Cluster RCT (349 patients, 2 teams) | Academic primary care clinic in United States | Alert to providers about eligibility of HIV-positive patients for various recommended processes of care | None | Yes | No | NR |
| Sequist et al., "2005 | Cluster RCT (6243 patients, 20 clinics) | Outpatient primary clinics (academic and community) in United States | Display of guidelines for recommended management of patients with diabetes and coronary artery disease | Paper reminders to providers | No | NR | 10% absolute increase in adherence |
| Tamblyn et al., "2003 | Cluster RCT (12 560 encounters, 107 providers) | Primary care practices in Canada | Alert to providers to various potential adverse drug events (e.g., based on drug-drug interactions, and drug-disease or drug-age contraindications) | None | Yes | Yes | 30% relative reduction in inappropriate prescriptions (~6% absolute reduction) |
| Tape et al., "1993 | Cluster quasi-RCT (1809 patients, 2 clinics) | Internal medicine teaching clinic in United States | Alert to clinicians to deficiencies in preventive care measures for a given patient | Provider education (conferences); paper reminders to providers | NR | NR | 50% relative increase in adherence (~10% absolute increase using control adherence rates) |
| Tierney et al., "2003 | Cluster RCT (378 encounters, 32 practice sessions) | Academic primary care group practice in United States | Display of guideline-based suggestions for management of heart failure and coronary artery disease | Provider education (printed materials, workshops, outreach visits), use of local opinion leaders | Yes | Yes | 1-unit change in standard error of measurement for each subscale of Chronic Heart Failure Questionnaire |
| Tierney et al., "2005 | RCT (363 episodes of care) | General medicine practice at teaching hospital in United States | Display of guideline-based suggestions for management of asthma and chronic obstructive pulmonary disease | Provider education (printed materials and workshops) | Yes | Yes | 1-unit change in standard error of measurement for health-related quality of life using SF-36 |
| Van Wyk et al., "2008 | Cluster RCT (3955 patients, 24 clinics) | General practice clinics in the Netherlands | Automatic display of patient-specific guidelines for screening and treatment of dyslipidemia | None | No | Yes | NR |
| Van Wyk et al., "2008 | Cluster RCT (3876 patients, 23 clinics) | General practice clinics in the Netherlands | Display on demand of patient-specific guidelines for screening and treatment of dyslipidemia | None | No | Yes | NR |
| Zanetti et al., "2003 | Quasi-RCT (449 operations) | Cardiac surgery service at academic medical centre in United States | Written reminder supplemented by auditory cue on computer screen in operating room alerting operating room staff that patient should receive second dose of antibiotic prophylaxis because of prolonged time in surgery | None | Yes | Yes | NR |

Note: ASA = acetylsalicylic acid, CPOE = computerized provider order entry, EMR = electronic medical record, NR = not reported, RCT = randomized controlled trial.

*Analysis adjusted for key demographic variables.
†Adjustments made in analyses for observed differences.