

The effect of electronic audit and feedback in primary care and factors facilitating effectiveness: a systematic review.

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Abstract

Rationale, aims and objectives: Little is known about the effect of electronic audit and feedback (A&F) in primary care and its features affecting intervention effectiveness. The aim of this systematic review is: 1) to assess electronic A&F's effectiveness in primary care and 2) to investigate facilitating factors of electronic A&F in primary care, as proposed in previous research. These factors are the use of benchmarks, frequency, cognitive load and evidence-based aspect of the feedback. Methods: The authors searched MEDLINE, Embase, CINAHL and CENTRAL from 2010 onwards by replicating the search strategy provided in the last Cochrane review on A&F. Two independent reviewers assessed the records for their eligibility, performed the data extraction and evaluated the risk of bias of the included studies using a tool provided by Cochrane. Results: Our search resulted in 8,744 records, including the 140 RCTs from the last Cochrane Review, of which 431 full-text articles were assessed for their eligibility. Twenty-nine articles were included, of which 22 studies (76%) showed an effect of the electronic A&F intervention. Of these, only 3 studies (10.5%), targeting the quality of diabetes care and the prescription of antibiotics by dentist & physicians, met all the investigated feedback features and were effective. There was a high heterogeneity in the results and the design of the A&F interventions, causing a meta-analysis to be unreliable. Conclusion: This systematic review included 29 articles describing an electronic A&F intervention in primary care, of which 22 studies (76%) showed an effect of the intervention. It was not feasible to compare the different electronic A&F interventions and their facilitating factors because they were designed and implemented very diversely. Developing a framework or methodology for automated A&F interventions in primary care could be useful for investigating future interventions although further research is necessary.

Introduction

Audit and feedback (A&F) is a well-known healthcare intervention, which can be defined as 'any summary of clinical performance of healthcare providers over a specific period in time'.¹ A&F has proven to be effective and the intervention generally leads to small but potentially important improvements in professional practice.² For A&F to be effective a number of features, such as the feedback frequency, are known to be important and certain modifiable design elements have been identified to help understand the differences in A&F interventions and to indicate gaps in reporting of interventions.^{2,3} Previous work has also defined theory-informed hypotheses as a foundation for the development of future A&F interventions and suggestions for improving the interventions' effectiveness have been published.⁴⁻⁶ These hypotheses can be classified based on different aspects of the intervention. For example, A&F interventions can be evaluated based on recipient related aspects of the intervention, the behavior that was targeted, delivery and content of the feedback.^{4,5} For feedback content, features such as the use of benchmarks for comparative purposes and of feedback with a low cognitive load could be important in an A&F intervention.⁴ Furthermore, the credibility of the feedback, for example feedback based on good quality evidence, has also been suggested to play an

important role because of its potential to increase recipient’s trust in the feedback.⁴ However, the importance of these hypotheses and feedback features in the design of an A&F intervention needs to be investigated.^{4,5}

In addition to the many studies being conducted to examine why and when A&F are of use, research is being published on creating tools to facilitate feedback, especially via an electronic medium.⁷⁻¹⁰ Electronic A&F can be defined as ‘the utilization of interactive computer interfaces to provide clinical performance summaries to healthcare professionals.’^{8,11,12} With the evolution in health information technology, electronic A&F based on data stored in the electronic health record (EHR) offers a promising evolution in A&F interventions.^{13,14} By automating an A&F intervention and providing the feedback in electronic form to the healthcare provider, the number of patients whose quality of care can be evaluated could increase drastically, which in turn could lead to a better quality of care.¹⁵ Large data repositories are already available in several countries and could be useful for this purpose.¹⁶⁻¹⁸ These databases collect routine primary healthcare data, anonymized at the source and use it to address many research questions of interest.¹⁹ EHR-extractable quality indicators are also available and can be used in an electronic A&F intervention to evaluate and improve the care for different diseases in primary care.^{20,21}

A previous systematic review on electronic A&F performed in a primary care and hospital context investigated the effectiveness and use of behavioral change mechanism underlying these electronic A&F interventions.¹² However, due to the high heterogeneity in the included studies, the effect of the interventions was highly variable and inconclusive.¹² Furthermore, there is evidence that new research is not benefiting the field and that new trials fail to explore factors responsible for A&F effectiveness²², and more in particular that of electronic A&F. For improving and understanding future electronic A&F interventions it is thus important that these factors are identified and that we understand why electronic A&F work so that an intervention can be designed that is best suited for its needs.²³ In addition, little is known about electronic A&F and its features that are useful for optimizing an electronic A&F intervention in primary care. The aim of this systematic review is therefore: 1) to assess whether electronic A&F is effective for improving health provider performance and healthcare outcomes in primary care and 2) to uncover facilitating factors that contribute to the effectiveness of electronic A&F in primary care, as proposed in previous research.

Methods

Background

The protocol of this systematic review is described in detail on PROSPERO: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018089069

Our inclusion & exclusion criteria and our search strategy were based on the Cochrane review on A&F.² Although this Cochrane review examined A&F in primary and non-primary care, we opted to use the same strategy and criteria and applied our extra inclusion & exclusion criteria (primary care and electronic A&F) after the search. Our methods report adheres to guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.²⁴ (see Appendix 1)

Inclusion and exclusion criteria

Randomized controlled trials in which the intervention was set up for primary healthcare providers responsible for patient care were included. The interventions studied in the included RCTs had to be electronic A&F, either alone or as a core element of a multifaceted intervention. Electronic A&F was defined as ‘any summary, which was delivered electronically, of clinical performance of healthcare over a specified period of time’. To distinguish between a core and not core element of an intervention, the same criteria used in the Cochrane review of 2012 on A&F were adopted. Non-core interventions were classified as those that could easily be offered in the absence of the A&F component.²

As in the Cochrane review, studies in which real-time feedback was provided during procedural skills were excluded as well as studies that examined feedback on performance with simulated patient interactions or

studies in which the term feedback would be best classified as ‘facilitated relay’ of patient-specific clinical information.² Randomized controlled trials that were not conducted in a primary care setting were also excluded. Studies without full-text availability (e.g. conference abstracts) were excluded. Studies were also excluded if they lacked clarity as to whether feedback was delivered electronically.

Searches

We replicated the search strategy provided in the Cochrane review on A&F.² Although our systematic review only addressed randomized controlled trials about electronic A&F in primary care, we opted to use exactly the same search terms as those used in the Cochrane review (see Appendix 2) but used an Elsevier-Embase search instead of an Ovid-Embase search (see Appendix 3).

Our search included MEDLINE (Ovid) (2010 –October Week 4 2018) (searched 25 November 2018), EM-BASE (Elsevier) (2010 - October Week 4 2018) (searched 25 November 2018); CINAHL (Ebsco) (2010 –October Week 4 2018) (searched 31 October 2018) and the Cochrane Central Register of Controlled Trials (CENTRAL) (2010 – February Week 2 2019) (searched 14 February 2019). These searches were conducted from 2010 until the beginning of November 2018, based on the earliest publication date of papers found during scoping searches. The CENTRAL database search had to be repeated at a later date due to technical issues. Our search started on 1 January 2010, in order to ensure some overlap with the results from the Cochrane review from 2012 and to avoid articles being missed. The search strings are available in Appendix 2.

In addition the 140 RCTs included in the Cochrane review were added to our search results.²

Data collection and analysis

Selection of studies

After removing duplicate references, all references were screened for title and abstract independently by two review authors (SVDB and DS). Randomized controlled trials were classified as inclusion, doubt or exclusion. Disagreements were resolved by discussion. The full text of all articles that were classified as doubt and inclusion were obtained. Two review authors (SVDB and DS) independently read all full manuscripts, and re-applied the inclusion criteria. If there was still no consensus or if doubt remained after reading the full text, a third review author (PV) was consulted to give his opinion. If doubt remained on the form of delivered feedback after consulting the third reviewer, the article was excluded.

Data extraction

Two independent reviewers (SVDB and DS) used a data extraction sheet to extract the data from the included studies. This data extraction sheet was tailored based on the Cochrane handbook and the EPOC data collection checklist.²⁵²⁶ A separate data extraction file was made for dichotomous and for continuous data.

Audit and feedback features which are known to be important or were suggested by other authors as potentially facilitating A&F interventions, were also incorporated on our data extraction sheet.²⁻⁵ These features were: feedback frequency, evidence-based aspect of the feedback (yes, no or unclear), the use of benchmarks as comparisons in the feedback (yes, no or unclear) and the cognitive load of the feedback (does the feedback have a low cognitive load: yes, no or unclear). Interventions with feedback consisting of many graphs and/or text were considered as having a high cognitive load, while interventions with few graphs and no unnecessary in-depth elements or text, were considered as having a low cognitive load.

Discrepancies were resolved by discussion. If no consensus was reached, another reviewer (PV) was consulted. In case of missing data the first author was contacted. For each article standard data were extracted, such as authors, year of publication & the year of data collection, study design, number of participants, type of participants, duration of the trial, type of intervention, how this intervention was organized (e.g. No. randomized participants, providers, delivery, . . .) and outcome (including dichotomous, continuous or other

outcome). (see Appendix 4 and 5 for the data extraction sheets for continuous and dichotomous outcomes, respectively)

Data analysis

If appropriate, a meta-analysis was carried out. If not, the results were described narratively. A meta-analysis was carried out if there were at least two studies with a similar intervention, in a similar population, which addressed similar outcomes and if sufficient data were available. If high heterogeneity was found, the meta-analysis was not reported since the results would be unreliable.

Risk of bias assessment

Included in the data extraction sheet was a list used by two independent reviewers (SVDB and DS) to assess the risk of bias. This list was tailored based on the Cochrane Collaboration tool for assessing the risk of bias in randomized trials.²⁷ Discrepancies in the findings were solved by consensus or by consulting a third reviewer (PV) if consensus was not possible. For our risk of bias summary, blinding of participants and personnel (performance bias) was not considered a key domain since the nature of an A&F intervention makes blinding difficult. The risk of performance bias was therefore not used to calculate the summarized risk of bias of the different studies. However, all of the other forms of bias were considered key domains and if one of them had a high or an unclear risk of bias, the summary was considered as having a high or an uncertain risk of bias, respectively.

Results

Searches

In this systematic review, a total of 12,054 records were identified through database screening. The 140 articles from the Cochrane review (on A&F in primary and non-primary care) were also included, which resulted in a list of 8,744 records that were screened after removing the duplicates. (see Figure 1)

Data collection and analysis

Selection of studies

In total, 8,313 records were excluded because they did not meet the inclusion criteria. Most of them were excluded because there was no (electronic) A&F intervention or because they were not conducted in a primary care setting. A total of 431 full-text articles were assessed for eligibility and 402 articles were excluded (see Figure 1). The total number of studies included through database searching was 23²⁸⁻⁵⁰ and an additional 6⁵¹⁻⁵⁶ articles published before 2010 were included from our screening of the Cochrane review published in 2012. One article was available as a conference abstract in the 2012 Cochrane review but the full-text article was included, which was identified through our database search and published in 2012.⁵⁰

Insert Figure 1: PRISMA flow-chart

Description of studies and electronic feedback features

The standard data we extracted showed 12 articles (41%) with continuous^{28,32-35,37-39,43,51,54,56} and 17 articles (59%) with dichotomous outcome measures^{29-31,36,40-42,44-50,52,53,55}. There was a high heterogeneity in the outcome measures of the trials and a wide range of clinical conditions were targeted by the interventions. Examples of outcome measures included the proportion of patients in compliance with guidelines for dental problems, the total number of antibiotic items dispensed, a composite measure of clinically significant depression, etc. (see Table 1 and 2) The targeted clinical conditions included for example diabetes, depression, preventive medicine, hypertension management, etc. (see Table 1 and 2). The trials usually had a cluster RCT design although 5 studies (17%) used an RCT design^{34,36,37,52,55}. The interventions mostly included general physicians but there were also 2 trials (7%) aimed at dentists^{35,54} and 1 trial (3.5%) at pharmacists³⁶. Patients were mostly the unit of analysis (19 studies, 65.5%), but some studies also used the providers (7

studies, 24%) or the distribution/prescriptions of medication (2 studies, 7%) as the unit of analysis. Finally, one study (3.5%) analyzed both data on patient and provider level (see Table 1 for continuous outcomes and Table 2 for dichotomous outcomes).

Insert: Table 1 + table 2

The data on the different features of electronic feedback showed 12 studies (41%) where feedback was provided less than monthly^{29,34,35,37,40,42,43,47,50,51,53,54}, 11 studies (38%) where the frequency of the feedback was unclear^{30,32,33,41,44-46,48,52,55,56}, 4 (14%) with feedback provided monthly^{28,38,39,49}, 1 (3.5%) with weekly feedback³¹ and 1 study (3.5%) where feedback was delivered only once³⁶. In 19 studies (65.5%) the feedback was evidence-based^{28,31-36,39-43,45,46,49,51,54-56}. The evidence-based quality of the feedback was unclear in 9 studies (31%)^{29,30,37,38,44,47,50,52,53} and 1 study (3.5%) had a low evidence base of the feedback⁴⁸. The use of benchmarks as a comparison in the feedback was present in 20 studies (69%)^{28,29,32,34-36,39-41,43-47,49,51-53,55,56}, unclear in 7 (24%)^{30,31,37,42,48,50,54}. Only 2 studies (7%) did not use benchmarks as a comparison in their feedback^{33,38}. The cognitive load of the feedback was low in 12 studies (41%)^{29,32,33,35,37,39,41,43,46,49,53,56}, high in 3 (10.5%)^{34,36,40} and unclear in 14 studies (48.5%)^{28,30,31,38,42,44,45,47,48,50-52,54,55}. Finally, the direction of change was to increase behavior in 18 (62%)^{28,30,33,36,38,39,41,42,45-48,51-56} and to decrease behavior in eleven studies (38%)^{29,31,32,34,35,37,40,43,44,49,50}. (see Table 3 for studies with continuous outcomes and Table 4 for studies with dichotomous outcomes)

Insert: Table 3 + table 4

Results data analysis

Twenty-two studies (76%) showed an effect of the intervention^{28-31,35-41,43-46,48,50-53,55,56}, of which 3 studies only had a partial effect (10.5%)^{36,41,51}, and 7 (24%) without any significant effect^{32-34,42,47,49,54}. There were 3 studies (10.5%)^{35,39,43} that met all the different characteristics of the feedback we examined (the feedback was evidence-based, provided more than once with the use of benchmarks as a comparison and with a low cognitive load) and that were effective while 1 study (3.5%) with the same feedback features showed no effect.⁴⁹

Of these 3 studies with an effect of the intervention, Elouafkaoui et al. investigated the effectiveness of an electronic A&F intervention on the prescription of antibiotics by dentists. This resulted in a 5.7% reduction (95% CI -1.1% to -10.2%) in the antibiotics prescription rate in the intervention group relative to the control group.³⁵ Furthermore, Hayashino et al. evaluated the effectiveness of a multifaceted intervention, consisting of monthly feedback reports using the Achievable Benchmark of Care method, on the technical quality of diabetes care by primary care physicians. This improved the quality of care with 19.0%-point (95% confidence interval 16.7%- to 21.3%-point; $P < 0.001$).³⁹ Finally, Gerber et al. studied the effect of a multifaceted intervention, consisting of education and quarterly A&F, on the prescription of antibiotics for acute respiratory infections by primary care pediatricians and showed that broad-spectrum antibiotics prescription decreased from 26.8% to 14.3% (absolute difference, 12.5%) among intervention practices vs from 28.4% to 22.6% (absolute difference, 5.8%) in controls.⁴³

However, because of the high heterogeneity of our results no meta-analysis was performed since the results would be inconclusive.

Risk of bias assessment

There was a high risk of performance bias in 17 of the included studies (59%), while the risk of selection and detection bias was minimal. The risk of both attrition and reporting bias was high in 6 different studies (21%). (see figure 2). To summarize, 4 studies (14%) had a low overall risk of bias^{28,30,34,40}, while 12 studies (41%) had a high risk^{29,32,37-39,41,45-47,51-53} and 13 studies (45%) had an unclear risk of bias.^{31,33,35,36,42-44,48-50,54-56} (see Figure 3)

Out of the 4 articles with a low risk of bias summary, 3 included feedback features which are known to be effective (feedback provided more than once) or were suggested as potentially important for improving A&F

interventions (evidence-based feedback with the use of benchmarks).

Insert Figure 2: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Insert Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

Discussion

Principal findings and comparison with previous work

This systematic review identified 29 articles describing an electronic A&F intervention in primary care. Overall, 22 studies (76%) showed an effect of the intervention on outcome measures such as the change in systolic blood pressure, medication prescriptions, the proportion of patients with a medication error and the change in the proportion of patients treated with oral anticoagulants. Three of these studies (10.5%) included all the features of the feedback that were investigated (the feedback was evidence-based, had a low cognitive load, used benchmarks as a comparison and was provided more than once).^{35,39,43} The interventions in these 3 studies targeted behaviors such as prescribing antibiotics for infections by dentists, improving the technical quality of diabetes care by primary care physicians and prescribing antibiotics for respiratory tract infections by primary care pediatricians. However, there was a high heterogeneity in the primary outcomes of these studies and the electronic A&F interventions were designed very diversely with various feedback features, making a meta-analysis unreliable. Because of this, we were also unable to make generalizable claims about the importance of the feedback features we examined. Furthermore, only 4 studies (14%) had a low risk of bias summary, not counting performance bias. In addition, these 4 articles had been published more recently from 2016 onwards, possibly indicating some new evidence toward a maturing methodology in the A&F research field.^{28,30,34,40}

In general these findings confirm the overall stagnation in A&F research, as described by other authors²² and show there is insufficient research on implementation so as to further the field and build further on existing knowledge.²³ Previous work showed that feedback is best provided more than once and our findings indicate this is only the case in 12 of the included studies (41%). However, 3 out of 4 articles with a low risk of bias summary that were from a more recent publication date, included feedback features which are known to be effective (feedback provided more than once) or were suggested to be potentially important in improving A&F interventions (the feedback was evidence-based and included use of benchmarks as a comparison).^{28,34,40} Hence, despite the stagnation described in the past, more recent publications were of high quality and built on existing research, which could indicate a trend towards reinvigorating A&F research. These findings also correspond with the latest innovation to investigate the effectiveness of A&F interventions, the implementation laboratories.⁵⁷ Implementation laboratories are being developed to promote collaborative research between healthcare system partners & researchers and to create an opportunity for experimentation. These laboratories thus aim to produce generalizable knowledge about how to optimize A&F. Internationally, these implementation laboratories are united in a 'meta-laboratory' approach to facilitate cumulative research in the field of A&F research.⁵⁷

Although A&F, and more precisely electronic A&F, were studied extensively in primary care, a meta-analysis to pool the results and produce some generalizable data was not feasible. This emphasizes the difficulties in designing complex healthcare interventions and the need for a framework and a well-defined research agenda when setting up electronic A&F trials so that interventions can be reproduced and compared.^{23,58} Designing a methodology for developing generalizable automated A&F interventions in primary care could be useful for this purpose since automated quality assessment based on EHR data offers promising prospects if the challenges are answered.¹⁵ Another important challenge when using EHR data is the completeness of these data. Provision of data quality feedback could improve this.⁵⁹ After all, if the data stored in the EHR are not complete, using them for an electronic A&F intervention will produce unreliable results.

Large data repositories, such as those of the Dutch institute for research of healthcare (NIVEL), the British Royal College of General Practitioners (RGCP) Research and Surveillance Centre (RSC) network, and the Belgian INTEGEO database, have already been available for many years in primary care^{17,60,61}. Using the facilities of these institutes in a well-designed trial with a standardized methodology could address some of the problems in evaluating the effectiveness and features of electronic A&F interventions. In this respect, recent research indicates the need for an evolution from a two-arm trial of A&F versus control to head-to-head trials of various A&F variants to measure small differences in effectiveness of different A&F features.⁵⁷ Such trials need to be sufficiently powered, requiring large sample sizes which could be provided by these large primary care data repositories.⁵⁷ However, further research, mainly into describing a methodology for an automated and EHR-based A&F intervention in primary care, is necessary. Designing and using a standardized methodology to create automated A&F interventions based on EHR data could allow comparison of future electronic A&F interventions. They could be used to investigate different features of the intervention, which in turn could advance the field of A&F research in general.

Strengths and limitations

To our knowledge, this is the first systematic review that investigated electronic A&F only in primary care. One of the strengths of this review is our search, which was identical to the last Cochrane review. By replicating the search strings of the Cochrane review, followed by screening abstracts and full-text articles based on our in- and exclusion criteria, this review had a broad basis. Our search led to a higher number of articles that were screened for in-or exclusion based on abstract (n=8744) and on full-text (n=431) compared with that of a previous review performed in a primary and non-primary care setting.¹² This method reduced the risk that relevant articles were missed.

Our review also has several limitations. Because our results showed high heterogeneity, no meta-analysis could be meaningfully performed and no generalizable data could be produced. Therefore, results were described narratively. Our definition of electronic A&F was strict and articles for which it was unclear if the A&F intervention was performed electronically were excluded, thus possibly missing some relevant articles. However, compared with a previous review on electronic A&F, which included 7 articles, our review included a higher number of articles since studies in which electronic A&F was part of a multifaceted intervention were also withheld.¹² Finally, for the calculation of our risk of bias summary every form of bias was considered as a key domain, except for performance bias, which may have produced too severe an overall risk of bias evaluation.

Conclusion

This systematic review included 29 articles describing an electronic A&F intervention in primary care, of which 76% showed an effect of the intervention on outcome measures such as change in systolic blood pressure, medication prescriptions, proportion of patients with a medication error and change in the proportion of patients treated with oral anticoagulants. Approximately 10% of the studies included all the facilitating feedback conditions we examined and showed an effect of the intervention, particularly on the prescription of antibiotics by dentists & primary care physicians and on the technical quality of diabetes care. There was a high heterogeneity in the results, making a meta-analysis unreliable. The design of the A&F interventions showed a great variability and overall, our results confirmed the previously described stagnation in the field of A&F research. However, 4 recent publications with a low risk of bias showed a positive evolution in the design and description of A&F interventions. Developing a framework or methodology for automated A&F interventions in primary care could be useful for necessary future research.

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Conflict of Interest

None declared

Abbreviations

A&F: Audit & Feedback

EHR: Electronic Health Record

RCT: Randomized Controlled Trial

Figure legends

Figure 1: PRISMA flow-chart

Figure 2: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

Appendices

Appendix 1: PRISMA checklist

Appendix 2: Search strings and results

Appendix 3: Elsevier-Embase search: syntax used for translation

Appendix 4: Data extraction sheet continuous outcomes

Appendix 5: Data extraction sheet dichotomous outcomes

Tables

Table 1: Studies with continuous outcomes

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Osvaldo P. Almeida, 2012	CRCT	The care for patients with depression and self-harm behavior in a large sample of primary care patients aged 60 years or older	A composite measure of clinically significant depression (Patient Health Question- naire score [?]10) or self-harm behavior (suicide thoughts or attempt during the previous 12 months)	The intervention consisted of a practice audit with personalized automated audit feedback, printed educational material, and 6-monthly educational newsletters delivered over a period of 2 years. Control physicians completed a practice audit but did not receive indi- vidualized feedback. They also received 6-monthly newsletters describing the progress of the study, but they were not offered access to the educational material about screening, diagnosis and management of depression, and suicide behavior in later life.	Depression	GP

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Anthony J Avery, 2012	CRCT	Medication errors	The proportions of patients at 6 months after the intervention who had had any of three clinically important errors: non selective NSAIDs prescribed to those with a history of peptic ulcer without co- prescription of a proton- pump inhibitor; β blockers prescribed to those with a history of asthma; long-term prescription of ACE-I or loop diuretics to those 75 years or older without assessment of urea and electrolytes in the preceding 15 months.	Computer- generated simple feedback for at-risk patients (control) versus a pharmacist- led information technology intervention, composed of feedback, educational outreach, and dedicated support.	Medication safety	GP

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
B. Bonevski, 1999	RCT	Preventive medicine	Assessing smoking and benzodi- azepine use sensitivity, specificity, and overall accuracy and whether blood pressure and cholesterol screening levels were obtained.	Those given the intervention received a computer- ized feedback system; control group was given usual care	Preventive medicine	GP
Carlos A. Estrada, 2011	CRCT	Improving diabetes control	‘Acceptable control’: [hemoglobin A1c <9%, blood pressure <140/90 mmHg, LDL cholesterol <130 mg/dl] and ‘optimal control’: [hemoglobin A1c <7%, blood pressure <130/80 mmHg, LDL cholesterol <100 mg/dl].	A multi- component intervention including Web-based CME, performance feedback and quality improve- ment tools versus usual care (physicians in the control group did not receive performance feedback reports or electronic communications)	Diabetes	Primary care physicians

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Trine Lignell Guldberg, 2011	CRCT	Quality of type 2 diabetes care	Processes of care according to guidelines on redeemed prescriptions for recom- mended type 2 diabetes treatment, measuring of HbA1c and cholesterol and visits to ophthalmologists	To receive or not to receive electronic feedback on quality of care	Type 2 diabetes	GP
Bruce Guthrie, 2016	CRCT	Safety of prescribing	Proportion of patients included in one or more of the defined 6 individual secondary outcomes (denomina- tor) who receive any high risk prescription (numerator)	3 arms: “usual care,” (consisting of emailed educational material with support for searching to identify patient); usual care plus feedback on practice’s high risk prescribing; usual care plus the same feedback in- corporating a behavioral change component	Safety of prescribing	GP

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Wei Yin Lim, 2018	CRCT	Manual prescribing medication	The percentage of prescriptions with at least one error (error versus no error)	a) full feedback intervention [structured prescription review and prescribing performance feedback (league tables and authorized feedback letter)], b) partial feedback intervention [structured prescription review and prescribing performance feedback (league tables only)], or c) usual care as control (structured prescription review only).	Errors in prescribing	Primary care prescribers
Jeffrey A. Linder, 2010	CRCT	Antibiotic prescribing	The primary outcome was the intent- to-intervene antibiotic prescribing rate for acute respiratory infection visits.	the ARI Quality Dashboard, an EHR-based feedback system versus usual care	Acute respiratory infections	Primary care physicians

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
James W. Mold, 2008	RCT	Preventive service delivery	The number of practices who implemented one or more evidence- based processes and the total number of processes imple- mented, as determined by a blinded expert panel from transcripts of structured clinician interviews conducted at baseline and after a 6-month intervention period	Comparing a multicom- ponent quality im- provement intervention (Interven- tion practices received performance feedback, peer-to-peer education (academic detailing), a practice facilitator, and computer (information technology) support) to feedback and bench- marking (= control)	Preventive medicine	Clinicians

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Gbenga Ogedegbe, 2014	CRCT	Blood Pressure controle	The rate of BP control at 12 months, defined as mean BP <140/90 mm Hg (or mean BP <130/80 mm Hg for those with diabetes mellitus or kidney disease)	Patients at the intervention sites received patient education, home BP monitoring, and monthly lifestyle counseling, whereas physicians attended monthly hypertension case rounds and received feedback on their patients' home BP readings and chart audits. Patients and physicians at the usual care sites received printed patient education material and hypertension treatment guidelines, respectively.	Hypertension	GP

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Steven Ornstein, 2010	CRCT	Colorectal cancer (CRC) screening	Proportion of active patients up to date with CRC screening and having screening recom- mended within past year among those not up to date	A quality improve- ment intervention combining EHR based audit and feedback, practice site visits for academic detailing and partici- patory planning, and “best- practice” dissemina- tion on CRC screening versus usual care	Colorectal cancer	Primary care physicians

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
Ginger A. Pape, 2011	CRCT	Cholesterol Management in Diabetes Mellitus	Proportion of participants in each arm achieving a target LDL level of 100 mg/dL or lower	The intervention included remote physician- pharmacist team-based care focused on cholesterol management in DM versus control. All clinicians in the study had access to a health information technology tool, which provided automated DM-related point-of-care prompts, a Web-based registry, and performance feedback with benchmarking.	Cholesterol management in diabetes mellitus	Family practice and internal medicine physicians

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
David Peiris, 2015	CRCT	Cardiovascular disease risk management	There are 2 coprimary outcomes: 1. The proportion of eligible patients who received appropriate screening of CVD risk factors by the end of study. 2. The proportion of eligible patients defined at baseline as being at high CVD risk, receiving recommended medication prescriptions at the end of study.	The intervention arm consisted of a computer- guided QI intervention comprising point-of care electronic decision support, audit and feedback tools, and clinical workforce training versus usual care.	Cardiovascular disease risk management	GP
Inés Urbiztondo, 2017	CRCT	Antibiotic prescribing in patients with suspected respiratory tract infection	The change in the proportion of patients treated with antibiotics for respiratory tract infection	Intervention (evidence- based online feedback) versus control (no exposure to the evidence- based online feedback)	respiratory tract infections	GP
Dragos Vinereanu, 2017	CRCT	Use of oral anticoagu- lant medication in atrial fibrillation to avoid stroke	The change in the proportion of patients treated with oral anticoagulants	Intervention consisting of 2 components (education and regular monitoring & feedback) versus usual care	Atrial fibrillation	Health care providers

Study ID (first author, year)	Study design	Type of targeted behaviour	Primary outcomes	Type of interventions compared	Clinical condition	Targeted health professional
William C. Wadland, 2007	CRCT	Smoking cessation	Changes from baseline to post intervention (18 months) in clinician referrals in both intervention and control groups	Comparing the impact of 6 quarterly feedback reports (intervention) with that of general reminders (control)	Smoking cessation	Clinicians
N. Winslade, 2016	RCT	Provision of professional services and the quality of patients' medication use	The number of hypertension/asthma services billed per pharmacy and percentage of dispensing to non-adherent patients over the 12 months post intervention.	Pharmacy-specific performance feedback reports versus no feedback reports	Astma and hypertension	Pharmacist

CRCT: Cluster Randomized Controlled Trial; RCT: Randomized Controlled Trial; SIGN: Scottish Intercollegiate Guidelines Network; NHS: National Health Service; GP: General Practitioner; DDD: Defined Daily Dose; OAC: Oral Anticoagulants; EHR: Electronic Health Record; PSs: Parenteral Steroids; UTI: Urinary Tract Infection; LQIC: Local Quality Improvement Collaboratives

Table 2: Studies with dichotomous outcomes

CRCT: Cluster Randomized Controlled Trial; RCT: Randomized Controlled Trial; GP: General Practitioner; NSAID: Non-Steroidal Anti-Inflammatory Drugs; ACE-I: Angiotensin Converting Enzyme Inhibitor; LDL: low-density lipoprotein; CME: Continuing Medical Education; ARI: Acute Respiratory Infections; EHR: Electronic Health Record; BP: Blood Pressure; CRC: Colorectal Cancer; DM: Diabetes Mellitus; CVD: Cardiovascular Disease

Table 3: Continuous outcomes, feedback features

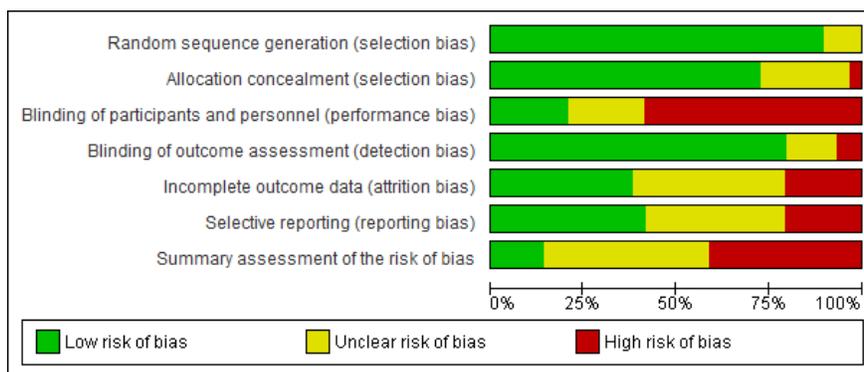
Study ID (first author, year)	Unit of analysis	Frequency of the feedback	Evidence-based feedback
Osvaldo P. Almeida, 2012	Patients	Unclear	Unclear
Anthony J Avery, 2012	Patients	Less than monthly	Unclear
B. Bonevski, 1999	Patients	Unclear	Yes

Study ID (first author, year)	Unit of analysis	Frequency of the feedback	Evidence-based feedback
Carlos A. Estrada, 2011	Patients	Less than monthly	Unclear
Trine Lignell Guldborg, 2011	Patients	Unclear	Yes
Bruce Guthrie, 2016	Patients	Less than monthly	Yes
Wei Yin Lim, 2018	Number of prescriptions	Less than monthly	Unclear
Jeffrey A. Linder, 2010	Providers	Monthly	Yes
James W. Mold, 2008	Providers	Unclear	Unclear
Gbenga Ogedegbe, 2014	Patient	Less than monthly	Yes
Steven Ornstein, 2010	Patients	Unclear	No
Ginger A. Pape, 2011	Patients	Unclear	Yes
David Peiris, 2015	Patient-level data analysis	Unclear	Yes
Inés Urbiztondo, 2017	Individual data at patient and GP level	Weekly	Yes
Dragos Vinereanu, 2017	Patients	Unclear	Unclear
William C. Wadland, 2007	Providers	Less than monthly	Unclear
N. Winslade, 2016	Number of dispensings	Once	Yes

Table 4: Dichotomous outcomes, feedback features

Hosted file

Figure 1.docx available at <https://authorea.com/users/291736/articles/419188-the-effect-of-electronic-audit-and-feedback-in-primary-care-and-factors-facilitating-effectiveness-a-systematic-review>



	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Summary assessment of the risk of bias
Almeida 2012	+	+	-	?	+	?	?
Avery 2012	+	+	-	+	?	+	?
Bahrami 2004	+	+	-	+	+	?	?
Bonevski 1999	?	?	-	?	?	?	?
Elouafkaoui 2016	+	?	-	+	?	+	?
Estrada 2011	+	+	?	+	-	+	-
Gerber 2013	+	+	-	+	?	?	?
Guldberg 2011	+	-	-	+	+	+	-
Guthrie 2016	+	+	+	+	+	+	+
Hayashino 2015	+	+	+	+	?	-	-
Hemkens 2017	+	+	+	+	+	+	+
Holt 2017	+	+	-	+	?	+	?
Lim 2018	+	+	-	-	+	?	-