Use of electronic health records to support smoking cessation (Review)

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[Intervention Review]

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ABSTRACT

Background

Health information systems such as electronic health records (EHR), computerized decision support systems, and electronic prescribing are potentially valuable components to improve the quality and efficiency of clinical interventions for tobacco use.

Objectives

To assess the effectiveness of electronic health record-facilitated interventions on smoking cessation support actions by clinicians and on patient smoking cessation outcomes.

Search methods

We searched the Cochrane Tobacco Addiction Group Specialised Register, CENTRAL, MEDLINE, EMBASE, PsycINFO, CINAHL, and reference lists and bibliographies of included studies. We searched for studies published between January 1990 and May 2011.

Selection criteria

We included both randomized studies and non-randomized studies that reported interventions targeting tobacco use through an EHR in health care settings. The intervention could include any use of an EHR to improve smoking status documentation or cessation assistance for patients who use tobacco, either by direct action or by feedback of clinical performance measures.

Data collection and analysis

Characteristics and content of the interventions, participants, outcomes and methods of the included studies were extracted by one author and checked by a second. Because few randomized studies existed, we did not conduct a meta-analysis.

Main results

We included three randomized and eight non-randomized observational studies of fair to good quality that tested the use of an existing EHR to improve documentation and/or treatment of tobacco use. None of the studies included a direct assessment of patient quit rates. Overall, these studies found only modest improvements in some of the recommended clinician actions steps on tobacco use.

Authors' conclusions

At least in the short term, documentation of tobacco status and increased referral to cessation counseling do appear to increase following the introduction of an expectation to use the EHR to record and treat patient tobacco use at medical visits. There is a need for additional research to further understand the effect of EHRs on smoking treatment in healthcare settings.

PLAIN LANGUAGE SUMMARY

Does use of an electronic health record to enhance the delivery of effective tobacco cessation treatment to patients using tobacco accomplish that?

In many countries a large investment is being made in technology to computerize patient medical records. One potential of electronic health records (EHR) is that they could be used to remind clinicians to record tobacco use, to give brief advice to quit, to prescribe medications and to refer to cessation counseling. They could also facilitate those referrals and performance measures with feedback. We included 11 studies in this review, but most were observational studies. Of the recommended actions for clinicians with tobacco using patients we found only modest improvements in recommended clinician actions for tobacco users associated with the EHR changes. While documentation of tobacco use and referral to cessation counseling appear to increase, patient smoking cessation was not demonstrated.

BACKGROUND

Description of the condition

In 2002, an estimated 1.2 billion people in the world were smokers (WHO 2002). While the rates of smoking have declined in many developed countries, increased prevalence in developing countries has offset these improvements. Currently, an estimated 41.1% of men and 8.9% of women worldwide smoke (WHO 2010). This global rate of smokers is expected to grow throughout the coming decades, with women particularly at risk for increased prevalence (WHO 2002). Tobacco use currently kills more than five million people each year and this number is expected to increase substantially (WHO 2009). Even if prevalence rates remain unchanged, an estimated 500 million people will die as a direct result of tobacco usage over the next fifty years (WHO 2002).

The health care setting remains an underused venue to provide cessation assistance to tobacco users, particularly in developing countries. Recognizing this, Article 14 of the World Health Organization (WHO) Framework Convention on Tobacco Control emphasizes the necessity of promoting evidence-based tobacco cessation and disseminating comprehensive guidelines and best practices. To achieve the goals of Article 14, such evidence-based clinical practice guidelines exist, outlining strategies that health care settings can use to help smokers quit (Fiore 2008; NHS 2011).

Evidence-based clinical practice guidelines for tobacco cessation support recommend systematic identification and intervention for tobacco use. Changes in health systems operations that institutionalize the identification and clinical treatment of patients using tobacco, are a particularly promising way to take advantage of the primary care visit to help patients quit tobacco use.

A system level change that might increase the frequency of effective cessation delivery is to take advantage of the electronic medical record for clinician reminders, linking patients to cessation services, monitoring performance, and providing feedback.

Description of the intervention

We included both direct and indirect types of EHR-based interventions. EHRs could be used directly to remind clinicians to document tobacco use, to deliver brief advice, and to prescribe cessation medications, as well as to facilitate other cessation support such as referral to counseling. They also could be used indirectly to provide performance measures of cessation support by clinics or individual clinicians that are then publicly reported or fed back to those studied or to leaders for quality improvement.

How the intervention might work

Treatment for tobacco use in a health care setting first requires an assessment of tobacco use and patient willingness to stop using tobacco (Fiore 1991). Health care clinician advice has a small effect on cessation - leading between three and six per cent of patients to

stop using tobacco (Stead 2008). However, higher rates of cessation are achieved when a coordinated system within the healthcare setting facilitates evidence-based actions such as cessation counseling and use of cessation medications. In the absence of electronic records, a stamp or similar visual aid in a paper chart can serve as a clinician reminder to discuss tobacco use, to provide treatment and to facilitate referrals. Chart audits by hand can also provide the performance measures needed for quality improvement. However, these paper-based methods are time and resource expensive and unlikely to be performed consistently. EHRs provide a systematic mechanism to improve the fidelity of following clinical practice guidelines consistently (Hesse 2010).

Why it is important to do this review

Health information systems such as EHRs, computerized decision support systems, and electronic prescribing are increasingly identified as potentially valuable components to improve the quality and efficiency of patient care. EHRs are also very likely to disseminate rapidly, at least in developed countries, as health care systems modernize away from paper records.

Two occurrences - inadequate tobacco cessation support during clinical encounters (Solberg 2005) and the rapid dissemination of EHRs - create a need to evaluate the evidence for any beneficial connections between the two, and to identify any gaps in this evidence requiring additional research.

OBJECTIVES

To assess the effectiveness of electronic health record-facilitated interventions on smoking cessation support actions by clinicians and on patient smoking cessation outcomes.

METHODS

Criteria for considering studies for this review

Types of studies

Randomized controlled trials and methodologically strong observational studies.

Rationale for including non-randomized studies: Our primary aim in this review is to determine the extent of evidence supporting EHRs as a means of enhancing the delivery of effective tobacco use cessation treatments in healthcare settings. Most clinical research in healthcare settings including preventive measures such as smoking treatment have involved observational rather than randomized studies. In part this reflects the challenges of the health care setting. Therefore it is especially important to learn what we can from observational studies. Well-done observational designs have the potential to fill the need for evidence when it is unavailable from randomized trials as well as to supplement those trials.

Types of participants

Adult smokers who are patients of healthcare delivery settings.

Types of interventions

We included any interventions that involved electronic health record systems in healthcare settings that were intended to improve documentation or assistance for patients who use tobacco, either by direct action or by measuring and reporting on clinical performance.

Types of outcome measures

Primary outcomes

Included studies measured abstinence from smoking at a minimum of six months from the date of the intervention. Smoking status was measured directly from patient self reports or indirectly from patient medical records. We did not require biochemical validation of quit rates.

In addition to quit rates we included changes in smoking cessation support actions by clinicians. These steps include: *Ask* - systematically identify all tobacco users, *Advise* - advising all users to quit, *Assess* - determine willingness to make a quit attempt, *Assist* - provide tobacco cessation counseling and medications, and *Arrange* - ensure follow-up contact. Changes in the rates of these action steps are equally important outcomes, since there is good evidence that they are associated with increased quit rates.

Search methods for identification of studies

Electronic searches

We searched the Specialised Register of the Cochrane Tobacco Addiction Group: this register includes controlled studies identified by systematic electronic searches of various databases including CENTRAL, MEDLINE, EMBASE, PsycINFO, hand searching of relevant specialist journals, conference proceedings and 'grey literature' (e.g. unpublished reports, literature which is not covered by most electronic databases). We searched for the following keywords; 'Medical Records Systems*' OR 'Electronic Health Records*', or the following combinations of terms in title or abstract: '(electronic or automated or medical) AND record*'

In addition, we searched the following electronic databases without study design term limits in order to identify observational studies; The Cochrane Central Register of Controlled Trials (CENTRAL) via Cochrane Library, PUBMED (MEDLINE), OVID CINAHL, ISI Web of Science, Engineering Village, EMBASE, and Academic Search Premier. In each database we searched for the combination of the following key terms: (1) 'medical records' or 'health records'; (2) 'electronic' or 'automated'; (3) 'smoking or tobacco'; (4) 'cessation or quitting'; (5) 'feedback or reminders'. We limited these searches to records where at least the abstract was published in English from January 1990 through May 2011.

Searching other resources

In addition, we scanned the reference lists of retrieved studies for additional papers. Content experts were asked to identify other published or unpublished studies.

Data collection and analysis

Randomized or cluster randomized trials were analysed separately from non-randomized studies.

Selection of studies

The title and abstract of records identified using the keyword searches were read independently by two of the authors. We looked for studies of interventions involving adult smokers and an electronic medical or health record that was used to directly or indirectly facilitate cessation support (e.g. by providing audit and feedback).

Data extraction and management

The full text of each article was read and study quality was assessed using a data abstraction form. Two authors independently extracted data about the research design, outcomes, and analysis, and adjudicated any significant differences between the two extracts. We contacted authors of any papers where the methods or results were unclear.

Assessment of risk of bias in included studies

We estimated the risk of bias (ROB), including both the direction and magnitude. We independently assessed the ROB in randomized trials using the following ROB items:
(1) The presence of any sequence generation during randomization
(2) Allocation sequence concealment
(3) Blinding
(4) The completeness of outcome data
(5) Selective outcome reporting

We categorized each trial as being at low, uncertain, or high risk of bias according to the standards described in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2008). We recognise that the potential biases are likely to be greater in observational studies. We used the ROB items as a starting point to assess included observational studies.

Measures of treatment effect

For the cluster randomized trials we examined the treatment methods to determine if there was an acceptable level of inter-study homogeneity to enable us to draw any inference.

Unit of analysis issues

For cluster randomized trials we determined if appropriate adjustment was made to account for the clusters such as adjusting estimates for intra-cluster correlation.

Dealing with missing data

For quit rates, we assumed an intention to treat analysis was followed - this assumes missing participants have not quit smoking and are not included in the denominator.

Assessment of heterogeneity

The collection of methodological information on any non-randomized observational studies enabled us to determine the extent of heterogeneity between studies.

Data synthesis

Rather than pool the included observational studies we reported descriptively the relationships between and within studies.

Subgroup analysis and investigation of heterogeneity

We did not test for statistical heterogeneity or perform any subgroup analyses. The majority of studies involved patients seen in general medicine or primary care clinics. Only one study involved hospitalized patients while one other included patients receiving pharmacy education for anticoagulation medication or diabetes mellitus.

Sensitivity analysis

We did not conduct a sensitivity analysis of included studies.

RESULTS

Description of studies

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

We found 11 studies that met the eligibility criteria. Details of the design, intervention, and measures are presented in the 'Characteristics of included studies.' Ten of the studies were conducted in the United States and one in Australia. Consistent with the on-going adoption of electronic health records within health care settings, eight of the studies were published in the past five years, and only one was published before 2000. Ten of the studies were conducted in general practice/primary care medical clinics. The other study (Koplan 2008) was conducted in a single large hospital. One study (Ragucci 2009) tested an intervention delivered by pharmacists working in primary care clinics. We characterized the studies as follows: three were cluster randomized trials (Bentz 2007; Sherman 2008; Linder 2009), and one was a patient randomized study conducted in a single clinic Frank 2004. A further two studies included a control or comparison group, four studies measured outcomes using a before and after design, and one study followed a cohort of smokers.

Length of follow up

The cluster randomized trials conducted follow-up data collection for nine months or more from the beginning of the intervention. Of those with a control condition, Szpunar 2006 collected follow-up data through a patient survey about two weeks after a medical care visit during an eight month study period. Bentz 2002 collected data during a three month period, and Frank 2004 collected 12 month outcome data.

The observational studies varied in the length of the study follow-up period. Spencer 1999 followed patients to 19 months. Lindholm 2010 provided data one year before and one year after the intervention. Koplan 2008 examined outcomes 4 months before and after implementation. McCullough 2009 followed a cohort for eight months.

Excluded studies

See: 'Characteristics of Excluded Studies'

Risk of bias in included studies

Study Design

Randomized Studies

We found three cluster randomized clinical trials (Bentz 2007; Sherman 2008; Linder 2009) that assigned medical clinics to either intervention or control conditions. In each of these studies both treatment conditions tested a common electronic health record with various enhancements provided to the intervention clinics. Linder 2009 provided the intervention clinics with additional tools within the electronic health record and clinical staff were reminded to use them. In Bentz 2007, the enhancement was based on information in an existing electronic health record. Clinical staff (physicians and medical assistants) in the intervention clinics received feedback reports on their use of the electronic health record tools with smoking patients. Sherman 2008 also provided additional tools for clinical staff in the electronic health record system with some restrictions on use of the tools by the control clinics.

Other studies

Of the other eight studies, three used a control condition or comparison clinic (Bentz 2002; Frank 2004; Szpunar 2006). In Bentz 2002, the comparison clinic was a paper records-based clinic without an electronic health record. Szpunar 2006 used four control clinics, two were based on usual care and two had access to a new electronic health record vital sign screen but were provided no training or support on the use of the vital sign. Frank 2004 randomly assigned patients in one clinic to either intervention or usual care based on their family medical record number.

The additional studies (Koplan 2008; Lindholm 2010; McCullough 2009; Ragucci 2009; Spencer 1999) measured outcomes before and after the introduction of an enhancement to an existing electronic health record, without any comparison group. Koplan 2008 studied the intervention in a single hospital, and the study by Spencer 1999 was conducted in a single family medicine clinic. The McCullough 2009 and Ragucci 2009 studies involved 3 clinics, and Lindholm 2010 studied one large health system with 18 primary care clinics. The Ragucci 2009 study was conducted as a retrospective cohort study.

Allocation

Selection of clinics

One of the benefits of randomizing clinics rather than individual patients is the added protection against contamination of the control conditions when patients are seen in the same clinic (Campbell 2000). Two studies (Bentz 2007; Linder 2009) were conducted in large health systems and, prior to randomization, clusters of clinics were created based on predetermined criteria such as the proportion of payment from government versus private insurance payers (Bentz 2007) or practice type (hospital based, community based or community health center) (Linder 2009). In both of these studies all patients in a medical practice were included in the cluster.

The Sherman 2008 study was conducted in a government funded health system, and clinics were randomly assigned, stratified by region (Northern vs Southern California) and size (large vs small). Among the controlled observational studies, there was no consistent method for choosing the control group. Bentz 2002 selected two clinics that were willing to participate, one used a paper chart and the other had recently switched to an electronic health record. Frank 2004 randomly assigned patients within a single medical clinic. Szpunar 2006 selected clinics based on a variety of criteria, including number of patients (population size), willingness to participate, and technical ability to complete the study. Control clinics were selected to match the intervention clinics based on a combination of number of patients and number of clinical providers.

Incomplete outcome data

We considered both exclusions and attrition and found no concerns.

Selective reporting

We examined studies for the completeness of their results. Sherman 2008 reported an increase within intervention clinics but failed to describe the comparable referral rate within control clinics.

Other potential sources of bias

We examined the three cluster randomized trials for the potential of recruitment bias. Linder 2009 included all the medical clinics that belonged to a practice-based research network. Bentz 2007 reported the inclusion of 19 medical clinics that were part of a large health system. The selection of clinics to participate was not provided but all patients in the selected clinics were included. The Sherman 2008 study involved 18 clinics but the criteria for study inclusion were not reported.

Effects of interventions

Smoking cessation

Only Linder 2009 reported a comparison of quit rates between control and intervention measured indirectly based on changes in the electronic health record documentation of smoking status. Significantly more smokers in the intervention clinics were subsequently documented as nonsmokers as compared to smokers in the control clinics (5.3% vs 1.9%, p < 0.001).

Clinical guideline recommended actions

Smoking status

Bentz 2007 and Linder 2009 measured documentation of smoking and found significantly higher rates. Comparing control to intervention, Bentz 2007 found that documentation had increased from 88.1% to 94.5% (p<0.05). In Linder 2009 the comparable rates were 46% vs 54% (p < 0.001).

Advise and assess interest in quitting

Bentz 2007 found higher rates of advice (71.6% vs 52.7%), and assessment (65.5% vs 40.1%), when comparing intervention and control clinics.

Cessation assistance

A logical approach to increase the number of smokers who make attempts to quit smoking is to connect patients during a medical visit to the necessary resources to assist quitting. These resources might include physician assistance with a quitting plan or medications, or a referral to telephone based cessation counseling.
Linder 2009 found more smokers in the intervention clinics were referred to cessation counseling compared to the control clinics (4.5% vs 0.4% p<0.001) and making a contact with a cessation counsellor was more likely among intervention clinic smokers compared to control (3.9% vs 0.3%, p<0.001). However, they found smokers in the intervention clinics no more likely to be prescribed a cessation medication. Bentz 2007 found documented assistance increased in the intervention clinics compared to the control clinics (20.1% vs 10.5%, p<0.001). However, referrals to the telephone-based quitline did not increase. The researchers found variation across clinics and therefore adjusted their analysis for two factors: the presence of a "clinic champion" advocating for cessation support and the proportion of patients with more documented illnesses. This adjustment revealed an increase in referrals from intervention clinics (adjusted OR 1.5). Sherman 2008 found an increase in the last month estimated number of patients referred to telephone counseling from clinician self-reports (15.6 vs 0.7), but no difference in the likelihood of patients from intervention clinics to receive a prescription for cessation medications.

Evidence from observational and patient randomized studies

Of the other eight studies, documentation of smoking status was the most commonly measured and six of seven reported an increase in documentation. In the patient randomized study (Frank 2004) a preventive care reminder did not increase documentation of smoking status.

These studies provided additional evidence of clinician assistance to smokers following an amended EHR. Four measured assistance with quitting at baseline and follow up (Koplan 2008; McCullough 2009; Spencer 1999; Szpunar 2006). All four found the intervention increased the rate of assistance provided to smokers. McCullough 2009 found an increase in documented assistance among smokers who were also asked about plans to quit smoking. After the EHR change, Koplan 2008 found an increase in both the proportion of admitted smokers referred to cessation counseling and an increase in physician orders for cessation medication.
Across the observational studies, no additional evidence was reported on patient quit rates following changes to EHRs.

DISCUSSION

Summary of main results

We included randomized and non-randomized studies that tested the use of an existing EHR to improve documentation and treatment of tobacco use. None of the studies included a direct assessment of patient quit rates. At least in the short term, documentation of tobacco status and quit assistance to smokers does increase following the introduction of an electronic expectation to provide clinical support for patients who smoke.

Overall completeness and applicability of evidence

The goal of this review was to evaluate the depth of available evidence supporting computerized medical record systems as a method to enhance the delivery of effective tobacco use treatments. The most common study design measured changes in clinician actions before and after the introduction of an enhancement to an electronic health record, but often without a control or comparison condition. Randomized controlled trials in real-world settings such as medical clinics could benefit from the use of cluster randomized designs. However, these are often lacking from the scientific literature in part because they are more complex to design and analyse.

Quality of the evidence

Overall the studies in this review were heterogeneous in design and intervention. For example, across all the studies patient surveys, provider surveys, or medical record reviews were used to measure outcomes. Each of these methods introduces a different view of outcomes and each introduces a potential bias. Therefore we did not perform statistical analysis or a meta-analysis of the included studies.
Although 11 studies were included, we determined that two were high quality randomized controlled trials. The third randomized trial (Sherman 2008) demonstrated the difficulty of researcher control within an existing health care system. In this study the researchers were unable to restrict the enhancement of the medical record system to only the intervention clinics. Instead, they relied on a visual request to maintain the delivery of the intervention.
There were various limitations to the non-randomized studies. Most studies (5/8) lacked a control group and adopted a before and after design. Other limitations included small sample sizes and convenience sampling of included clinics which increases the potential risk of selection bias.

AUTHORS' CONCLUSIONS

Implications for practice

Adding tobacco use as an electronic vital sign collected during a medical visit increases some of the recommended clinician actions for treating patients who use tobacco.

Implications for research

The findings of this review highlight the need for well designed randomized controlled studies that can better assess the promise of EHRs to enhance the clinical treatment of tobacco dependence.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Bentz 2002

Methods	Country: USA Setting: Portland, Oregon Design:Tracking codes to measure and report tobacco cessation guideline provider activities were introduced in two primary care clinics. One clinic was using an electronic health record and the comparison clinic a paper chart
Participants	2 Primary care clinics, one using an internally developed, web-based electronic health record and another using a paper medical record
Interventions	The EHR clinic was prompted to ask patients about smoking, give advice to quit, and to document these actions in the EHR. A tracking form was attached to the paper chart in the non-EHR clinic
Outcomes	Documentation of tobacco use was collected from a sample of 50 patient charts. Billing and claims databases were used to measure code utilization
Notes	

Bentz 2007

Methods	Country: USA Setting: Primary care clinics, Portland, Oregon Design: Cluster randomized controlled trial. Clinics were grouped by business affiliation, payer mix, and baseline rate of recorded smoking status (ask rate); then randomized into intervention and control. A case-mix score was calculated to control for age and illness diagnosis. Regression analysis was performed using generalized estimating equations. Intra-cluster correlation coefficients (ICC) were calculated for the analysis
Participants	19 Primary care clinics (n=10 intervention) using a common electronic health record within one health system
Interventions	Intervention group clinics received written reports showing individual provider, and clinic performance on tobacco clinical guideline actions: ask, advice, assess, assist, arrange. Written reports were provided monthly to the clinic manager
Outcomes	Rates of asking about tobacco use, advising to quit, assessing interest in quitting, and assistance with referral to the telephone quitline
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Bentz 2007 (*Continued*)

Random sequence generation (selection bias)	Low risk	Cluster randomized, clinics were grouped by pre-determined criteria prior to randomization
Allocation concealment (selection bias)	Low risk	Cluster randomization reduced the risk
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Entire clinics were randomized thus eliminating this risk
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Cluster randomization reduced the risk

Frank 2004

Methods	Country: Australia Setting: Urban general practice clinic of 10 physicians Design: Quasi-randomized controlled study. Data were analysed with regression using generalized estimating equations
Participants	Intervention sample n=5118; Control sample n=5389; 56% female
Interventions	Reminders for preventive activities including recording smoking status appeared as a field in the electronic health record
Outcomes	Documentation of smoking status in the electronic health record
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Patients were randomized by family record number
Blinding of participants and personnel (performance bias) All outcomes	High risk	Single clinic with no blinding of physicians

Koplan 2008

Methods	Country: USA Setting: Boston, Massachusetts Design: Uncontrolled before-and-after study. Pre-intervention period (4 months) was compared to post-intervention (4 months)
Participants	Admitted hospital patients in a large multi-specialty hospital affiliated with a University. Records for 17,530 admissions were examined
Interventions	A series of check boxes (tobacco order set) was added to admission screens of the hospital computerized order-entry system. The assessment included smoking/nonsmoking, cessation materials, cessation consultation, and orders for nicotine replacement medications or bupropion
Outcomes	Referral to smoking cessation counseling and ordering cessation medications
Notes	

Linder 2009

Methods	Country: USA Setting: Boston, Massachusetts Design: Cluster randomized controlled trial. Clinics were matched based on size (number of annual visits) and practice type (hospital based, community based, or community health center) then randomly assigned to intervention or usual care. Intra-cluster correlation coefficients (ICC) were calculated for the analysis. A generalized linear model controlled for the clusters and possible interactions
Participants	Documented smokers (n=9589) in 26 Primary care clinics (n=12 intervention) using an internally developed, web-based electronic health record
Interventions	Intervention group clinicians experienced three changes to the electronic health record - a cigarette icon on the top of the health record was either black when smoking status was missing or scarlet for current smokers. Tobacco treatment reminders were listed in the patient record; and treatment order forms for cessation medication and telephone Quitline referral were added
Outcomes	Primary outcome was documented smoking cessation counseling (smoking counselor reached a patient by telephone, or a patient attended a program, or the Quitline reached a patient by telephone Secondary outcomes included documentation of smoking status, prescribing cessation medication, and referral to cessation treatment, and smokers subsequently documented as non smokers
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Linder 2009 (*Continued*)

Random sequence generation (selection bias)	Low risk	Cluster randomized, clinics were matched on pre-determined criteria then randomized
Allocation concealment (selection bias)	Low risk	Cluster randomization reduced the risk
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Clinic was randomized

Lindholm 2010

Methods	Country: USA Setting: Madison, Wisconsin Design: Uncontrolled before-and-after study. Pre-intervention period (12 months) was compared to post-intervention (12 months). Chi² tests were performed
Participants	Primary care patients attending 18 general internal medicine and family medicine clinics. About 250,000 patient visits were examined pre and post intervention
Interventions	A tobacco use box was added to the vital signs patient window; if a tobacco user was identified, the patient was asked if they were willing to talk to the doctor about quitting; If yes, a three question paper survey asked about past cessation medication use, cigarettes used per day, and a possible quit date. This survey was left for the physician to review during the visit
Outcomes	Assessment of smoking status pre-post from the electronic health record; proportion provided medication (post intervention only), clinician documentation of smoking cessation counseling (post intervention only)
Notes	

McCullough 2009

Methods	Country: USA Setting: Chapel Hill, North Carolina Design: Uncontrolled before-and-after study. Pre-intervention period (4 months) was compared to post-intervention (8 months). Chi² tests were performed
Participants	Primary care patients attending 3 family medicine clinics (n=899)
Interventions	Two questions were added to the patient vital signs in the electronic health record - "Current smoker?" and "Plan to quit?"
Outcomes	Documented smoking status, assessment of quit plan, and smoking cessation counseling recorded in the electronic health record
Notes	

Ragucci 2009

Methods	Country: USA Setting: Columbia, South Carolina Design: Uncontrolled before-and-after study. Pre-intervention period (4 months) was compared to post-intervention (8 months). Pharmacist delivered intervention during drug therapy management
Participants	Anticoagulation patients or diabetes patients who were current smokers (n=90) attending 3 University-based primary care clinics
Interventions	A smoking template was added to the pharmacy-related progress notes within the electronic health record. The template queried on smoking status, type of tobacco, amount of tobacco, years of tobacco use, past quit attempts, desire to quit, and assessment of nicotine addiction. Based on smoking status, pharmacist provided a message on the benefits of smoking cessation and education on cessation medications
Outcomes	Smoking cessation and readiness to quit smoking if not quit.
Notes	

Sherman 2008

Methods	Country: USA Setting: Los Angeles, California and Palo Alto, California Design: Cluster randomized clinical trial. The method of randomization was not described. Regression analysis performed; no assessment of group correlation. Access to the intervention was incompletely controlled
Participants	18 Primary care clinics (n=10 intervention) affiliated with the Veterans Health Administration (VA)
Interventions	A simplified method was added to an existing electronic health record for referral to telephone-based cessation counseling. Electronic mail reminders were sent to providers. Project staff promoted the referral tool during visits to the intervention clinics
Outcomes	Primary outcome was provider self reported referrals to telephone-based cessation counseling
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Cluster randomization reduced the risk
Blinding of participants and personnel (performance bias) All outcomes	High risk	The change to the electronic record could not be restricted in control clinics

Spencer 1999

Methods	Country: USA Setting: Eau Claire, Wisconsin Design: Uncontrolled before-and-after study. Pre-intervention period (9 months) was compared to post-intervention (19 months)
Participants	Primary care patients attending a single family medicine clinic affiliated with a university
Interventions	Smoking status was documented in a single location - the major problem list in the electronic health record. Medical Assistants were assigned the role of documenting smoking status and providing cessation education
Outcomes	Documentation of smoking status and cessation counseling by clinicians
Notes	

Szpunar 2006

Methods	Country: USA Setting: Detroit, Michigan Design: Controlled before-and-after study. Pre-intervention data collection (9 weeks) and post intervention data collection (14 weeks). Two intervention clinics were compared to 4 control clinics. Regression analysis controlled for baseline demographics and co-morbidities. Patient surveys were completed at baseline and 2 weeks following a visit in the post-intervention period
Participants	Primary care patients attending 6 primary care clinics. These clinics form part of a large health care system. Clinics were selected based on convenience and size
Interventions	Screens were added to the electronic health record. A vital sign entry recorded smoking status and willingness to quit. Further screens were automated to provide information to the provider, suggested dialogue to use, and encouraged referral to a smoking cessation program
Outcomes	Documentation of clinician actions - ask, advise, assess, assist, arrange based on patient surveys
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Clinics were selected on ability to participate

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

Study	Reason for exclusion
Bentz 2006	Descriptive study, not testing any change
Conroy 2005	Not an electronic medical record intervention
Dubey 2006	Intervention was not electronic
Ellrodt 2007	Intervention was not electronic
Fung 2004	Survey, not an intervention
Hung 2007	Descriptive study, no intervention
Mullins 2009	Intervention was not electronic
Norris 2004	Descriptive study, no intervention
Ornstein 1995	Interevention no based on active smoking
Soto 2002	Descriptive study, no intervention
Yano 2008	Intervention was not electronic

DATA AND ANALYSES

Comparison 1. Study results

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 All outcomes			Other data	No numeric data
1.1 Randomized controlled trials			Other data	No numeric data
1.2 Controlled trials			Other data	No numeric data
1.3 Uncontrolled trials			Other data	No numeric data

Analysis 1.1. Comparison 1 Study results, Outcome 1 All outcomes.

All outcomes

Study	Smoking cessation	Guideline recommended actions
Randomized controlled trials		
Bentz 2007		Guideline actions increased within the intervention clinics for smoking status (94.5% vs 88.1% p<0.05), advised to quit (71.6% vs 52.7%, p<0.001), assessed interest in quitting 65.5% vs 40.1% p<0.001), and provided assistance (20.1% vs 10.5%, p < 0.001) Quitline referral increased in the intervention clinics (adjusted OR 1.53)
Linder 2009	Significantly more smokers in the intervention clinics were subsequently documented as nonsmokers compared to smokers in the control clinics (5.3% vs 1.9%, p < 0.001)	Significantly more smokers were referred to cessation counseling in the intervention clinics (4.5% vs 0.4% in control clinics, p<0.001), and significantly more smokers from intervention clinics made contact with a cessation counselor (3.9% vs 0.3% in control clinics, p<0.001). No difference in the proportion of documented smokers from control or intervention clinics prescribed any cessation medication (2.0% vs 2.0%)
Sherman 2008		The average number of smokers per month referred to telephone counseling increased from 1.0 to 15.6 (p< 0.001) among intervention clinic providers, and from 0.2 to 0.7 (p<0.04) among control clinic providers
Controlled trials		
Bentz 2002		Documentation of tobacco use was unchanged in the paper chart clinic, but increased from 79% to 88% in the enhanced EHR clinic

All outcomes (*Continued*)

Frank 2004		Assessment of smoking status was unchanged between intervention and control patient visits (2.0% vs 1.8%)
Szpunar 2006		Asking about tobacco use increased in the intervention clinics from 88.4% to 92.8%
Uncontrolled trials		
Koplan 2008		The proportion of smoking patients referred to cessation counseling increased from 0.8% to 2.1%; and medication ordered increased from 1.6% to 2.5%
Lindholm 2010		Tobacco use status in the EHR increased from 71.6% to 78.4% (p<0.001)
McCullough 2009		Tobacco use status increased from 71% to 84% (p<0.001). Assessement of plan to quit increased from 25.% to 51% (p<0.005), and smokers assessed for a plan to quit were more likely to receive cessation counseling (46% vs 14% among smokers not assessed, p<0.001)
Ragucci 2009	Of 90 smokers in the study, 29 were quit at 6 months (32%)	
Spencer 1999		Tobacco use status increased from 18.4% to 80.3%.

HISTORY

Protocol first published: Issue 10, 2010

Review first published: Issue 12, 2011

CONTRIBUTIONS OF AUTHORS

RB completed the search and screening.

RB and LS completed study selection; checking by MF.

RB extracted the data; checked by LS.

RB, LS, and MF wrote the text of the review.

DECLARATIONS OF INTEREST

Dr Boyle has no competing interest.

Dr Solberg has no competing interest.

Over the last five years, Dr Fiore has served as an investigator in research studies at the University of Wisconsin that were funded by Pfizer, GlaxoSmithKline and Nabi Biopharmaceuticals. From 1997 to February 2010, Dr. Fiore held a University of Wisconsin (UW) named Chair for the study of nicotine addiction, made possible by a gift to UW by GlaxoWellcome.

INDEX TERMS

Medical Subject Headings (MeSH)

*Electronic Health Records; Randomized Controlled Trials as Topic; Smoking [therapy]; Smoking Cessation [*methods]

MeSH check words

Humans