Implementation of Hypertension Clinical Practice Guidelines:

A Systematic Review of Strategies to Change Physician Behavior and Improve Patient Outcomes

By

Kevin Fischer

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Advisor: Stacey Sheridan, MD, MPH

Second Reader: Morris Weinberger, Ph.D.

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Abstract

Background: Hypertension remains a major cause of cardiovascular disease morbidity and mortality worldwide. There is strong evidence that blood pressure control is associated with significant reduction in morbidity and mortality caused by cardiovascular events. However, only one-third of Americans with hypertension have adequate blood pressure control. Clinical practice guidelines have been established to guide physician treatment of hypertension, yet many physicians do not follow these guidelines. In response to this problem, there is a growing body of literature regarding interventions designed to help physicians adhere to hypertension clinical practice guidelines.

Objectives: To systematically identify, appraise and synthesize studies of professional educational or quality assurance interventions designed to improve physician adherence to hypertension clinical practice guidelines. The effectiveness of various intervention strategies in changing physician behavior and improving patient outcomes will be evaluated

Research design: I performed a systematic review of studies published in MEDLINE between 1966 and 2005 describing interventions to improve physician adherence to hypertension guidelines in primary care. Randomized controlled trials, cohort studies, case control studies and time-series analyses describing physician-targeted educational or quality assurance interventions with objective measures of physician hypertension management behavior or patient blood pressure outcomes were included. Data from each study was abstracted in to evidence tables for review and all studies were assigned a quality grade based (good, fair, poor) based on their study design and potential for selection bias, measurement bias, and confounding.

Results: The initial Medline search yielded 574 citations of which 32 were included in this review. Three citations additional were identified through manual searching, These studies examined the following interventions: educational outreach (n=12), local opinion leaders (n=5), audit and feedback (n=16), decision support (n=5), reminders (n=11), and local consensus development (n=4). Interventions involving Educational Outreach, especially when combined with Local Opinion Leader and Audit and Feedback, resulted in moderate changes in prescribing behavior and small increases in blood pressure control. No studies examined the independent effects of educational outreach or local opinion leaders, but audit and feedback appeared to have no effect on its own. Interventions involving Reminders were highly effective in increasing screening and prescribing, but did not reduce blood pressure; while decision support was generally ineffective on its own. Local Consensus Development of Guidelines had moderate to large effects on prescribing behavior and had mixed results on blood pressure control.

Conclusions: No single educational or quality assurance intervention is superior to others in improving physician adherence to hypertension guidelines, although several interventions appear to be ineffective or untested on their own. Multifaceted Interventions especially those involving Educational Outreach by Local Opinion Leaders, Audit and Feedback, Local Consensus Guideline Development and/or Reminders appear to be the most promising physician oriented interventions to improve patient blood pressure control.

Introduction:

Hypertension:

Hypertension remains a major cause of cardiovascular disease morbidity and mortality worldwide. According to the World Health Organization (WHO), the worldwide prevalence of hypertension is estimated to be about 1 billion people, accounting for approximately 7.1 million deaths per year. Suboptimal blood pressure (>115mm hg systolic blood pressure, as defined by the WHO) is responsible for 49% of ischemic heart disease and 62% of cerebrovascular disease; and is the number one attributable risk factor for death throughout the world.[1] In the United States, 50 million people have high blood pressure warranting some form of therapy.[2, 3]

There is strong evidence that blood pressure control is associated with significant reduction in morbidity and mortality caused by cardiovascular events.[4-6] The number of deaths from both ischemic heart disease and stroke increase progressively and linearly from blood pressure levels as low as 115 mm Hg systolic and 75 mm Hg diastolic upward.[7] In clinical trials, antihypertensive therapy has been associated with a 35 to 40 percent mean reduction in stroke incidence; a 20 to 25 percent reduction in myocardial infarction; and more than a 50 percent reduction in heart failure.[6] Epidemiologic data from the National Health and Nutrition Examination Survey (NHANES) shows that the percentage of hypertensive patients receiving treatment increased from 31 percent in the period from 1976 to 1980 to 59 percent in the period from 1999-2000. During this time frame the

age-adjusted death rates from stroke and coronary heart disease declined by approximately 60 percent and 50 percent respectively.[7] It is reasonable to assume that much of this reduction in the rate of death from stroke and coronary heart disease can be attributed, at least in part to increasing treatment of hypertension.

Suboptimal Treatment of Population:

Despite widespread recognition of the high prevalence of hypertension, the high morbidity and mortality associated with hypertension and of the strong evidence that reducing blood pressure decreases cardiovascular morbidity and mortality, recognition and treatment of this condition remains suboptimal. Among a national sample of hypertensive patients (BP > 140/90 mm Hg), approximately 30 percent were unaware of their hypertension, 40 percent were not being treated, and two-thirds were not being controlled to blood pressure levels less than 140/90.[7] In a study of hypertensive patients in Veterans Affairs hospitals, 75 percent were not optimally controlled.[8] Furthermore, the prevalence of both congestive heart failure and end-stage renal disease have increased, due primarily to poor blood pressure control.[7]

As a result of poor hypertension control, at least two-thirds of the estimated 50 million Americans with hypertension are at increased risk for vascular complications.[9] It has been estimated that control of hypertension to below 140/90 mmHg could prevent 19 percent of coronary heart disease

events in men and 31 percent in women.[10] Although there have been improvements in the diagnosis and management of hypertension over the last few decades, current efforts to control hypertension are clearly suboptimal and a substantial amount of morbidity and mortality from cardiovascular events could be avoided with optimal treatment.

Clinical Practice Guidelines for Hypertension Treatment:

Over the last few decades an increasing number of committees and organizations have issued clinical practice guidelines for the diagnosis and treatment hypertension in an attempt to improve the care for hypertensive patients.[7, 11, 12] Guidelines have been defined as "systematically developed statements to assist practitioner and patients decisions about appropriate health care for specific clinical circumstances."[13] These clinical practice guidelines generally establish criteria for the diagnosis of hypertension, recommend treatments stratified by severity of disease, and provide blood pressure targets for treatment.

Although guidelines have been promoted as a means to influence physician behavior and improve patient outcomes, there is little evidence to show change or improvement in either.[14-16] Indeed many studies have shown that the passive dissemination of guidelines alone has only limited impact on outcomes for any disease.[17] If hypertension clinical practice guidelines are based on sound scientific research and provide guidance to physicians

regarding the most appropriate treatment for their patients, why then have they not had more impact on physician behavior or patient outcomes?

Barriers to Adherence to Clinical Practice Guidelines:

Failure of blood pressure control has been attributed to patient related barriers, physician-related barriers and external barriers. Patient noncompliance has been frequently proposed as a major cause of low blood pressure control rate. Causes of patient noncompliance include: limited access to care, financial restraints, and lack of knowledge about the seriousness of uncontrolled hypertension.[7, 18, 19] However, blood pressure control is still suboptimal even among patients who receive regular care and do not have difficulty accessing care.[20]

The treatment of hypertension is complex; and while patient-related and external barriers are significant impediments to care, physician related barriers to aggressively pursue recommended goals for blood pressure treatment are also major barriers to proper care;[20, 21] some contend that they may be the most important modifiable barrier to hypertension control.[19] For this reason, examining interventions designed to overcome physician-related barriers to proper blood pressure management is the focus of this paper.

Cabana and coworkers identified seven common barriers that keep physicians from following clinical practice guidelines. Barriers identified were: lack of awareness of guidelines, lack of familiarity with guidelines, lack of agreement with guidelines, lack of self-efficacy, lack of outcome

expectancy, inertia of previous practice, and external barriers.[16] With a rapidly expanding body of scientific knowledge, many physicians are not aware of the most applicable guidelines for each clinical situation. Even if physicians are aware of guidelines, lack of familiarity with the guidelines keeps physicians from employing them in clinical practice. Lack of agreement with guideline specifics or guidelines in general is a less common but important barrier. Self-efficacy is the belief that one can actually perform a behavior. Many physicians lack the self-efficacy to make a change recommended by a guideline. Even if physicians feel that they can make a change, without clear expectations for improved patient outcomes, physicians often will not initiate a change. Inertia of previous practice is often difficult to overcome; old habits are hard to break. Finally external barriers, such as lack of time, facilities or staff may also keep a physician from making a change based on a practice guideline.

Hypertension-Specific Barriers to Adherence to Clinical Practice Guidelines:

Although the general barriers to guideline adherence apply to the management of hypertension, the relative importance of each barrier differs from those of other diseases. Hypertension management is different than the management of most other conditions. Unlike the management of acute diseases and many chronic diseases, in which symptoms, treatment and outcome can easily be correlated and understood by patient and physician, hypertension generally persists without symptoms for years making it

difficult for both physicians and patients to see the consequences of treatment or non-treatment. Therefore lack of outcome expectancy may be a very important barrier to overcome in the management of hypertension; this may be especially true with small elevations in blood pressure that seem inconsequential but contribute importantly to overall risk. Without clear expectations for improved patient outcomes, physicians often will not initiate a change in care, which makes lack of self-efficacy particularly important in the treatment of hypertension.

Lack of awareness of guidelines and lack of familiarity with guidelines are important barriers in the management of hypertension, but are similar to other disease states. In one study 52 percent of primary care physicians said that they were very familiar with JNC VI guidelines in 2001.[18] Cabana and colleagues found that the median awareness rate of guidelines across 46 disease states was 54.5 percent.[16] Lack of awareness and familiarity with guidelines are important barriers to proper hypertension management, but these barriers are not specific to hypertension.

Lack of agreement with guidelines may be a significant specific barrier to proper hypertension management. Many physicians believe that the treatments suggested by guidelines are too aggressive and are fearful of adverse drug effects.[22] Fear of injuring patients may be a deterrent to treat a symptom-free disease, especially when lack of outcome expectancy is high. Indeed, several studies indicate that physicians are not aggressive enough in management of hypertension.[8, 18, 19, 23]

Physicians appear to over-estimate their adherence to hypertension guidelines, particularly with regards to the proportion of their patients with controlled blood pressure.[24] This limited awareness of practice performance may also represent a barrier to successful implementation of guidelines. If physicians believe that most patients in their practices have controlled blood pressure, they may be less aggressive about identifying and treating uncontrolled hypertension. Without evidence of how they are actually performing, physicians may not be able to overcome inertia of previous practice. This lack of evidence also prevents physicians from seeing the improvements in hypertension management that occur after a change, and so lack of self-efficacy may also be an important barrier to hypertension management, although this is unproven.

Hypertension is a complex, often symptom-free, chronic condition that is difficult to treat. In order to improve physician adherence to hypertension management guidelines and improve the quality of patient care, interventions must be designed to overcome the general barriers to implementing guidelines as well as the specific barriers to implementing hypertension guidelines. The specific barriers to hypertension management that may be more important than in other conditions include: lack of outcome expectancy, lack of agreement with aggressive management guidelines, lack of self-efficacy and inertia of previous practice. Figure 1 summarizes general and specific barriers to hypertension guideline adherence.

Interventions to Increase Physician Adherence to Guidelines:

Given the failure of passive guideline dissemination strategies to affect physician behavior or patient outcomes, several active dissemination and implementation strategies have been employed. Grimshaw and coworkers have provided a framework for categorizing quality assurance and educational interventions designed to change physician behavior.[25] The categories of interventions include: passive dissemination of guidelines, educational outreach, local opinion leaders, audit and feedback, computer-based decision support systems, reminder systems, continuing medical education, local consensus guideline development and multifaceted interventions. See Figure 1 for a list of interventions and what barriers they may address.

"**Passive Dissemination** of educational materials involves distribution of published or printed recommendations for clinical care, including clinical practice guidelines, audio-visual materials, and electronic publications. These materials may have been delivered personally or through mass mailings."[25] Passive dissemination of educational materials is familiar, convenient and low cost and may be useful in overcoming several physician-related barriers to hypertension guideline adherence: including lack of awareness, lack of familiarity and lack of agreement with guidelines. The low intensity nature of passive dissemination of educational materials makes it difficult to measure the effects of this intervention strategy.

Educational Outreach visits include "use of a trained person who meets with providers in their practice settings to provide information with the intent of changing the provider's performance."[25] Educational outreach has the potential to overcome many physician-related barriers to hypertension guideline adherence. Like passive dissemination of educational materials, educational outreach can address barriers relating to lack of awareness, lack of familiarity and lack of agreement with guidelines. Furthermore, by delivering tailored messages to individual practitioners, educational outreach can address barriers including: lack of outcome expectancy, lack of self-efficacy, and inertia of previous practice.

Local Opinion Leaders are "providers nominated by their colleagues as educationally influential."[25] Local opinion leaders advocate a change and attempt to influence the behavior of colleagues. Local opinion leaders are often used to deliver educational outreach, and in this review I will treat local opinion leaders as a subgroup of educational outreach interventions. Local opinion leaders can strengthen educational outreach, by lending authority to the message delivered. Since they are generally respected authorities, local opinion leaders may be effective in improving hypertension guideline adherence by overcoming the following barriers: lack of agreement with guidelines, lack of outcome expectancy, and lack of self-efficacy.

Audit and Feedback includes "any summary of clinical performance over a specified period of time" given to the provider in written or verbal format, and "may include recommendations for clinical care."[25] Generally

audit and feedback appears to be a useful way of measuring physician performance and providing specific guidance to physicians in areas that need improvement. Audit and Feedback may be beneficial in overcoming outcome expectancy and self-efficacy by demonstrating to the physician the effects of treatment in his or her patient population. Audit and feedback may also help to overcome inertia of previous practice by giving underperforming physicians hard evidence that their patient management is below either goal performance or the performance of peers.

Computer-Based Decision Support Systems provide diagnostic or therapeutic advice to physicians at the point of care. In the management of hypertension, computer-based decision support may help to overcome several barriers to guideline adherence. First, by providing information about problem-specific guidelines, physicians can gain familiarity with appropriate guidelines. Decision support can also address lack of self-efficacy and inertia of previous practice, by providing targeted advice to the physician for each patient. Currently, computer-based decision support may be too expensive for most practitioners, but wider use may make it affordable in the near future.

Reminder Systems include "Any intervention that prompts the health care provider to perform a patient- or encounter-specific clinical action."[25] Like decision support systems, reminder systems may be effective in overcoming lack of familiarity, lack of self-efficacy, and inertia of previous practice regarding hypertension management. Reminder systems can be

paper-based or computer-based and may currently be more feasible and less costly to individual providers than computerized decision support.

Continuing Medical Education (CME) is compulsory for many health care providers and is very heterogeneous in terms of the nature of the educational method, the duration, the content and the intensity. Continuing medical education may involve self-study, meetings, conferences, lectures, workshops, seminars, symposia and classes. In a review by Thomson O'Brien and coworkers, traditional didactic lectures appeared to be generally ineffective in changing physician behavior. However, interactive meetings, small group meetings, and practice sessions to improve skills were moderately effective in several studies.[26] In the management of hypertension, CME may help overcome barriers relating to: lack of awareness, lack of familiarity, and lack of agreement with guidelines.

Local Consensus Development of guidelines involves "inclusion of participating providers in discussion to ensure that they agree that the chosen clinical problem is important and the approach to managing the problem is appropriate."[25] Involving people in the decision-making process about issues that will affect them may lead to their having more of a sense of ownership and a greater commitment to adhering to the decision reached.[27] In the management of hypertension, local consensus development and implementation of guidelines may help to overcome barriers relating to: lack of awareness, lack of familiarity, lack of agreement, lack of self-efficacy, and inertia of previous practice.

Multifaceted Interventions, which include any combination of the strategies discussed above, are generally more effective than any one strategy alone.[25, 28] In general, active approaches are much more effective than passive strategies and no one strategy is effective in all circumstances. Interventions based on assessment of potential barriers and targeted to specific circumstances are more likely to be effective than interventions not targeted to specific circumstances.[25] Multifaceted interventions have the potential to overcome many barriers simultaneously and may provide the best means to affect physician behavior change.

Interventions to Increase Adherence to Hypertension Guidelines:

Although there have been a large number of studies examining the effectiveness of professional educational or quality assurance interventions to broadly affect physician change or patient outcomes, there are very few studies examining the effects of these interventions on the management of specific disease states.[29] Because no single physician change intervention has been shown to work best in all circumstances, it follows that interventions should be tailored to specific circumstances. Given its profound societal health impacts, the suboptimal treatment of the population, and the complexity of its management, hypertension is an important clinical condition that warrants an evaluation of educational or quality improvement interventions specifically targeting physician behavior related to its diagnosis and treatment. The relative importance of barriers to hypertension

management may be different enough from other disease states, that effective interventions may differ for treating hypertension and treating other conditions. It is not known if the effectiveness quality assurance or educational interventions is different across disease states.

To date there has been one review of interventions designed to change physician behavior with regards to hypertension management.[29] Tu and coworkers reviewed twelve studies published between January 1966 and August 2000 and found that most interventions were ineffective in changing physician behavior. This review included only randomized controlled trials. Although controlled cohort studies, time-series analyses and case control studies are weaker designs, much can still be learned from these types of studies. The authors also fail to provide any perspective on the relative size or quality of the studies reviewed, making their findings difficult to interpret. Additionally, since 2000 several additional studies describing interventions designed to change physician behavior with regards to hypertension management have been published. Therefore a current systematic review of interventions designed to change physicians' hypertension management behaviors is necessary.

Figure 1. Physician-Related Barriers to Guideline Adherence and Interventions Designed to Overcome these Barriers.

General Physician-Related Barriers to Guideline Adherence*	Hypertension-Specific Physician-Related Barriers to Guideline Adherence	Interventions Designed to Overcome these Barriers+
1) Lack of Awareness →	In one study only 52% of primary care physicians said that they were very familiar with JNC VI Guidelines.[18]	Passive Dissemination (1,2,3)$
2) Lack of Familiarity →		Educational Outreach (1,2,3,4,5,6)
3) Lack of Agreement →	Many physicians do not feel that patients should be treated as aggressively as recommended and fear adverse drug effects.[22]	Local Opinion Leaders (3,4,5)
4) Lack of Outcome Expectancy →	Hypertension has a long symptom-free course and many doctors believe that patients will be non-compliant with therapy.[19]	Audit and Feedback (4,5,6)
5) Lack of Self-Efficacy →	It is difficult to change practice patterns especially in hypertension management, given constantly evolving guidelines for diagnosis and treatment of hypertension.	Decision Support (2,5,6)
6) Inertia of Previous Practice →	Many physicians also overestimate their adherence to hypertension guidelines and do not realize that they are not treating most of their patients correctly according to guidelines.[24]	Continuing Medical Education (1,2,3)
		Reminder Systems (2,5,6)
7) External Barriers →	Limited time with patients. Prevention issues often overshadowed by acute care needs of patient. Inefficient medical record keeping. Patient related barriers.	Local Consensus Guideline Development (1,2,3,5,6)
		Multifaceted Interventions (1-7)

Figure 1.
* adapted from Cabana et al[16]
+ adapted from Grimshaw et al[25]
$ Numbers in parenthesis indicate which barriers each intervention may help to overcome.

Methods

Search Strategy

I conducted a systematic review of the literature regarding interventions aimed at changing physician behavior to adhere to clinical practice guidelines in the treatment of hypertension. I searched all articles limited to English language published from January 1, 1966 to May10, 2005 using MEDLINE. The following search phrase was used: "Hypertension AND (guideline adherence OR academic detailing OR guideline dissemination OR opinion leader OR chart review OR continuing medical education OR audit and feedback OR outreach OR physician behavior OR practice guidelines OR program evaluation OR quality assurance OR continuous quality improvement OR recall system OR reminder system OR decision support system OR registries OR medical record system) AND (trial OR clinical trial OR randomized control trial OR intervention)." The above search phrase was exploded by the MEDLINE search engine to include both MESH terms and Text terms. Additional candidate articles were identified by reviewing bibliographies of articles from the search and bibliographies from various review articles and books.

Inclusion and Exclusion Criteria

Randomized controlled trials, cohort studies, case control and time-series analyses with objective measures of the effects of a physician-targeted

educational or quality assurance intervention on physician hypertension management behavior or patient blood pressure outcomes were included. Articles that described case series studies or studies that did not measure either physician behavior or patient outcomes were excluded from the study. Studies were excluded in which physician self-reported change, physician competency exams, or patient compliance was the outcome measure. Studies were also excluded if the major target of the intervention was the patient or a healthcare professional other than a physician.

Data Extraction

I reviewed the abstracts of candidate articles from the initial search. I then reviewed the full text of those articles that appeared to meet the initial inclusion criteria. The following data was then abstracted from each article: study design, study population, description of the intervention, comparability of the subjects, outcomes (description of physician behavior measurement, description of patient outcome measurement), potential for bias, and a description of the overall quality. Scores were determined from the sum of study design (1 point for time-series analysis, or case control, 2 points for controlled cohort study, 3 points for randomized controlled trial), selection bias (3 points for low potential, 2 points for medium potential, 1 point for low potential), measurement bias (3 points for low potential, 2 points for medium potential, 1 point for low potential), and confounding (3 points for low potential, 2 points for medium potential, 1 point for low potential). A quality

rating was assigned to each article based on a total score of 1-12. Good articles scored from 9-12, fair articles scored from 5-8, and poor articles scored from 1-4. The data abstraction form used for this review is included in Appendix A.

Results

Search results

The initial MEDLINE search yielded 574 citations. After review of abstracts 537 studies were excluded for reasons including: excluded study design, physicians were not the targeted group, review article, protocol article, duplicate article or no objective measurement. The remaining 37 full text articles were reviewed in their entirety. After applying inclusion and exclusion criteria to the full text articles, 32 were included in the review. Five full text articles were excluded because they had no objective measurements (2 studies), unclear intervention (1 study) or intervention did not target physicians (2 studies). After manual review of bibliographies, 3 additional studies were found that met inclusion and exclusion requirements. In total, information from 35 studies was abstracted into evidence tables for review. See Figure 2 for flow of articles. See Tables 1-7 and Appendix B and Appendix C for summary data on each reviewed article.

Figure 2 Search Results

The Medline search was conducted using the following search term: "Hypertension AND (guideline adherence OR academic detailing OR guideline dissemination OR opinion leader OR chart review OR continuing medical education OR audit and feedback OR outreach OR physician behavior OR practice guidelines OR program evaluation OR quality assurance OR continuous quality improvement OR recall system OR reminder system OR decision support system OR registries OR medical record system) AND (trial OR clinical trial OR randomized control trial OR intervention)." Manual search strategy included review of bibliographies and discussion with experts.

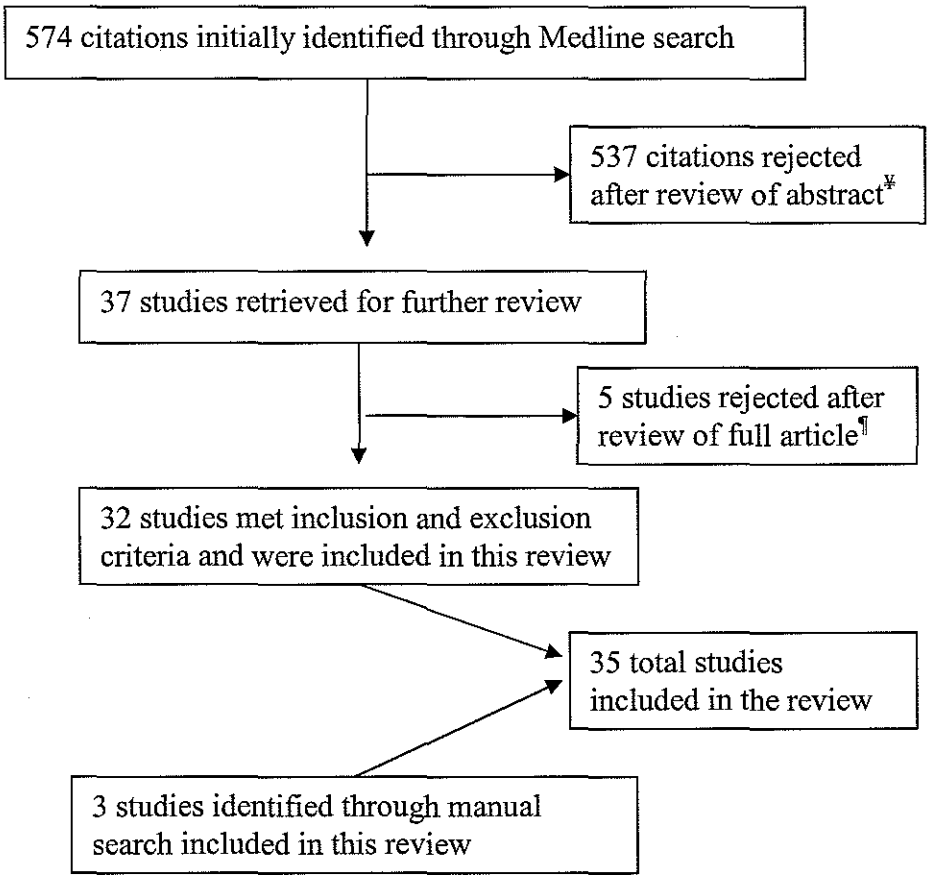

Figure 1. Flow of articles

¥ Reasons for exclusion of abstracts included: review article, protocol article non-experimental study, duplicate article, study design, no objective measures or physician not targeted group.

¶ Reasons for exclusion of full articles included: no objective measurements (2 studies), unclear intervention (1 study) or intervention did not target physicians (2 studies).

Table 1 Studies Involving Educational Outreach

Study/year	Simon[30] (2005)	Nilsson[31] (2001)	Denton[32] (2001)	Ornstein[33] (2004)	Maue[34] (2002)
Intervention	Educational Outreach, Local Opinion Leader	Educational Outreach, Local Opinion Leader, Audit and Feedback	Educational Outreach, Local Opinion Leader, Audit and Feedback	Educational Outreach, Audit and Feedback, CME	Educational Outreach, Audit and Feedback, CME
Study Design	RCT	RCT	RCT	RCT	TSA
Quality	Good	Good	Fair	Good	Fair
Results	**Screening:** N/A **Therapy:** Positive **BP Control:** Negative	**Screening:** N/A **Therapy:** Positive **BP Control:** N/A	**Screening:** N/A **Therapy:** Positive **BP Control:** N/A	**Screening:** Positive **Therapy:** N/A **BP Control:** Positive	**Screening:** N/A **Therapy:** Negative **BP Control:** Positive
Comment	Size: 367 Clinicians *Local opinion leaders*, trained in educational outreach, delivered one-time targeted messages 15-45 minutes in length to HMO primary Care Physicians. Targeted messages were developed through focus group discussions, and focused on using guideline-specified drugs. Diuretic and B-blocker use increased 13% compared to 6% in control group after 1 year.	Size: 40 Clinicians *Local opinion leaders* delivered educational outreach visits to general practitioners three times for 1 hour. Educational message focused on using guideline-specified drugs and provided each clinician data on personal prescribing rates. Small increase in use of diuretics and small decrease in use of ACEI and ARB after 1 year.	Size: 44 Clinicians *Local opinion leader* vs. Medical Intern delivered a one-time group outreach visit to attending and resident physicians, focusing on guideline-specified management of HTN and incorporating feedback on personal prescribing rates. Decisions consistent with guidelines improved 29% in opinion leader group vs. 4% in intern group.	Size: 61 Clinicians Quarterly reports of performance indicators were sent to each practice over two years. Quarterly outreach visits by a *physician* and, focused on quality improvement, education and motivation. There was a small improvement in screening and diagnosis in the intervention group. 60% of intervention hypertensive patients were controlled vs. 40% in the control group.	Size: 62 Clinicians Several outreach visits were performed by *clinical pharmacists* over one year. Visits included educational material and personal performance profiles with names of hypertensive patients not well controlled. Blood pressure control (<140/90) improved from 41% to 52% before and after intervention. There was no change in drug therapy before and after intervention.

Table 1 Studies Involving Educational Outreach

Study/year	New[35] (2004)	Frijling[36] (2003)	Siegel[37] (2003)	Inui[38] (1976)
Intervention	Educational Outreach, Audit and Feedback	Educational Outreach, Audit and Feedback	Educational Outreach, Audit and Feedback	Educational Outreach, Audit and Feedback
Study Design	RCT	RCT	CCT	RCT
Quality	Good	Good	Fair	Fair
Results	**Screening:** N/A **Therapy:** N/A **BP Control:** Negative	**Screening:** N/A **Therapy:** Negative **BP Control:** N/A	**Screening:** N/A **Therapy:** Positive **BP Control:** Negative	**Screening:** N/A **Therapy:** N/A **BP Control:** Positive
Comment	Size: 44 Clinicians *Specialist nurses* performed four quarterly educational outreach visits including protocols and clinical targets to intervention GPs. Visits also included lists of patients not at target and performance feedback. There was no difference in BP control in intervention group vs. control group: 48.2% vs. 47.9%.	Size: 121 Clinicians A single educational outreach visit by a *trained non-physician* was provided to GPs in the intervention group. Visit included feedback of personal performance and education about guidelines, management of hypertension and ways to change practice. There was no difference in antihypertensive therapy between groups before and after the intervention.	Size: 5 Clinics, # clinicians NR Trained *pharmacists* delivered several 15 minute outreach visits to resident physicians consisting of discussion of guidelines, hypertension management and barriers to successful treatment. Visits also included feedback of individual hypertension management performance. No change in BP control. The use of Calcium Channel blockers decreased 5% and the use of B-blockers and diuretics increased 6% before and after intervention.	Size: 62 Clinicians A single educational outreach visit lasting 1 hour was provided to attending and resident physicians by a *physician*. The meeting focused on strategies to identify and manage uncontrolled patients and included feedback on personal performance. After 6 months, 69% of intervention group patients had DBP < 100, vs. 32% of control group. Both groups were similar at baseline.

Table 1. Nine studies involving Educational Outreach. Three other studies involving Educational Outreach are included in Table 7 (multifaceted interventions). RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial. The characteristics of the person delivering the outreach are in italics.

Table 2 Studies Involving Audit and Feedback

Study/year	Simon[39] (2005)	Kogan[40] (2003)	Winickoff[41] (1985)	Dickinson[42] (1981)	New[35] (2004)
Intervention	Audit and Feedback	Audit and Feedback	Audit and Feedback	Audit and Feedback	Audit and Feedback, Educational Outreach
Study Design	TSA	RCT	RCT	RCT	RCT
Quality	Fair	Fair	Fair	Good	Good
Results	**Screening:** N/A **Therapy:** Negative **BP Control:** Negative	**Screening:** N/A **Therapy:** Negative **BP Control:** N/A	**Screening:** Negative **Therapy:** N/A **BP Control:** Negative	**Screening:** Positive **Therapy:** N/A **BP Control:** Negative	**Screening:** N/A **Therapy:** N/A **BP Control:** Negative
Comment	Size: 12 Clinicians Resident physicians were encouraged to view an online report card reviewing prescribing performance. *Only 33% of residents viewed the report card.* There was no change in the percentage of patients receiving diuretics or B-blockers before and after the intervention.	Size: 44 Clinicians Residents in intervention group were given a single report card based on personal performance, giving *comprehensive scores for 78 categories of preventive care.* There was no difference in change in hypertension management scores in the intervention group and control group before and after intervention.	Size: 30 Clinicians Physicians in the intervention group received quarterly performance reports concerning their performance in managing hypertension and lists of patients who were uncontrolled during one year. There was no difference in blood pressure control or screening in the intervention group vs. control.	Size: 41 Clinicians Resident physicians in the intervention group received feedback of personal performance and *lists of patients requiring further screening*. They also received self-guided CME. The percentage of patients screened was twice as high in the intervention group vs. control. No difference in average blood pressure between groups.	Size: 44 clinicians Specialist nurses performed four quarterly educational outreach visits including protocols and clinical targets to intervention GPs. Visits also included lists of patients not at target and performance feedback. There was no difference in BP control in intervention group vs. control group: 48.2% vs. 47.9%.

Table 2 Studies Involving Audit and Feedback

Study/year	Frijling[36] (2003)	Siegel[37] (2003)	Inui[38] (1976)	Nilsson[31] (2001)	Denton[32] (2001)
Intervention	Audit and Feedback, Educational Outreach	Audit and Feedback, Educational Outreach	Audit and Feedback, Educational Outreach	Audit and Feedback, Educational Outreach, Local Opinion Leader	Audit and Feedback, Educational Outreach, Local Opinion Leader
Study Design	RCT	CCT	RCT	RCT	RCT
Quality	Good	Fair	Fair	Good	Fair
Results	**Screening:** N/A **Therapy:** Negative **BP Control:** N/A	**Screening:** N/A **Therapy:** Positive **BP Control:** Negative	**Screening:** N/A **Therapy:** N/A **BP Control:** Positive	**Screening:** N/A **Therapy:** Positive **BP Control:** N/A	**Screening:** N/A **Therapy:** Positive **BP Control:** N/A
Comment	Size: 121 Clinicians A single educational outreach visit by a trained non-physician was provided to GPs in the intervention group. Visit included feedback of personal performance and education about guidelines, management of hypertension and ways to change practice. There was no difference in antihypertensive therapy between groups before and after the intervention.	Size: 5 Clinics, # clinicians NR Trained pharmacists delivered several 15 minute outreach visits to resident physicians consisting of discussion of guidelines, hypertension management and barriers to successful treatment. Visits also included feedback of individual hypertension management performance. No change in BP control. The use of Calcium Channel blockers decreased 5% and the use of B-blockers and diuretics increased 6%.	Size: 62 Clinicians A single educational outreach visit lasting 1 hour was provided to attending and resident physicians. The meeting focused on strategies to identify and manage uncontrolled patients and included feedback on personal performance. After 6 months, 69% of intervention group patients had DBP < 100, vs. 32% of control group. Both groups were similar at baseline.	Size: 40 Clinicians Local opinion leaders delivered educational outreach visits to general practitioners three times for 1 hour. Educational message focused on using guideline-specified drugs and provided each clinician data on personal prescribing rates. Small increase in use of diuretics and small decrease in use of ACEI and ARB after 1 year.	Size: 44 Clinicians Local opinion leader vs. Medical Intern delivered a one-time group outreach visit to attending and resident physicians, focusing on guideline-specified management of HTN and incorporating feedback on personal prescribing rates. Decisions consistent with guidelines improved 13% in opinion leader group vs. 4% in intern group.

Table 2 Studies Involving Audit and Feedback

Study/year	Ornstein[33] (2004)	Maue[34] (2002)	Mitchell[43] (2004)	Gullion[44] (1988)
Intervention	Audit and Feedback, Educational Outreach, CME	Audit and Feedback, Educational Outreach, CME	Audit and Feedback, Reminders	Audit and Feedback, CME
Study Design	RCT	TSA	RCT	RCT
Quality	Good	Fair	Good	Good
Results	**Screening:** Positive **Therapy:** N/A **BP Control:** Positive	**Screening:** N/A **Therapy:** Negative **BP Control:** Positive	**Screening:** Negative **Therapy:** Negative **BP Control:** Positive	**Screening:** N/A **Therapy:** N/A **BP Control:** Positive
Comment	Size: 61 Clinicians Quarterly reports of performance indicators were sent to each practice over two years. Quarterly outreach visits focused on quality improvement, education and motivation. There was a small improvement in screening and proper diagnosis in the intervention group. 60% of intervention hypertensive patients were controlled vs. 40% in the control group.	Size: 62 Clinicians Several outreach visits were performed by clinical pharmacists over one year. Visits included educational material and personal performance profiles with names of hypertensive patients not well controlled. Blood pressure control (<140/90) improved from 41% to 52% before and after intervention. There was no change in drug therapy before and after intervention.	Size: 54 Clinicians General practitioners in the intervention group received 2 annual feedback reports on the percentage of patients controlled compared with peers as well as a list of patients who were at high risk for cardiovascular events and required therapy. Patients with controlled blood pressure increased 4% (p=0.028) from 45% to 49% in the intervention group and did not change in the control group. There was no difference in screening or therapy between groups.	Size: 111 Clinicians Primary care physicians in the intervention group received personal performance report on hypertension management and participated in CME. There was a small decrease in the average blood pressure of patients in the intervention group vs. control group.

Table 2. Fourteen studies involving Audit and Feedback. Three other studies involving Audit and Feedback are included in Table 7 (multifaceted interventions). RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial.

Table 3 Studies Involving Decision Support

Study/year	Murray[45] (2004)	Montgomery[46] (2000)	Hetlevik[47] (1999)	McAlister[48] (1986)	Rogers[49] (1982)
Intervention	Decision Support	Decision Support	Decision Support, CME	Decision Support, Reminders	Decision Support, Reminders
Study Design	RCT	RCT	RCT	RCT	RCT
Quality	Good	Fair	Fair	Good	Fair
Results	**Screening:** N/A **Therapy:** Negative **BP Control:** Negative	**Screening:** N/A **Therapy:** Negative **BP Control:** Negative	**Screening:** N/A **Therapy:** N/A **BP Control:** Negative	**Screening:** N/A **Therapy:** N/A **BP Control:** Positive	**Screening:** Positive **Therapy:** N/A **BP Control:** Negative
Comment	Size: 150 Clinicians Pertinent JNC VI Guideline-consistent care suggestions were provided to physician at time of order entry for every patient. *Physicians were not required to interact or respond to suggestions and could easily bypass them.* There was no difference in therapy or BP control between groups	Size: 74 Clinicians Clinical decision support system incorporated into EMR provided 5-year cardiovascular risk to physician at time of visit. *No patient management suggestions were provided.* There was no difference in average BP between groups or rates of prescription of antihypertensive drugs. May not have been powered enough to see difference.	Size: 63 Clinicians Clinical decision support system provided as an external program to EMR that physicians must open separately. Program gave suggestions of diagnosis and treatment of hypertension. *The program was only used in the care of 12% of patient visits.* No significant difference between groups in average blood pressure.	Size: 60 Clinicians Clinical decision support provided to primary care physicians giving recommendations on care and *providing lists of patients with uncontrolled hypertension* and those who require further tests. Diastolic BP in the control group among newly diagnosed patients decreased 21.7 mm Hg, vs. 16.7 mm Hg in the control group.	Size: 1 clinic, 479 patients, # clinicians NR Intervention group received a computer-generated summary of patient blood pressure history, tests completed and medications tried, as well as suggestions for care. These suggestions and reminders were placed in the chart with the clinic note. There was a small positive effect on screening tests in the intervention group vs. control and no difference in average BP between groups.

Table 3. Five studies involving Decision Support. RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial.

Table 4 Studies Involving Reminders

Study/year	Toth-Pal[50] (2004)	Rossi[51] (1994)	McDowell[52] (1989)	Barnett[53] (1983)	Bulpitt[54] (1976)
Intervention	Reminders	Reminders	Reminders	Reminders	Reminders
Study Design	RCT	RCT	RCT	RCT	RCT
Quality	Good	Good	Good	Good	Good
Results	**Screening:** Positive **Therapy:** N/A **BP Control:** N/A	**Screening:** N/A **Therapy:** Positive **BP Control:** Negative	**Screening:** Positive **Therapy:** N/A **BP Control:** N/A	**Screening:** Positive **Therapy:** N/A **BP Control:** N/A	**Screening:** N/A **Therapy:** N/A **BP Control:** Negative
Comment	Size: 20 Clinicians Computerized reminder of tests that the individual patient required was displayed to the physician at the time of order entry and was integrated into the established EMR. The rate of screening was 13.3% higher in intervention group vs. control.	Size: 35 Clinicians Reminders consisted of a form placed in the chart of all patients taking calcium channel blockers (CCB) that asked the physician to switch to a diuretic or B-blocker or check a box describing the indication for the patient to remain on CCB. *The physician was required to interact with form and 72% were completed.* 11% of patients were switched from CCB in intervention group vs. 1% of controls. No difference in blood pressure between groups.	Size: 1 clinic, 5357 patients, # clinicians NR Printed reminders placed on the chart of patients requiring blood pressure screening. Screening increased in the intervention group 30.7% vs. 21.1% in the control group.	Size: 1 clinic, 115 patients, # clinicians NR Reminder lists of patients with diastolic BP > 100 mm Hg *were sent repeatedly to intervention physicians until patient follow- up was scheduled.* After 20 months, 98% of intervention group patients had follow-up appointment scheduled vs. 46% of controls.	Size: 3 clinics, 278 patients, # clinicians NR Computerized summary was placed in the chart with clinic note of intervention patients. The summary consisted of the patient's hypertension history, symptoms, treatment, and blood pressure for each visit. After one year, there was no difference in the average BP of intervention patients vs. control patients.

Table 4 Studies Involving Reminders

Study/year	Sanders[55] (2002)	Cohen[56] (1985)	Mitchell[43] (2004)	McAlister[48] (1986)	Rogers[49] (1982)
Intervention	Reminders	Reminders, Automatic Scheduling	Reminders, Audit and Feedback	Reminders, Decision Support	Reminders, Decision Support
Study Design	RCT	TSA	RCT	RCT	RCT
Quality	Poor	Fair	Good	Good	Fair
Results	**Screening:** N/A **Therapy:** Negative **BP Control:** N/A	**Screening:** Positive **Therapy:** Positive **BP Control:** N/A	**Screening:** Negative **Therapy:** Negative **BP Control:** Positive	**Screening:** N/A **Therapy:** N/A **BP Control:** Positive	**Screening:** Positive **Therapy:** N/A **BP Control:** Negative
Comment	Size: 22 Clinicians "Highly visible" reminder with JNC VI algorithm of care placed on the chart cover of intervention group before the patient visit. There was no difference in medication changes between intervention and control group. Serious flaws with internal validity, including: no physician randomization, possible large cluster effect, small sample, and no guarantee that physicians actually saw the reminders or knew what they were.	Size: 10 Clinicians *Automatic scheduling of patients* requiring further blood pressure screening combined with chart reminders led to 40% decrease in the number of patients who required screening but didn't get it. Also resulted in a 30% decrease in the number of patients without antihypertensive prescription who had an indication for drug therapy.	Size: 54 Clinicians General practitioners in the intervention group received 2 annual feedback reports on the percentage of patients controlled as well as a *list of patients who were at high risk for cardiovascular events.* Patients with controlled blood pressure increased from 45% to 49% in the intervention group and did not change in the control group. No difference in screening or therapy between groups.	Size: 60 Clinicians Clinical decision support provided to primary care physicians giving recommendations on care and *providing lists of patients with uncontrolled hypertension* and those who require further tests. Diastolic BP in the control group among newly diagnosed patients decreased 21.7 mm Hg, vs. 16.7 mm Hg in the control group	Intervention group received a computer-generated summary of patient blood pressure history, tests completed and medications tried, as well as suggestions for care. These suggestions and reminders were placed in the chart with the clinic note. There was a small positive effect on screening tests in the intervention group vs. control and no difference in average BP between groups. Study was of *small size.*

Table 4. Ten studies involving Reminders. One other study involving Reminders is included in Table 7 (multifaceted interventions). RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial.

Table 5 Studies Involving Continuing Medical Education

Study/year	Jennett[57] (1989)	Evans[58] (1986)
Intervention	Continuing Medical Education	Continuing Medical Education
Study Design	RCT	RCT
Quality	Good	Poor
Results	**Screening:** Positive **Therapy:** N/A **BP Control:** N/A	**Screening:** N/A **Therapy:** N/A **BP Control:** Negative
Comment	Size: 22 Clinicians Intervention was a 6 week education program, consisting of newsletters, small group discussions and teleconferences. The control group received no education. After 12 months, the intervention group performed 42.2% of recommended screening and follow-up behaviors from a baseline of 14.7%. The control group performed 10.1% of recommended screening and follow-up behaviors from a baseline of 13.5%.	Size: 76 Clinicians Hypertensive patients were identified through community survey and referred to their primary care provider for follow up. The intervention group of providers received 14 weekly installments of educational materials and the control group received no education. There were similar decreases in blood pressure in both groups. Referral alone may have accounted for decrease in BP in both groups. The study suffers from serious flaws in internal validity.

Table 5. Two studies involving Continuing Medical Education alone. RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial.

Table 6 Studies Involving Local Consensus Development of Guidelines

Study/year	Avanzini[59] (2002)	Onion[60] (1996)	Putnam[61] (1989)
Intervention	Local Consensus Guideline Development	Local Consensus Guideline Development	Local Consensus Guideline Development
Study Design	CCT	CCT	RCT
Quality	Fair	Fair	Fair
Results	**Screening:** N/A **Therapy:** Positive **BP Control:** Positive	**Screening:** N/A **Therapy:** Positive **BP Control:** N/A	**Screening:** N/A **Therapy:** N/A **BP Control:** Negative
Comment	Size: 90 Clinicians Small group of physicians developed a simple, evidence-based guideline protocol and implemented it in practice. Recommended drug use improved by several percentage points in intervention group vs. no change in control. Intervention group average blood pressure fell from 151.8/86.0 mm Hg to 143.1/81.4 mm Hg. There was no change in average blood pressure in control group.	Size: 69 Clinicians Small group of physicians produced evidence-based guidelines for hypertension management. Drug of choice was Bendrofluazide. The number of prescribed daily doses of Bendrofluazide in the intervention group was double that of the national (UK) average after the intervention. Prescription rates were similar at baseline.	Size: 40 Clinicians Small group of physicians produced evidence-based guidelines for hypertension management. There was no difference in the number of uncontrolled hypertensive patients becoming controlled between intervention and control.

Table 6. Three studies involving Local Consensus Development of Guidelines. One other study of Local Consensus is included in the Table 7 (multifaceted interventions). RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial.

Table 7 Studies Involving Multifaceted Interventions

Study/year	Mcdermott[62] (2003)	Goldberg[63] (1998)	Aucott[64] (1996)
Intervention	Educational Outreach, Audit and Feedback, Reminders, CME	Educational Outreach, Local Opinion Leader, Continuous Quality Improvement, CME	Educational Outreach, Local Opinion Leader, Audit and Feedback, Local Consensus Guideline Development
Study Design	TSA	RCT	CCT
Quality	Fair	Fair	Fair
Results	**Screening:** Positive **Therapy:** Positive **BP Control:** Positive	**Screening:** N/A **Therapy:** Negative **BP Control:** Negative	**Screening:** N/A **Therapy:** Positive **BP Control:** Positive
Comment	Size: 21 clinics, 921 patients# clinicians NR This multifaceted intervention used Educational outreach, Audit and Feedback, Reminders and CME targeted at providers of diabetic care in a remote indigenous community in Australia. Over three years, the % of patients with BP < 140/90 mm Hg increased from 40% to 64%. Screening rates increased from 70% to 77%. Prescriptions for hypertension increased from 80% to 91.4%. This is only a fair quality study though, given its uncontrolled before and after design.	Size: 95 clinicians The intervention was Educational Outreach with a Local Opinion Leader, CME and Continuous Quality Improvement (CQI). No difference was found between groups in average prescribing patterns or average blood pressure control. However, CQI is highly variable and depends on implementation in each practice. Some practices improved while others showed no improvement.	Size: 1 clinic, 2154 patients, # clinicians NR Intervention group received intense Educational Outreach with Local Opinion Leaders, Audit and Feedback of individual performance and employed local consensus development of guidelines. Diuretic therapy was initiated in 17.4% of intervention group vs. 11.9% in control. B-blockers were initiated in 7.2% of intervention vs. 4.7% in control. Calcium Channel Blockers (a non-indicated drug) were initiated in 7.8% of intervention group vs. 10.6% in control group. Blood pressure control was also moderately greater in the intervention group vs. control.

Table 7. Three studies of Multifaceted Interventions not included in above tables. RCT = Randomized Controlled Trial, TSA = Time-series Analysis, CCT = Controlled Cohort Trial.

General Results of Study

Abstracted data from each study appraised is presented in Tables 1-7 and Appendix B and C. Overall there were 18 studies of good quality, 15 studies of fair quality and 2 studies of poor quality. Of 11 studies measuring screening or follow-up, 6 studies of good quality were associated with a positive effect[33, 42, 50, 52, 53, 57] and 3 studies of fair quality were associated with a positive effect.[49, 56, 62] The remaining 2 studies measuring screening or follow-up had no effect and were of good quality.[41, 43] Of 19 studies measuring therapy change, 3 studies of good quality were associated with a positive effect,[30, 31, 51] 7 studies of fair quality were associated with a positive effect.[32, 37, 56, 59, 60, 62, 64] Of the 9 remaining studies measuring therapy change with no effect, 3 studies of were of good quality,[36, 43, 45], 5 studies were of fair quality,[34, 39, 40, 46, 63] and one study was of poor quality.[55] Of 24 studies measuring blood pressure control, 3 studies of good quality were associated with a positive effect[33, 43, 48] and 5 studies of fair quality were associated with a positive effect.[34, 38, 59, 62, 64] Of the remaining 16 studies measuring blood pressure control that had no effect, 8 were of good quality,[30, 35, 41, 42, 44, 45, 51, 54] 7 were of fair quality,[37, 39, 46, 47, 49, 61, 63] and one was of poor quality.[58]

This review included 11 of the 12 studies previously reviewed by Tu and colleagues.[42, 44, 46, 47, 49, 51, 53, 58, 61, 63, 65] Each study from the previous review was captured by the MEDLINE search strategy. One study by Lang and coworkers was excluded because it was a patient-focused intervention, not a physician-focused intervention.[66]

Interventions involving Educational Outreach

Educational Outreach was employed in 12 of the 35 studies (Table 1). No study employed Educational Outreach alone. Three studies explicitly described the use of a local opinion leader to deliver the outreach.[30-32] In one randomized controlled trial of good quality, a single Educational Outreach visit by a Local Opinion Leader led to significant improvement in the use of diuretics and B-blockers.[30] The intervention had no impact on blood pressure. Two randomized controlled trials involving Educational Outreach by Local Opinion Leaders combined with Audit and Feedback had positive effects on physician prescribing behavior. [31, 32] Of these two studies, one was of fair quality, consisted of a single outreach visit, and had a large impact on prescriptions consistent with guidelines (from 28% to 57%).[32] The other was of good quality, consisted of three visits, and was associated with a small increase in the use of diuretics and a small decrease in the number of prescriptions of ACE Inhibitors.[31]

Six studies combined Educational Outreach with Audit and Feedback, without the explicit use of a local opinion leader.[33-38] Three of these studies were of good quality and had mixed results. [33, 35, 36] In a randomized controlled trial by Ornstein and coworkers, physicians delivered four outreach visits with personal feedback data to 20 clinics in 14 states, resulting in a moderate positive impact on both screening and blood pressure control.[33] In a randomized controlled trial by New and colleagues, using specialist nurses to

deliver four outreach visits with personal feedback data to 44 clinics in England, no impact was observed on blood pressure control.[35] In a randomized controlled trial by Frijling and coworkers in 124 clinics in the Netherlands, a single outreach visit by a trained non-physician with personal feedback data resulted in no impact on prescribing behavior.[36]

Three other studies involving Educational Outreach combined with Audit and Feedback alone were of fair quality.[34, 37, 38] In a controlled cohort study by Siegel and colleagues in 5 VA medical Centers in western United States, several outreach visits by trained clinical pharmacists with personal performance feedback data were delivered to five clinics, resulting in a large significant decrease in prescriptions of calcium channel blockers, with no difference in average blood pressure.[37] In a time-series analysis in a large Florida HMO, several outreach visits by trained clinical pharmacists with personal performance feedback data was associated with an increase in the proportion of controlled hypertensive patients from 41% to 52%.[34] In a randomized controlled trial by Inui and coworkers at the Johns Hopkins Internal Medicine Outpatient Clinic, a single outreach visit by a physician with personal feedback data was associated with a large increase in the number of patients with diastolic blood pressure < 100 (69% in the intervention group versus 31% in the control group at 6 months post-intervention).

In this review educational outreach was found to be employed in over a third of the interventions. Its greatest effects were seen in changing

physician prescribing behavior, especially when local opinion leaders were involved and the educational material included physician-specific audit and feedback data.[30-32, 37] The perceived credibility of the person delivering the educational outreach appeared to have a strong impact on whether or not the intervention changed physician behavior. The use of local opinion leaders, physicians and trained pharmacists to deliver outreach generally resulted in more favorable outcomes than when nurses or trained non-clinicians delivered the outreach. The number of outreach visits surprisingly has little predictive power over which interventions worked. Single visit interventions were just as successful as multiple visit interventions.

Interventions involving Audit and Feedback

Audit and Feedback was involved in the intervention of 16 of the 35 studies reviewed. Audit and Feedback was the sole intervention in 4 studies with mostly negative results.[39-42] In a randomized controlled trial of good quality, Dickinson and colleagues used monthly Audit and Feedback to alert Family Practice physicians of patients requiring screening.[42] Screening rates were double that of control physicians. This intervention however, had no effect on average blood pressure between groups. In three studies of fair quality, audit and feedback alone had no effect on screening,[41] therapy,[39, 40] or blood pressure control.[39, 41] In the time-series analysis by Simon and coworkers, the intervention was an online report card ranking Internal Medicine resident performance for the control of hypertension and diabetes.[39]

The intervention was weak, because residents were not required to view report card and only 33% did so. In the randomized controlled trial by Kogan and colleagues, the intervention was a single report ranking performance in 78 categories of preventive care.[40] This may also have been a very weak intervention, given the single report with a large number of preventive health categories. In the randomized controlled trial by Winickoff and coworkers, the intervention involved quarterly reports to primary care providers on performance in hypertension management.[41] This was a stronger intervention, but was still not associated with positive effects on screening or blood pressure control. In the four studies of audit and feedback alone, it is either unclear how much the physicians interacted with the feedback data, or it is clear that they generally ignored it.

Eight studies combined Audit and Feedback with Educational Outreach and were reviewed above in the section examining the effects of Educational Outreach.[31-38] Briefly, 4 of these studies were of good quality with mixed results,[31, 33, 35, 36] having some positive effect on screening,[33] therapy,[31] or blood pressure control.[33] The other 4 studies using this intervention were of fair quality with mixed results,[32, 34, 37, 38] having some positive effect on therapy[32, 37] or blood pressure control.[34, 38]

In summary, the use of audit and feedback alone may be a fairly weak intervention. The combination of audit and feedback with educational outreach however, appears to be a much stronger intervention. Audit and feedback data provides the outreach visit with hard evidence of how the

physician is performing compared with peers, strengthening the educational message. When combined with educational outreach, audit and feedback appears to have a moderate impact on therapy and a small impact on blood pressure control.

Interventions involving Decision Support

Decision Support was involved in 5 of the 35 reviewed studies. Decision Support was used as the sole intervention in 3 studies with negative results.[45-47] In a randomized controlled trial of good quality by Murray and coworkers, an online decision support system displaying suggestions for treatment was displayed to physicians at the time of order entry.[45] This intervention had no effect on therapy consistent with guidelines or blood pressure. The authors concede though that the intervention was weak, because physicians could easily bypass or ignore prompts.

In two studies of fair quality using decision support alone, no intervention-associated effect was observed on therapy[46] or blood pressure.[46, 47] In a randomized controlled trial by Montgomery and colleagues, computerized Decision Support involving 5-year cardiovascular risk calculations was evaluated in New Zealand primary care clinics.[46] The Decision Support intervention resulted in no observed effect on 5-year cardiovascular risk, therapy or blood pressure, although it is notable that subgroup analysis revealed increased prescribing among high risk groups where the biggest effect would be expected. In a randomized controlled trial

by Hetlevik and coworkers, computerized Decision Support was evaluated in primary care clinics in Norway.[47] The intervention resulted in no observed effect on blood pressure between groups. The intervention was weak though, because it was used by physicians in only 12% of encounters.

Decision Support was combined with Reminders in 2 studies with mixed results.[48, 49] In a randomized controlled trial of good quality by McAlister and coworkers, a system of computer-generated Reminders and Decision Support was evaluated in 60 family medicine physicians.[48] This comprehensive intervention, which included care suggestions as well of lists of patients requiring further care, was associated with a moderate improvement in the proportion of hypertensive patients with good control of blood pressure (diastolic blood pressure < 90). In a randomized controlled trial of fair quality by Rogers and colleagues, a computer-generated summary of patient blood pressure history, completed tests, and medication history as well as care suggestions was placed in the patient's chart in one general practice clinic.[49] This intervention led to a small increase in the utilization of recommended screening tests and no difference in blood pressure. This study had medium potential for confounding, because cluster effects were not controlled for and contamination was present.

In this review, decision support was employed in 5 of the 35 interventions. Three studies employed decision support as the sole intervention and none of these studies had a positive effect on screening, therapy change, or blood pressure. The fatal flaw in two of these studies

though was that the reminder was easily bypassed and not often even viewed.[45, 47] When decision support was combined with reminders in two studies, positive effects were seen in screening[49] and blood pressurecontrol.[48]

Interventions involving Reminders

Reminders were included in 11 of the 35 reviewed interventions. Six studies employed reminders as the sole intervention with mixed results. Five of these studies were of good quality[50-54] and 1 study was of poor quality.[55] Of the good quality interventions positive effects associated with the intervention were observed for screening[50, 52, 53] and therapy;[51] and no effects were observed on blood pressure[51, 54] One randomized controlled trial by Rossi and coworkers was highly effective in prompting physicians to change from Calcium Channel Blockers (CCB) to a Diuretic or B-blocker.[51] In this study physicians were prompted at the time of order entry for all patients on CCB's to either change the prescription or provide contraindication. 11% of all patients receiving CCB were switched as compared to 1% of controls. In three randomized controlled trials, reminders were repeatedly presented to physicians until screening was completed.[50, 52, 53] These reminders were highly effective in increasing the proportion of patients screened for hypertension.

In a good quality randomized controlled trial combining Audit and Feedback with Reminders by Mitchell and colleagues, Scottish primary care physicians received feedback of performance as well as a reminder list of

patients who were poorly controlled.[43] There was no observed difference in the rates of screening or changes of therapy, but there was a small increase in the number of patients whose blood pressure became controlled (BP < 160/90) which may represent regression to the mean.

In a time-series analysis of fair quality, chart Reminders were combined with automatic scheduling of all patients with uncontrolled hypertension at a teaching hospital outpatient clinic.[56] This intervention was associated with a large increase in the number of patients screened and the percentage of indicated treatments initiated before and after the intervention. This study is of fair quality because it is a time-series analysis with no control and is susceptible to confounding.

When used alone reminders were highly effective in increasing rates of screening for hypertension, especially if the reminders were presented repeatedly until screening was completed. When reminders were combined with automatic scheduling of patients requiring further care, proper screening and therapy increased dramatically. When combined with audit and feedback, reminder lists of patients requiring further care led to a small decrease in blood pressure. When reminders about drug therapy were incorporated into order forms requiring the physician to interact with them, a large impact on drug therapy resulted. Reminders appear to be a strong intervention when physicians are required to interact with them, with there greatest benefit being the affect on screening rates.

Interventions involving Continuing Medical Education (CME)

Continuing Medical Education (CME) was explicitly involved in 8 of the 35 reviewed interventions. However only two of the studies employed CME as the sole intervention.[57, 58] In a randomized controlled trial of good quality by Jennett and coworkers, Canadian family medicine physicians were randomly allocated to a "usual care" control group or a 6 week education program consisting of newsletters, small group discussions and teleconferences.[57] The outcome measured was average proportion of recommended behaviors performed at each patient visit before and after the intervention. The experimental group increased from 14.7% at baseline to 42.2% at 12 months versus a decrease from 13.5% to 10.1% in the control group. The recommended behaviors involved documentation of screening, counseling and asking about compliance. The other study employing CME as the sole intervention was of poor quality and found no difference in their CME intervention.[58]

All other studies involving CME are reviewed in other sections of this review.[33, 34, 42, 44, 47, 62] CME was not the dominant intervention in any of these multifaceted interventions. It is difficult to determine the effects of CME from the reviewed studies. According to the one study of good quality employing CME alone, the intervention had a moderate impact on screening and follow-up.

Interventions involving Local Consensus Development of Guidelines

Local Consensus production and implementation of guidelines were involved in 4 of the 35 studies reviewed. Three studies employed Local Consensus development of guidelines as the sole intervention.[59-61] In a controlled cohort trial of fair quality by Avanzini and colleagues, Local Consensus guidelines were developed and implemented by Italian primary care providers. The intervention was associated with a moderate increase in the use of diuretics and B-blockers and a decrease in the use of ACE inhibitors. Average blood pressure in the intervention group decreased from 151.8/86.0 to 143.1/81.4, while there was no change in the control group. The study was of fair quality because it was a controlled cohort study made up of volunteers and there is a high potential for selection bias and confounding.

In a controlled cohort trial of fair quality, Onion and coworkers employed Local Consensus development of guidelines for drug therapy in Wirral, UK.[60] A large increase in the use of the recommended first line drug (Bendrofluazide) was observed in the intervention district versus the control of all districts in the UK. The study was of fair quality because it was a controlled cohort study with medium potential for selection bias and confounding. In randomized controlled trial of fair quality, Putnam and colleagues employed Local Consensus development of guidelines in Canadian primary care physicians and found no difference in the number of uncontrolled patients becoming controlled after the intervention.[61] Local

consensus was involved in one large multifaceted study and will be reviewed below.[64]

Of the three studies employing local consensus guideline development as the sole intervention, two had moderate to large positive effects on therapy[59, 60], one had a large effect on average blood pressure and the third study had no effect. It appears that local consensus guideline development may be a relatively strong intervention in changing physician prescribing behaviors, but more studies are needed.

Multifaceted Interventions (3 or more interventions)

Three studies not reviewed above were large multifaceted interventions of fair quality.[62-64] Goldberg and colleagues describe an intervention involving Educational Outreach, Local Opinion Leaders and Continuous Quality Improvement (CQI).[63] The study was a randomized controlled trial in 15 Seattle-area clinics. There were no observed effects on prescribing patterns or blood pressure control. However the CQI methods were highly variable and outcomes across clinics were also highly variable.

In a controlled cohort study by Aucott and coworkers, Educational Outreach, Local Opinion Leaders, Audit and Feedback, Local Consensus and CME were employed in a Cleveland teaching hospital clinic.[64] The intervention was associated with a moderate increase in guideline adherent prescribing behavior and a moderate decrease in average blood pressure in

study patients. This study was of fair quality because of its nonrandomized design, small size and potential for cluster effect.

McDermott and coworkers describe a time-series analysis of a program to improve diabetes care in 21 clinics in Torres Strait near Australia.[62] Their intervention involves Educational Outreach, Reminders, Audit and Feedback, and CME. The intervention resulted in an increase in screening from 70% to 77%, an increase in drug treatment from 80% to 91%, and an increase from 40% to 64% in the number of patients brought under blood pressure control (BP < 140/90 mm Hg).

Multifaceted interventions presented here and dual interventions presented in the sections above generally have more positive impact on screening, therapy and blood pressure control than single interventions. More multifaceted intervention studies are needed to fully evaluate the effects of large multifaceted interventions.

Discussion

Study Findings

The interventions reviewed in this study had very heterogeneous results with regards to changes in screening, physician prescription behavior, and blood pressure control. No intervention was clearly superior to others in all categories of outcome. The outcomes, strengths and weaknesses, and relation to existing literature of each intervention type are discussed below.

Educational Outreach interventions generally had moderate to large positive effects on physician prescribing behavior and small improvements in blood pressure control, especially when combined with Audit and Feedback and Local Opinion Leaders. Local Opinion Leaders, physicians and pharmacists were more effective than nurses and non-physicians. The small to moderate improvements in prescribing patterns found in this study are consistent with results from existing reviews.[67, 68] Educational Outreach may be effective in changing prescribing behavior because of its ability to provide targeted, personalized educational messages to overcome physician related barriers including: lack of awareness, lack of familiarity, lack of agreement, lack of outcome expectancy, lack of self-efficacy and inertia of previous practice.

Audit and Feedback interventions when used alone generally had no effect on screening, therapy or blood pressure control in this study. These interventions may have suffered from the fact that physicians were generally not required to interact with feedback data. When Audit and Feedback was combined with Educational Outreach, there was a moderate improvement in prescribing behavior and a small improvement in blood pressure control. By combining Audit and Feedback with Educational Outreach, the physicians were forced to review the feedback data, and this appears to have strengthened the intervention. The small to moderate improvements in care are consistent with previous reviews.[69-71] By giving physicians hard evidence of the consequences of their practice behavior, Audit and Feedback

interventions may help to overcome physician related barriers including: outcome expectancy, self-efficacy, and inertia of previous practice.

Decision Support when used alone in the reviewed studies had no effect on screening, prescribing behavior, or blood pressure control. These interventions all suffered from the fact that physicians could easily bypass them. When combined with reminders and physicians were forced to interact with the decision support, the intervention led to a small increase in screening and a small decrease in average blood pressure. Previous studies have shown small improvements with the use of decision support.[72] This review found similar small positive results in studies where the physician must interact with the program. Indeed in a previous review, requiring physicians to interact with computerized suggestions was shown to improve compliance with many preventive care recommendations.[73] By displaying targeted guideline-consistent suggestions for each patient, Computerized Decision Support may help overcome lack of familiarity with guidelines, lack of self-efficacy, and inertia of previous practice.

Reminder Systems in this study when used alone were highly effective in increasing the rates of hypertension screening, especially when physicians were repeatedly reminded or when an automatic scheduling component was added. A reminder system was also highly effective in one study in changing prescribing patterns when physicians were forced to interact with the reminder and provide reasons for not changing medication.[51] Reminder systems have generally been found to provide small to moderate

changes in provider behavior in previous reviews.[74, 75] Like decision support systems, reminder systems may be effective in changing physician behavior by overcoming barriers including: lack of familiarity with guideline recommendations, lack of self-efficacy and inertia of previous practice.

Continuing Medical Education was used as the sole intervention in only one study of good quality. The intervention used small group discussions, newsletters and teleconferences and resulted in a small positive increase in screening and follow-up behavior. Reviews have shown that didactic lecture based CME is generally ineffective in changing physician behavior, however, small group interactive CME provides small changes in physician behavior.[26] CME may help overcome physician related barriers including: lack of awareness, lack of familiarity and lack of agreement with guidelines. The low intensity nature of most CME programs and the widely heterogeneous nature of CME programs make it difficult to discern and generalize the effects of CME on professional practice.

Local Consensus Guideline Development was used as the sole intervention in three studies and led to small decrease in average blood pressure in one study and a large change in prescribing behavior in two studies. This intervention appeared to be a relatively strong one in changing physician prescribing behavior. In a previous review, this intervention was associated with an increase in the implementation of guidelines.[76] However there are still few good quality studies of local consensus guideline development. This intervention may be effective because it involves

physicians in the decision-making process about issues affecting them, and may lead to more sense of ownership and commitment to adhering to guidelines. Local consensus guideline development may help overcome barriers relating to: lack of awareness, lack of familiarity, lack of agreement, lack of self-efficacy, and inertia of previous practice.

Multifaceted Interventions and the **Dual Interventions** presented above generally provide stronger results for all three of the outcomes of interest (screening, prescribing, and blood pressure control). This finding is consistent with existing literature.[25, 28] For the outcome of blood pressure control, Multifaceted Interventions, especially those involving three or more of the following: Educational Outreach, Local Opinion Leaders, Audit and Feedback, Reminders and/or Local Consensus Guideline Development provided strongest results. For the outcome of screening, interactive Reminders, especially combined with Audit and Feedback, were most effective, followed by large multifaceted interventions. For the outcome of prescribing behavior, Local consensus guidelines alone, Educational Outreach with Local Opinion Leaders and Audit and Feedback, or large Multifaceted Interventions provided the strongest results. Multifaceted Interventions have the potential to address and overcome more barriers than individual interventions.

Limitations and Future Research Directions

This study is limited by the search strategy employed and the quantity and quality of the existing literature. The search strategy was developed to be a comprehensive literature search, but studies may have been missed, especially those in different languages. There are still relatively few studies available in this field and the findings in this review may change when more studies become available. Publication bias is always a potential limitation in systematic reviews however, in this review there were 27 positive results reported and 27 negative results reported. These mixed results suggest that publication bias may not be major problem in this field. Lastly classification of studies for this review was difficult. Many interventions overlapped making it difficult to determine the independent effects of any one. Additionally, interventions within a category varied significantly. For instance some decision support interventions recommended different choices of medication, while others tried to align clincians' interventions with patient need by showing them their overall cardiovascular risk. These two interventions are targeting fundamentally different barriers (i.e. knowledge and inertia) and we did not attempt to tease apart such subtle effects.

The studies themselves also suffer from several limitations. First, many of the studies were small and insufficiently powered, making negative results difficult to interpret. Many of the studies were of less than good quality and only about half were randomized controlled trials. No study in this review lasted longer than three years. These short studies may not

capture average changes in blood pressure and long term changes in physician behavior.

More research is needed in this field. Large, long-term, well-conducted randomized controlled trials of each study are needed to more accurately identify the effects of each study. Promising interventions on which few studies exist include local consensus guidelines, large multifaceted interventions and decision support that requires physician interaction. Many of these interventions do affect change and more research is needed to determine which combination of interventions will work best.

Although more research is necessary to further understand the effects of various interventions on hypertension management, several conclusions can be drawn from this study that may allow health care systems to improve hypertension management. Low cost interventions involving educational outreach from local opinion leaders using audit and feedback data does improve physician management of hypertension. Another low cost intervention would be reminders to prescribe medications best supported by evidence. Multifaceted interventions involving electronic medical record audit and feedback, decision support and reminders may be effective especially if physicians are required to interact with audit data and suggestions. These electronic interventions may be very costly initially, but as electronic medical records become the standard of care, these types of interventions may become cheap and easy to implement. The most important conclusion that can be drawn from this study is that quality assurance and

educational interventions do work and can be used to promote significant physician behavioral change with regards to hypertension management.

Conclusion

Hypertension management is difficult, involving patient, physician and environmental barriers persisting over long periods of symptom-free time. No single educational or quality assurance intervention is superior to others in improving physician adherence to guidelines. In the management of hypertension, Multifaceted Interventions especially those involving Educational Outreach by Local Opinion Leaders, Audit and Feedback, Reminders and/or Local Consensus Development of Guidelines appear to be the most promising physician oriented interventions to improve hypertension management. These interventions led to moderate to large increases in screening, small to moderate increases in guideline-consistent therapy and small increases in blood pressure control.

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Appendix A Data Abstraction Form

Author/Year:

Study Design: RCT Cohort Other:

Intervention: Passive dissemination CME Mailing Outreach
Decision support Reminders Computers
Opinion Leader Audit and feedback
Local Consensus Multifaceted Other

Comment:

Study Population:

Patients:

Physicians:

Unit Randomized: Patients Physicians Clinics

Comparability of groups:

Potential for selection bias: low medium high

Comment:

Outcomes measured: Screening Prescription BP Control
Other

Potential for measurement bias: low medium high

Comment:

Confounding potential: low medium high

Comment:

Results: Positive Negative Mixed

Quality of study: poor fair good

Comment:

Appendix B Working Evidence Tables

Author/Year	Simon 2005 [30]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach with Local Opinion Leader in group outreach versus individual outreach versus Control
Study Population	New England Primary Care Clinics: N = 9 All patients with diagnosis of Hypertension: N = 3692
Outcomes	1) Average blood pressure 2) Change in drug therapy consistent with guidelines
Results	Mixed 1) No difference in average blood pressure between intervention and control. 2) Moderate increase in the use of diuretics and B-blockers in both interventions versus control.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	Simon 2005 [39]
Study Design	Time-Series Analysis
Intervention	Audit and Feedback – online report card
Study Population	Internal Medicine Residents at a Harvard Primary Care Clinic: N = 12 All patients seen with hypertension in the 6 months before and 6 months after the intervention: N = 800
Outcomes	1) Percent of hypertensive patients on B-blocker or diuretic 2) Average blood pressure before and after intervention
Results	Negative 1) No change in the percentage of patients with a prescription for a B-blocker or diuretic. 2) No change in blood pressure
Internal Validity	Low potential for selection bias or measurement bias. High potential for confounding given the lack of a control. Also, only 4 residents viewed their reports, so intervention only reached 33% of participants.
Quality of Study	Fair

Author/Year	Ornstein 2004 [33]
Study Design	Randomized Controlled Trial
Intervention	Multifaceted intervention including Audit and Feedback, Educational Outreach and CME versus Audit and Feedback alone.
Study Population	20 primary care clinics in 14 states, all using the same electronic medical record. 13,846 hypertensive patients.
Outcomes	1) Process measures: percent of patients with BP measurement in the last 12 months, diagnosis of hypertension for three elevated measures, BP measurement in last 3 months for hypertensive patients. 2) Outcome measures: percent of patients whose most recent BP measurement was less than 140/90 and percent of hypertensive patients whose most recent BP measurement was less than 140/90.
Results	Positive 1) Significant moderate increases in practices reaching targets for process measures in intervention versus control. 2) Significant moderate increase diagnosis and blood pressure control in intervention versus control.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	Toth-Pal 2004 [50]
Study Design	Randomized Controlled Trial
Intervention	Computerized Reminder System integrated into electronic medical record reminding physician to screen for hypertension versus Control.
Study Population	Primary Care Clinics in Stockholm, Sweden: N = 4 Patients over 70 years old requiring screening: N = 5182
Outcomes	1) Percent of eligible patients screened for hypertension
Results	Positive 1) Proportion of patients screened was 13% higher in intervention group versus control
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	New 2004 [35]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach by specialist nurses combined with Audit and Feedback of poorly controlled patients versus Control
Study Population	Primary Care Clinics in Salford, England: N = 44 All patients with diabetes and BP > 140/80 N = 4949
Outcomes	1) Percent of patients below target blood pressure one year after the intervention. 2) Average Blood Pressure after intervention
Results	Negative 1) No difference in proportion of patients reaching target. 2) No difference in average blood pressure between intervention and control groups.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	Murray 2004 [45]
Study Design	Randomized Controlled Trial
Intervention	Computerized Decision Support at the time of order entry versus Control
Study Population	Internal medicine resident and attending physicians at Indiana academic primary care clinic: N = 150. Patients with uncomplicated hypertension agreeing to be in study: N = 712.
Outcomes	1) Average blood pressure 2) Prescriptions consistent with guidelines
Results	Negative 1) No difference in average blood pressure between intervention and control groups. 2) No difference in the proportion of orders consistent with guidelines.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding. Intervention was weak though because suggestions could be easily bypassed.
Quality of Study	Good

Author/Year	Mitchell 2004 [43]
Study Design	Randomized Controlled Trial
Intervention	Audit and Feedback of proportion of controlled hypertensive patients versus Audit and Feedback with list of patients ranked by cardiovascular risk score versus Control
Study Population	Scottish Primary Care General Practices with GPASS electronic medical record: N = 54 All patients aged 65 – 79: N = 40,294
Outcomes	1) Percent of patients screened 2) Percent of patients treated appropriately 3)Average blood pressure control
Results	Mixed 1) No change in proportion of patients screened 2) No change in proportion of patients treated appropriately 3) Small increase in the proportion of patients with BP < 160/90 in the Audit plus stratified risk group versus Audit and feedback and control.
Internal Validity	Medium potential for selection bias; high slightly differential drop out rate. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	McDermott 2003 [62]
Study Design	Time-Series Analysis
Intervention	Multifaceted program involving CME, Educational Outreach, Computerized Reminders and Audit and Feedback.
Study Population	Primary Care clinics in Torres Strait near Australia: N = 21 Patients with Type 2 Diabetes Mellitus: N = 921
Outcomes	1) Percent of patients screened for hypertension 2) Percent of hypertensive patients with treatment 3) Percent of patients with BP < 140/90
Results	Positive 1) Screening increased from 70% to 77% 2) Drug treatment for hypertensive patients increased from 80% to 91%. 3) The proportion of patients with BP < 140/90 increased from 40% to 64%
Internal Validity	Low potential for selection bias. Medium potential for measurement bias; measurements came from register that was still in development and may have been different before and after intervention. Medium potential for confound given uncontrolled before and after design.
Quality of Study	Fair

Author/Year	Siegel 2003 [37]
Study Design	Controlled Cohort Study
Intervention	Educational Outreach by pharmacists combined with Audit and Feedback versus Usual care controls
Study Population	All physicians at 5 VA Medical Centers (VISN # 21) were included in intervention group. Control group contained all VA physicians nationwide. All patients with ICD-9 diagnosis of hypertension: N=27,066
Outcomes	1) Percentage of patients with various prescriptions 2) Average blood pressure in 308 randomly selected intervention patients before and after intervention.
Results	Mixed 1) Proportion of patients on calcium channel blockers decreased 12% compared with a 5% drop nationwide ($p<.001$). Proportion of patients on diuretics increased 10% compared to 7% nationwide ($p<.001$). 2) No difference in BP before and after intervention in experimental group.
Internal Validity	Medium potential for selection bias given nonrandomized design. Low potential for measurement bias for prescription data given use of electronic medical record. Medium potential for measurement bias for blood pressure because there was no control, only before and after measurements in the experimental group. Medium potential for confounding given non-randomized design
Quality of Study	Fair

Author/Year	Frijling 2003 [36]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach combined with Audit and Feedback versus Controls
Study Population	General Practices in the Netherlands: N = 124
Outcomes	1) Change or increase in prescription when indicated 2) Provision of information and advice to the patient
Results	Mixed 1) No difference between groups in the proportion of patients receiving a change in medication when indicated. 2) Small increase in the intervention group in the proportion of patients receiving information and advice about hypertension.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good.

Author/Year	Kogan 2003 [40]
Study Design	Randomized Controlled Trial
Intervention	Audit and Feedback – single report with scores for 78 categories of preventive care versus Control
Study Population	Internal Medicine resident physicians at University of Pennsylvania outpatient clinic: N = 44 All new patients seen during study period before and after intervention: N = 781
Outcomes	Hypertension management score
Results	No difference between the groups in hypertension management score.
Internal Validity	Medium potential for selection bias given possibility of cluster effect and small numbers of patients per physician. Low potential for measurement bias. Medium potential for confounding given small size, possible cluster effect and possible contamination. Weak intervention, hypertension management score diluted by 77 other scores.
Quality of Study	Fair

Author/Year	Avanzini 2002 [59]
Study Design	Controlled Cohort Study
Intervention	Local Consensus – intervention group participated in design of clinical practice guideline and implementation protocol versus Control
Study Population	Primary care physicians in Italy: N = 90 Intervention and control groups were both composed of volunteers Random sample of treated hypertensive patients: N = 1,771
Outcomes	1) Percentage of patients with various prescriptions before and after intervention. 2) Average blood pressure before and after intervention
Results	Positive 1) Diuretics and B-blockers use increased more in intervention versus controls. ACE inhibitors decreased more in intervention versus controls. 2) Blood pressure decreased from 151.8/86.0 to 143.1/81.4 in intervention group and did not change in control group.
Internal Validity	High potential for selection bias. Intervention group consisted of volunteers who may have been more motivated to change than controls. Low potential for measurement bias. High potential for confounding.
Quality of Study	Fair

Author/Year	Maue 2002 [34]
Study Design	Time-Series Analysis
Intervention	Multifaceted intervention consisting of Passive Dissemination, CME, Educational Outreach, Audit and Feedback
Study Population	Primary Care Physicians in a large HMO in Florida. N = 30 physicians at baseline sample and 32 physicians at post-intervention sample. 540 Patients at baseline and 492 patients at post-intervention sample.
Outcomes	1) Proportion of patients with blood pressure less than 140/90 before and after intervention 2) Percentage of patients with various prescriptions before and after intervention.
Results	Mixed 1) The proportion of patients with BP < 140/90 increased from 41% before to 52% after the intervention. 2) There was no significant change in the proportion of patients receiving various drugs before or after the intervention.
Internal Validity	Low potential for selection bias within intervention group. Low potential for measurement bias. High potential for confounding given uncontrolled study design
Quality of Study	Fair

Author/Year	Sanders 2002 [55]
Study Design	Randomized Controlled Trial
Intervention	Chart based guideline Reminders versus Control
Study Population	2 VA medical clinics in Richmond Virginia. 22 physicians 320 patients with hypertension and type 2 diabetes mellitus, with high blood pressure reading
Outcomes	Prescription change consistent with guidelines
Results	No difference between intervention and control groups in indicated medication changes.
Internal Validity	High potential for selection bias, with high drop-out rate, no information on physician characteristics, cluster effect possible. Medium potential for measurement bias with no mention of blinding or process of chart audit. High potential for confounding.
Quality of Study	Poor

Author/Year	Denton 2001 [32]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach by Local Opinion Leader with Audit and Feedback versus Educational Outreach with Audit and Feedback by resident physician.
Study Population	Internal medicine attending physicians, resident physicians and nurse practitioners at Maryland outpatient clinic: N = 44
Outcomes	Number of changes in prescription consistent with guidelines
Results	Positive Intervention group with local opinion leader increased changes consistent with guidelines from 28% to 57% ($p<.01$) Intervention group with resident physician led outreach increased from 35% to 39% (non-significant)
Internal Validity	Medium potential for selection bias; small randomized blocks with different provider make-up. Low potential for measurement bias. Medium potential for confounding, given small size and cluster effect not controlled for in statistical analysis.
Quality of Study	Fair

Author/Year	Nilsson 2001 [31]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach by Local Opinion Leader combined with Audit and Feedback versus control.
Study Population	General Practitioners in Stockholm Sweden: N = 40
Outcomes	Change in rates of prescription of various drugs
Results	Mixed Small significant difference between intervention and control group in lowering rate of ACEI's/ARB's. No difference between groups in the change of B-blocker, diuretics, or calcium channel blockers.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Medium potential for confounding, given small size and possible cluster effects.
Quality of Study	Good

Author/Year	Montgomery 2000 [46]
Study Design	Randomized Controlled Trial
Intervention	Computer Decision support plus Cardiovascular Risk Chart versus Cardiovascular Risk Chart alone versus Control
Study Population	Primary Care Clinics in New Zealand: N = 27 All patients between the ages of 60 and 80 diagnosed with hypertension with history of drug therapy: N = 614
Outcomes	1) Average blood pressure 2) Five-year cardiovascular risk 3) Appropriate prescriptions
Results	Mixed 1) Small decrease in SBP in chart only group, no other changes in blood pressure. 2) No difference in cardiovascular risk between groups. 3) Chart only group was more likely to prescribe 2 or 3 drugs than other groups.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding. Not powered enough to find a difference due to drop-outs.
Quality of Study	Fair

Author/Year	Hetlevik 1999 [47]
Study Design	Randomized Controlled Trial
Intervention	Computerized Decision Support combined with CME versus Controls
Study Population	General practice clinics in Norway: N = 29 Patients with the diagnosis of hypertension: N = 2239
Outcomes	Average blood pressure at baseline and at 18 months
Results	Negative No significant difference between groups in average blood pressure change from baseline to 18 months post-intervention
Internal Validity	Low potential for selection bias. Medium potential for measurement bias; measurements made by author with no mention of blinding. Medium potential for confounding; cluster analysis not performed. Also, experimental software was only used in 12% of intervention-group patient visits.
Quality of Study	Fair

Author/Year	Goldberg 1998 [63]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach with Local Opinion Leader versus Educational Outreach with Local Opinion Leader combined with Continuous Quality Improvement versus Control
Study Population	Seattle, Washington primary care clinics: N = 15 Primary Care Providers: N = 95 Patients with hypertension: N = 9046
Outcomes	1) Prescribing patterns 2) Percent of patients with average blood pressure < 160/90
Results	No difference was found between the three groups in 1) prescribing patterns or 2) number of patients with controlled hypertension.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. High potential for confounding; CQI and educational outreach were performed differently in each practice
Quality of Study	Fair

Author/Year	Rossi 1997 [51]
Study Design	Randomized Controlled Trial
Intervention	Computer assisted Reminder order form in chart versus Usual Care Controls
Study Population	VA general internal medicine clinic in Seattle All staff physicians, resident physicians and nurse practitioners providing care at the clinic: N=71 All patients on calcium channel blockers (CCB's): N = 719
Outcomes	1) Percent of patients changed from CCB to another drug 2) Average Blood Pressure
Results	Positive 1) 11% of patients in intervention group versus 1% of patients in control group switched from CCB to another drug. 2) No difference in average blood pressure between groups.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding. Statistical controls for cluster effect employed. 72% of order forms were filled out and returned.
Quality of Study	Good

Author/Year	Aucott 1996 [64]
Study Design	Controlled Cohort Study
Intervention	Educational Outreach, Opinion Leaders, Audit and Feedback, Local Consensus versus Passive Dissemination and CME
Study Population	General internal medicine teaching clinics at Cleveland VA Medical Center: N = 2 All patients seen in the 3 months after intervention: N = 2154
Outcomes	1) Percent of patients with various prescription changes 2) Average blood pressure (in 50 random patients)
Results	Positive 1) The intervention group initiated hydrochlorothiazide, atenolol, nifedipine in 17.4%, 7.2% and 7.8% of patients. The control group initiated hydrochlorothiazide, atenolol, nifedipine in 11.9%, 4.7% and 10.6% of patients. 2) Average blood pressure was lower in intervention group.
Internal Validity	Medium potential for selection bias; clinicians were non-randomly allocated into 2 clinics (intervention and control clinic). Low potential for measurement bias. Medium potential for confounding; small study size and very small size group of measured blood pressure.
Quality of Study	Fair

Author/Year	Onion 1996 [60]
Study Design	Controlled Cohort Study
Intervention	Local Consensus – intervention group participated in design of clinical practice guideline and implementation protocol versus Control
Study Population	Intervention group – General Practices in Wirral UK: N = 69 Control Group – All General Practitioners in UK
Outcomes	Prescribed daily doses (PDD) of bendrofluazide per 1000 patients
Results	Positive The difference in PDD of bendrofluazide per 1000 patients between Intervention and control doubled after intervention and persisted for 2 years.
Internal Validity	Medium potential for selection bias; much of the intervention group were highly motivated volunteers. Low potential for selection bias. Medium potential for confounding given the nonrandomized design.
Quality of Study	Fair

Author/Year	Jennett 1989 [57]
Study Design	Randomized Controlled Trial
Intervention	CME – 6 week education program, including newsletter, small group discussion and 2 teleconferences versus Control
Study Population	Family medicine physicians in Saskatchewan: N = 22 All patients with elevated blood pressure: N = 1,538
Outcomes	Percent of recommended physician behaviors performed at each visit (screening, counseling, asking about compliance)
Results	Positive The intervention group increased from 14.7% at baseline to 42.2% after 12 months. The control group decreased from 13.5% at baseline to 10.1% after 12 months
Internal Validity	Low potential for selection bias. Medium potential for measurement bias; no mention of blinding of chart reviewers. Low potential for confounding.
Quality of Study	Good

Author/Year	McDowell 1989 [52]
Study Design	Randomized Controlled Trial
Intervention	Reminder to check blood pressure placed in chart of patients requiring blood pressure check versus Controls
Study Population	Family Medicine Resident Clinic in Ottawa All patients requiring blood pressure screening N = 5357
Outcomes	Percent of eligible patients screened for hypertension
Results	Positive Blood pressure screening in intervention group was 30.7% versus 21.1% in control group.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding. Small cluster effect may be possible given that patients were randomized not physicians.
Quality of Study	Good

Author/Year	Putnam 1989 [61]
Study Design	Randomized Controlled Trial
Intervention	Local Consensus versus Passive dissemination versus Control
Study Population	Canadian family physicians: N = 40 Patients with uncontrolled hypertension: N = ?
Outcomes	Percent of "uncontrolled" patients becoming "controlled"
Results	Negative No difference in proportion of patients becoming controlled across groups.
Internal Validity	Medium potential for selection bias; no information provided about patient comparability. Low potential for measurement bias. Medium potential for confounding given possibility of cluster effects.
Quality of Study	Fair

Author/Year	Gullion 1988 [44]
Study Design	Randomized Controlled Trial
Intervention	CME combined with Audit and Feedback versus Control
Study Population	San Francisco area primary care physicians: N = 111 All patients with diastolic BP > 90 mm Hg: N = 2231
Outcomes	Average blood pressure
Results	Positive Experimental group had moderate decrease in blood pressure.
Internal Validity	low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	Evans 1986 [58]
Study Design	Randomized controlled Trial
Intervention	CME – 14 weekly installments of educational material versus Control
Study Population	183 Canadian patients identified through community screening were identified and told to have blood pressure checked by their primary care providers. 76 Primary care providers randomized to intervention or control.
Outcomes	Average blood pressure before and after intervention
Results	Negative No difference in average blood pressure change between groups. In both groups systolic and diastolic blood pressure both fell about 10 mm Hg.
Internal Validity	Medium potential for selection bias given high drop-out rate and low number of patients per physician. Low potential for measurement bias. High potential for confounding; patients in both groups were referred to their primary care physician for evaluation of hypertension, overwhelming impact CME.
Quality of Study	Poor

Author/Year	McAlister 1986 [48]
Study Design	Randomized Controlled Trial
Intervention	Decision Support and Reminders versus Control
Study Population	Family medicine physicians in Toronto area: N = 60 All patients with diastolic BP > 90 mm Hg: N = 2231
Outcomes	Average blood pressure
Results	Positive Experimental group had moderate decrease in average blood pressure.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Author/Year	Cohen 1985 [56]
Study Design	Time-Series Analysis
Intervention	Audit and Verbal Feedback plus Passive Dissemination then 2 months later automatic scheduling of hypertensive patients and Chart Reminder.
Study Population	Resident physicians at academic primary care clinic: N = 10 All patients with hypertension: N = 231
Outcomes	1) Blood Pressure screening in eligible patients 2) Proper treatment initiated when indicated
Results	Mixed Audit and Verbal Feedback plus Passive Dissemination intervention resulted in no difference from baseline in 1) proportion of patients screened or 2) initiation of proper treatment. Automatic scheduling with Chart Reminder resulted in a large increase in 1) proportion of patients screened and 2) initiation of treatment.
Internal Validity	Medium potential for selection bias; not much information on patient characteristics given. Medium potential for selection bias; no mention of chart review process or blinding. Medium potential for confounding given uncontrolled study design.
Quality of Study	Fair

Author/Year	Winickoff 1985 [41]
Study Design	Randomized Controlled Trial
Intervention	Audit and Feedback quarterly reports versus Control
Study Population	Physicians and Nurse Practitioners at Harvard affiliated outpatient internal medicine clinic: N = 30 All patients with hypertension: N = ?
Outcomes	1) Blood pressure control 2) Percent of patients screened 3) Percent of patients with follow-up
Results	Negative No difference in 1) blood pressure control, 2) screening or 3) follow-up between groups.
Internal Validity	Medium potential for selection bias; no information provided about patient demographics. Low potential for measurement bias. Medium potential for confounding; no control for possible cluster effects.
Quality of Study	Fair

Author/Year	Barnett 1983 [53]
Study Design	Randomized Controlled Trial
Intervention	Computerized Reminders sent to physician every month until follow-up scheduled versus Control
Study Population	Patients requiring blood pressure screening at New England primary care clinic: N = 115
Outcomes	Percent of eligible patients screened
Results	Positive After 2 years 98% of experimental group patients had follow-up scheduled compared to 46% of control group patients.
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Medium potential for confounding; physicians had both experimental and control patients, which may have caused contamination lessening difference in outcomes.
Quality of Study	Good

Author/Year	Rogers 1982 [49]
Study Design	Randomized Controlled Trial
Intervention	Computer generated Reminder and Decision Support versus Control
Study Population	All patients with hypertension at a primary care clinic: N = 479
Outcomes	1) Screening for renal function and potassium levels 2) Average blood pressure
Results	Mixed 1) Small increase in renal function and potassium screening in intervention versus controls. 2) No difference in blood pressure between the two groups.
Internal Validity	Medium potential for selection bias; randomization failed for several patient characteristics. Low potential for measurement bias. Medium potential for confounding; cluster effects possible and not controlled for.
Quality of Study	Fair

Author/Year	Dickinson 1981 [42]
Study Design	Randomized Controlled Trial
Intervention	Audit and Feedback versus CME versus Both versus Control
Study Population	Duke family medicine practice Family medicine physicians: N = 41 Patients with hypertension: N = 250
Outcomes	1) Percent of patients screened 2) Average blood pressure
Results	mixed 1) The proportion of patients screened in the Audit and Feedback Groups was double the number screened in both the education and the control groups 2) No difference in Average blood pressure across the groups
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Medium potential for confounding because no attempts to control for possible cluster effect.
Quality of Study	Good

Author/Year	Inui 1976 [38]
Study Design	Randomized Controlled Trial
Intervention	Educational Outreach combined with Audit and Feedback versus Control
Study Population	Johns Hopkins internal medicine clinic Attending and resident physicians: N = 62 All patients with diagnosis of hypertension: N = 218
Outcomes	Percent of patients in each group with diastolic blood pressure < 100 mm Hg before and after the intervention.
Results	Positive After 6 months 69% of intervention group patients had DBP < 100 as compared to 32% of control group.
Internal Validity	Low potential for selection bias. Medium to high potential for measurement bias; investigators took all blood pressure measures in an unblinded manner. Medium potential for confounding; cluster effect possible given small sample size and no information on patients per physician.
Quality of Study	Fair

Author/Year	Bulpitt 1976 [54]
Study Design	Randomized Controlled Trial
Intervention	Computerized Reminders versus Control
Study Population	Outpatient clinics in UK: N = 3 Patients with hypertension: N = 278
Outcomes	Average blood pressure in each group after intervention
Results	Negative No difference in blood pressure between groups
Internal Validity	Low potential for selection bias. Low potential for measurement bias. Low potential for confounding.
Quality of Study	Good

Appendix B. Data abstracted from the 35 reviewed articles

Appendix C Summary Data for included Articles

Study	Design	Intervention	Outcome Result			Quality
			Screening or F/U	Therapy Change	BP Control	
Simon [30]	RCT	Educational Outreach with Opinion Leader	n/a	Positive	Negative	Good
Simon [39]	TSA	Audit and Feedback	n/a	Negative	Negative	Fair
Ornstein [33]	RCT	Multifaceted – A&F, Educational Outreach, CME	Positive	n/a	Positive	Good
Toth-Pal [50]	RCT	Reminders	Positive	n/a	n/a	Good
New [35]	RCT	Educational Outreach and Audit and Feedback	n/a	n/a	Negative	Good
Murray [45]	RCT	Decision Support	n/a	Negative	Negative	Good
Mitchell [43]	RCT	Audit and Feedback, Reminders	Negative	Negative	Positive	Good
Mcdermott [62]	TSA	Multifaceted – CME, Outreach, Reminders, A&F	Positive	Positive	Positive	Fair
Siegel [37]	CCT	Educational Outreach, Audit and Feedback	n/a	Positive	Negative	Fair
Frijling [36]	RCT	Educational Outreach, Audit and Feedback	n/a	Negative	n/a	Good
Kogan [40]	RCT	Audit and Feedback	n/a	Negative	n/a	Fair
Avanzini [59]	CCT	Local Consensus	n/a	Positive	Positive	Fair
Maue [34]	TSA	Multifaceted –A&F, Educational Outreach, CME	n/a	Negative	Positive	Fair
Sanders [55]	RCT	Reminders	n/a	Negative	n/a	Poor
Denton [32]	RCT	Educational Outreach, Local Opinion Leader, A&F	n/a	Positive	n/a	Fair
Nilsson [31]	RCT	Educational Outreach, Local Opinion Leader, A&F	n/a	Positive	n/a	Good
Montgomery [46]	RCT	Decision Support	n/a	Negative	Negative	Fair
Hetlevik [47]	RCT	Decision Support, CME	n/a	n/a	Negative	Fair
Goldberg [63]	RCT	Educational Outreach, Local Opinion Leader, CQI	n/a	Negative	Negative	Fair
Rossi [51]	RCT	Reminders	n/a	Positive	Negative	Good
Aucott [64]	CCT	Multifaceted – Educational Outreach, Opinion Leader, Audit and Feedback, Local Consensus	n/a	Positive	Positive	Fair

Onion [60]	CCT	Local Consensus	n/a	Positive	n/a	Fair
Jennett [57]	RCT	CME	Positive	n/a	n/a	Good
McDowell [52]	RCT	Reminders	Positive	n/a	n/a	Good
Putnam [61]	RCT	Local Consensus	n/a	n/a	Negative	Fair
Gullion [44]	RCT	CME, Audit and Feedback	n/a	n/a	Negative	Good
Evans [58]	RCT	CME	n/a	n/a	Negative	Poor
McAlister [48]	RCT	Decision Support and Reminders	n/a	n/a	Positive	Good
Cohen [56]	TSA	Automatic Scheduling and Chart Reminder	Positive	Positive	n/a	Fair
Winickoff [41]	RCT	Audit and Feedback	Negative	n/a	Negative	Good
Barnett [53]	RCT	Reminders	Positive	n/a	n/a	Good
Rogers [49]	RCT	Reminders and Decision Support	Positive	n/a	Negative	Fair
Dickinson [42]	RCT	Audit and Feedback, CME	Positive	n/a	Negative	Good
Inui [38]	RCT	Educational Outreach, Audit and Feedback	n/a	n/a	Positive	Fair
Bulpitt [54]	RCT	Reminders	n/a	n/a	Negative	Good

Appendix C. Short Description of studies, outcomes, and quality. Study Design: RCT = Randomized Controlled Trials, CCT = Controlled Cohort Trial, TSA = Time-Series Analysis. Intervention: CME = Continuing Medical Education, A&F = Audit and Feedback, CQI = Continuous Quality Improvement. Quality measures = poor, fair or good.