

Closing the Quality Gap: A Critical Analysis of Quality Improvement Strategies

Volume 3—Hypertension Care

Prepared for:

Agency for Healthcare Research and Quality
U.S. Department of Health and Human Services
540 Gaither Road
Rockville, MD 20850
www.ahrq.gov

Contract No. 290-02-0017

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Suggested Citation:

Walsh J, McDonald KM, Shojania KG, Sundaram V, Nayak S, Davies S, Lewis R, Mechanic J, Sharp C, Henne M, Shah B, Chan JK, Owens DK, Goldstein MK. Hypertension Care. Vol. 3 of: Shojania KG, McDonald KM, Wachter RM, Owens DK, editors. Closing The Quality Gap: A Critical Analysis of Quality Improvement Strategies. Technical Review 9. (Prepared by the Stanford University–UCSF Evidence-based Practice Center, under Contract No. 290-02-0017). AHRQ Publication No. 04-0051-3. Rockville, MD: Agency for Healthcare Research and Quality. January 2005.

Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-Based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new health care technologies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review prior to their release.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

We welcome written comments on this evidence report. They may be sent to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by e-mail to epc@ahrq.gov.

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Structured Abstract

Objective: Hypertension affects more than 50 million people in the United States alone. Despite clear evidence regarding the beneficial effects of quality treatment for high blood pressure, many millions of diagnosed and undiagnosed hypertensives are not receiving the optimal standard of care. The difference in patient outcomes achieved with present hypertension treatment methods and those thought to be possible using best practice treatment methods is known as a quality gap, and such gaps are at least partly responsible for the loss of thousands of lives each year. This review was organized to bring a systematic assessment of different quality improvement (QI) strategies and their effects to the process of identifying and managing hypertension.

Search Strategy and Inclusion Criteria: Investigators searched the MEDLINE[®] database, the Cochrane Collaboration's Effective Practice and Organisation of Care (EPOC) registry, article bibliographies, and relevant journals for experimental evaluations of QI interventions aimed at improving hypertension screening and management of non-pregnant adults with primary hypertension. The reviewers included randomized or quasi-randomized controlled trials, controlled before–after studies, and interrupted time series in which at least one reported outcome measure included changes in blood pressure, or provider or patient adherence to a recommended process of care.

Data Collection and Analysis: Relevant data were abstracted independently by two reviewers. Each QI intervention was classified into one or more of the following components: provider education, provider reminders, facilitated relay of clinical information, patient education, promotion of self-management, patient reminders, audit and feedback, organizational change, or financial incentives. Certain categories were further subdivided into major subtypes (e.g., professional meetings for provider education and disease management for organizational change). The researchers also evaluated the impact of clinical information systems as a mediator for interventions of all types. They compared the different QI strategies in terms of the median effects achieved for blood pressure control and for a generalized measure of provider or patient adherence.

Main Results: Sixty-three articles reporting a total of 82 comparisons met the inclusion criteria. Studies of hypertension identification were found to be too heterogeneous for quantitative analysis. The majority of screening studies were clinic-based (with a few offered at work sites), and the most common strategies involved patient and/or provider reminders. These generally showed positive results; several studies found that patients were more likely to know their blood pressure or attend clinic visits after receiving reminders. Across all studies with a variety of strategies, the median reductions in systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 4.5 mmHg (interquartile range: 1.5, 11.0) and 2.1 mmHg (interquartile range: -0.2, 5.0), respectively. The median increase in the proportion of patients in the target SBP range and target DBP range was 16.2 percent (interquartile range: 10.3, 32.2), and 6.0 percent (interquartile range: 1.5, 17.5), respectively. Studies that focused on improving provider adherence showed a range of median reduction of 1.3 percent to a median improvement of 3.3 percent across all QI strategies. Overall, patient adherence showed a median improvement of 2.8 percent (interquartile range: 1.9, 3.0).

Conclusion: The findings of this review suggest that QI strategies appear, in general, to be associated with the improved identification and control of hypertension. It is not possible to

discern with complete confidence which specific QI strategies have the greatest effects, since most of the studies included more than one QI strategy. All of the assessed strategies may be beneficial under some circumstances, and in varying combinations. There may be other useful strategies that have not been studied in trials meeting the inclusion criteria for evidence-based review; it is not possible to draw conclusions about these strategies.

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Appendixes and Evidence Tables for this report are provided electronically at <http://www.ahrq.gov/clinic/tp/hybergap3tp.htm>.

Summary

Introduction

In early 2003, the Institute of Medicine (IOM) released its report, *Priority Areas for National Action: Transforming Health Care Quality*. The report listed 20 clinical topics for which “best practices” were strongly supported by clinical evidence. The report—along with other literature—clearly documents the disappointingly low rates at which these practices have been implemented in the United States, at an annual cost of many thousands of lives.

To bring data to bear on the quality improvement opportunities articulated in the IOM’s 2003 report, the Agency for Healthcare Research and Quality (AHRQ) engaged the Stanford-UCSF Evidence-based Practice Center (EPC) to perform a critical analysis of the existing literature on quality improvement strategies for a selection of the 20 disease and practice priorities noted in the IOM Report. Rather than concentrating on the specific clinical practices that appear to improve health outcomes, the focus of this review is on translating research into practice—identifying those activities that increase the rate at which practices regarded as effective are applied to patient care in real world settings. In other words, the authors aim to narrow the “quality gap” that is in large part responsible for suboptimal health care practices and outcomes.

This report focuses on the clinical problem of hypertension. It, like the other reports in the series, aims to help readers assess whether the evidence suggests that a quality improvement strategy would work in their specific practice or with their specific patient population. The question of whether these may be crosscutting practices—that is, the manner in which those that have been studied for specific conditions such as hypertension might be applicable to others, such as asthma—remains to be seen. We will further address these practices in subsequent volumes, as we review the evidence for many of the other conditions highlighted in the 2003 IOM report.

We defined the *quality gap* as the difference between health care processes or outcomes observed in practice, and those potentially obtainable on the basis of current professional knowledge. We defined a *quality improvement (QI) strategy* as an intervention aimed at reducing the quality gap for a group of patients representative of those encountered in routine practice. Finally, a *quality improvement target* is an outcome, process, or structure that the QI strategy aims to influence, with the goal of reducing the quality gap. Examples of targets relevant to this volume include outcomes such as reductions in blood pressure, or processes such as improved provider adherence with medication choices in patients with hypertension. Nine types of QI strategies were considered; they are shown (with examples) in Table 1.

Table 1. Taxonomy of QI strategies with examples of substrategies

QI strategy	Examples
Provider reminder systems	<ul style="list-style-type: none"> • Reminders in charts for providers • Computer-based reminders for providers • Computer-based decision support
Facilitated relay of clinical data to providers	<ul style="list-style-type: none"> • Transmission of clinical data from outpatient specialty clinic to primary care provider by means other than medical record, e.g., phone call or fax
Audit and feedback	<ul style="list-style-type: none"> • Feedback of performance to individual providers • Quality indicators and reports • National/state quality report cards • Publicly released performance data • Benchmarking – provision of outcomes data from top performers for comparison with provider’s own data
Provider education	<ul style="list-style-type: none"> • Workshops and conferences • Educational outreach visits (e.g., academic detailing) • Distribution of educational materials
Patient education	<ul style="list-style-type: none"> • Classes • Parent and family education • Patient pamphlets • Intensive education strategies promoting self-management of chronic conditions
Promotion of self-management	<ul style="list-style-type: none"> • Materials and devices to promote self-management
Patient reminder systems	<ul style="list-style-type: none"> • Postcards or calls to patients
Organizational change	<ul style="list-style-type: none"> • Case Management, Disease Management • Total Quality Management, Cycles of Quality Improvement • Multidisciplinary teams • Change from paper to computer-based records • Increased staffing • Skill mix changes
Financial incentives, regulation, and policy	<p><i>Provider Directed:</i></p> <ul style="list-style-type: none"> • Financial incentives based on achievement of performance goals • Alternative reimbursement systems (e.g., fee-for-service, capitated payments) • Licensure requirements <p><i>Patient Directed:</i></p> <ul style="list-style-type: none"> • Co-payments for certain visit types • Health insurance premiums, user fees <p><i>Health System Directed:</i></p> <ul style="list-style-type: none"> • Initiatives by accreditation bodies (e.g., residency work hour limits) • Changes in reimbursement schemes (e.g., capitation, prospective payment, salaried providers)

Methodology

Our review involved an exhaustive search strategy of the Medline, Cochrane (including, quite importantly, the Cochrane Effective Practice and Organisation of Care (EPOC) Review Group registry), and other relevant databases, as well as hand searches of articles and bibliographies. We employed standard inclusion/exclusion criteria, definitions and protocols; re-review of exclusion decisions by study personnel, and independent abstractions by two reviewers, with conflicts resolved by consensus. In assessing the quality of a given study, we used a hierarchy of design (Level 1 studies were randomized controlled trials, Level 2 were controlled before–after studies, interrupted time series, and quasi randomized trials, and so on), and used the highest quality evidence available to assess the value of each QI strategy. We acknowledge that much of the important work in quality improvement is performed “in the trenches,” by front-line workers taking advantage of available resources to answer important, practical questions using simple designs (e.g., uncontrolled before–after studies). However, in a report of this type, we felt it important to strive to find and analyze studies whose research methodologies were likeliest to give scientifically correct answers. In analyzing our results, we performed quantitative analysis (including the calculation of summary effects, adjustment for unit of analysis errors, and meta-regression analysis) when enough studies with similar outcomes were available, and studies were sufficiently homogeneous in both design and population.

Hypertension has been defined as systolic blood pressure (SBP) greater than 140 mmHg and diastolic blood pressure (DBP) greater than 90 mmHg ($> 140/90$), with normal blood pressure set at $< 120/80$. It is estimated that 58.4 million Americans have hypertension, making it the most common primary diagnosis in the United States. Hypertension is a major risk factor for cardiovascular disease, and high quality evidence (codified in the periodic reports of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure (JNC)) supports the premise that treatment of hypertension, most commonly with drug therapy, reduces such risks. Even small reductions can have profound effects: a 1990 meta-analysis of 14 randomized treatment trials found that lowering DBP 5–6 mmHg reduced stroke rates by 42 percent. The recently issued JNC 7 has emphasized the efficacy of diuretics, recommending them as initial therapy for most patients, either alone or in combination with one of the other classes of agents (ACE inhibitors, angiotensin receptor antagonists, β -adrenergic receptor antagonists, calcium channel antagonists) demonstrated to be beneficial in randomized trials.

Despite this extraordinary clinical knowledge base and the link between treatment and outcomes, there is a profound quality gap in the management of hypertension. In the U.S. in 1999-2000, 69 percent of people with hypertension were aware of their condition, but only 58 percent of hypertensives were receiving treatment. Moreover, it is estimated that only 31 percent of known hypertensives in the United States have well-controlled blood pressure. Among the possible reasons for this gap are the asymptomatic nature of hypertension, the necessity of lifelong management for most patients, the frequently changing therapeutic recommendations, and the importance of individualizing and titrating treatment.

We focused on the quality gap in patients with primary hypertension (also called “essential” hypertension) in non-pregnant adults. This population makes up more than 90 percent of all patients with hypertension. Our quality improvement targets were primarily measures of blood pressure screening (i.e., strategies to increase the percentage of patients with high blood pressure who are aware of their condition) and control (i.e., fraction of patients with known hypertension whose blood pressure is within the range recommended by the JNC and others). We captured outcome measures (such as mortality) when they were reported, but they usually were not. We

also considered measures of both provider (e.g., adherence to specific medication recommendations) and patient (e.g., attending followup appointment) adherence to recommendations.

From our original sample of 3,071 potentially relevant articles, a total of 359 merited full-text review. Of these, 110 merited full abstraction. After excluding those consisting solely of a patient education strategy (to be reviewed separately in a subsequent volume in the Series), our sample consisted of 63 articles reporting a total of 82 comparisons of QI intervention to a control group.

Findings

Studies of hypertension identification and initial followup were too heterogeneous to be analyzed quantitatively. The majority were clinic-based (though a few were offered at work sites), and the most common strategies were *patient and/or provider reminders*. They generally showed positive results; several studies found that patients were more likely to know their blood pressure or attend clinic visits after receiving reminders. Frequently used strategies included patient reminder letters, computer identification of patients with historically poor follow-up (with computer-generated reminders to these patients), and the addition of a health promotion nurse to identify and followup with high-risk patients.

The evidence-base behind QI strategies designed to improve blood pressure control was more robust, and its results were generally positive. Across all studies (of a variety of strategies), the median reduction in SBP was 4.5 mmHg (IQ range: 1.5, 11.0), and median reduction in DBP was 2.1 mmHg (IQ range: -0.2, 5.0). Overall, the median increase in the proportion of patients in target SBP range and target DBP range in these comparisons was 16.2 percent (IQ range: 10.3, 32.2), and 6.0 percent (IQ range: 1.5, 17.5), respectively. Note that the QI strategies had a somewhat larger effect on SBP than on DBP; the latter was previously considered the more important target, but recent research has confirmed the importance of treating systolic hypertension.

Our findings suggest that quality improvement strategies, in general, appear to be associated with improved detection and control of hypertension. Since most studies included more than one QI strategy (although, unlike in diabetes, multiple interventions did not appear to be associated with greater effect sizes in hypertension), it is not possible to discern with complete confidence which QI strategies have the greatest effects. All of the strategies assessed--organizational change, patient education in combination with several other QI strategies, provider education, facilitated relay of clinical data, audit and feedback, promotion of self-management, provider reminders, patient reminders, and financial incentives--may be beneficial under some circumstances, and in varying combinations. Studies that involved *organizational change* appeared to have the largest effects on outcomes, although there were some methodologic concerns about confounding due to study size. Organizational change may work, at times, because the change meshes well with existing structures and resources in a given institution; the applicability of these changes to other settings may be limited. Moreover, a given organizational change (i.e., the hiring of a nonphysician provider to contact patients) may simply be a marker for high levels of administrative support or funding, further limiting the applicability of the change itself to other settings.

Like organizational change, studies including *patient education* as part of the QI strategy also appeared to have relatively large effects, but unfortunately these results also are confounded by study size.

Studies that focused on improving provider adherence with recommendations for the management of hypertension had less effect (median effects ranged from a 1.3 percent reduction to 3.3 percent improvement in adherence across the QI strategies). There are probably several reasons for this limited impact, including past controversies in the medical literature over treatment goals and therapeutic options, rapidly changing recommendations (best evidenced by a new JNC report every few years), practice “inertia,” and environmental influences such as time pressures, incentive structures, and resource constraints.

Conclusions

Despite the importance and prevalence of both diabetes and hypertension, and the richness of their clinical literatures, studies that would help patients, providers, and policymakers choose how best to close their quality gaps are somewhat confusing. For each entity, certain strategies (such as the use of multifaceted interventions, and perhaps disease management in diabetes, and the adoption of organizational change in hypertension) appear to be more effective than others. Yet, even in these areas, problems with publication bias, co-interventions, and secular trends make sweeping conclusions hazardous. Our review provides a huge collection of research data for the interested reader to dissect; undoubtedly, there is information that will be directly applicable to a given clinical situation or location. At the synthesis level, however, the most striking finding from these systematic reviews is the need for additional, high quality research to clarify how best to translate research into practice for these common, highly morbid disorders.

Technical Review

Chapter 1. Introduction

Background

The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7), issued in 2003, defines hypertension as a systolic blood pressure (SBP) greater than 140 mmHg and diastolic blood pressure (DBP) greater than 90 mmHg ($> 140/90$), compared with a normal blood pressure of $< 120/80$. This revised threshold represents a marked departure from the former standard for hypertension ($< 140/90$).¹ A new category—“pre-hypertension”—also was established for patients with a SBP of 120 to 139 mmHg, or a DBP of 80 to 89 mmHg. Hypertension often exhibits no clinical manifestations until the onset of organ damage, therefore screening, early detection, and proper disease control are critical to good health. The World Health Organization (WHO) credits hypertension with one in every eight deaths, making it the third leading cause of death worldwide,² and has described high blood pressure as “...the most important public health problem in developed countries.”³ In the United States, 28.7 percent of participants in the 1999–2000 National Health and Nutrition Examination Survey (NHANES) conducted by the National Center for Health Statistics were identified as hypertensive, either because they had elevated blood pressure, or because they were being treated with antihypertensive medications. Extrapolating from these findings, it is estimated that 58.4 million Americans have the condition. Hypertension is the most common primary diagnosis in the United States, and was the principal diagnosis for 35 million office visits during 2001.⁴

Hypertension is a major risk factor for cardiovascular disease,⁵⁻⁷ including coronary heart disease (CHD), heart failure, and stroke. The benefits of treating hypertension have been established for many years, and treatment standards have evolved continually. A 1990 meta-analysis of 14 randomized treatment trials of hypertensive patients showed that a 5–6 mmHg reduction in DBP could translate to a 42 percent reduction in stroke occurrences.⁸ A 1990 epidemiologic review reported that a lower blood pressure should confer a lower risk of vascular disease.⁹ Other major trials reported a significant overall decrease in cardiac events following treatment for hypertension, including the Systolic Hypertension in the Elderly Program (SHEP) (a 27 percent reduction),¹⁰ the Swedish Trial in Older Patients with Hypertension (STOP) (a 13 percent reduction),¹¹ and the Medical Research Council study (MRC) (a 19 percent reduction).¹²

While exact projections are difficult to establish, data from the Framingham Heart Study and the NHANES II indicate that even small improvements in blood pressure control can have a major impact on public health. Lowering the DBP by only 2 mmHg could result in a 6 percent reduction in the risk of coronary heart disease, and a 15 percent reduction in the risk of stroke and transient ischemic attacks.¹³ Moreover, in individuals with a SBP of 140–159 mmHg and/or a DBP of 90–99 mmHg, a sustained 12 mm reduction in SBP for a period of 10 years has been estimated to prevent one death among every 11 patients treated.¹

Important advances in hypertension care have occurred in the last ten to fifteen years. Previously, hypertension was generally treated only when the DBP exceeded 90 mmHg. But the 1991 publication of the SHEP study confirmed the benefits of treating isolated systolic hypertension.¹⁰ More recently, pooled individual data from 61 separate prospective studies confirmed the risks associated with an elevated SBP: for individuals aged 40–69, each increase of 20 mmHg of SBP (or 10 mmHg DBP) was associated with a two-fold increase in mortality

from both CHD and stroke.¹⁴ SBP is a robust indicator of risk of cardiovascular disease in the population at large. It is also a stronger predictor of risk than DBP, in those older than age 50.¹⁵ Current guidelines call for treating isolated systolic hypertension according to the same principles used in the general care of hypertension.¹ The therapeutic focus now is on achieving the SBP target goal, as most patients then will reach the DBP goal.¹ Lifestyle modifications and drug therapy are recommended for all patients with blood pressures above the normal range.

The prevalence of hypertension increases with age and tends to be higher among women.¹⁶ And while hypertension affects all races and ethnic groups, certain groups bear a disproportionate burden of risk. non-Hispanic blacks have higher rates of hypertension than do non-Hispanic whites and Mexican-Americans, while Mexican-Americans have the lowest reported rates of controlled hypertension.¹⁶ Blacks tend to develop high blood pressure at an earlier age, they generally have much higher blood pressures,¹⁷ and they have a four times higher age-adjusted risk of end-stage renal disease than do whites.¹⁸

Drug therapy for high blood pressure is equally effective among men and women.¹⁹ Blacks who receive appropriate treatment achieve overall decreases in blood pressure similar to those of whites, and also may experience a lower incidence of cardiovascular disease.^{17, 20, 21} Appropriate treatment and control of hypertension also reduces the risk of several associated complications, including end-stage renal disease, congestive heart failure, and peripheral vascular disease. The target blood pressures are less than 130/80 mmHg for hypertensive patients with diabetes or renal disease, and less than 140/90 mmHg for other patients with hypertension.

This review provides a systematic assessment of the effect of various quality improvement (QI) strategies on the screening and treatment of hypertension.

The Quality Gap

Despite clear evidence that treating hypertension reduces morbidity and mortality, the incidence of stroke, myocardial infarction, and heart failure, hypertension care in the United States often fails to comply with evidence-based guidelines.¹ And while 68.9 percent of the participants in the 1999–2000 NHANES study were aware of their hypertension, only 58.4 percent were receiving treatment.¹⁶

These rates are an improvement over those reported from 1991–1998, but they still are not optimal. The national wellness program, Healthy People 2010,²² includes four important goals for the detection and evaluation of hypertension:

- Reduce the proportion of U.S. adults with high blood pressure from the current rate of 28.7 percent,¹⁶ to 16 percent.²²
- Increase the proportion of hypertensive adults with controlled blood pressure from the current rate of 31 percent,¹⁶ to 50 percent.²²
- Increase the proportion of adults with high blood pressure who are taking action to help control their blood pressure (i.e., losing weight, increasing physical activity, or reducing sodium intake) from the current rate of 82 percent,²³ to 95 percent.²²
- Increase to 95 percent the proportion of adults who have had their blood pressure measured in the preceding two years and can state whether their blood pressure is normal or high.²²

Recent findings suggest the nation is approaching this last goal. Data from the National Health Interview Survey, collected from 2001–2003, indicate 90 percent of all adults had their blood pressure measured in the previous two years and could state whether or not it is high.²³

Evidence-based Guidelines and Quality of Care Measures

Guidelines

Many aspects central to high blood pressure detection, evaluation, and treatment have been studied and the findings have contributed to the development of one of the most extensive guidelines processes available: the JNC Reports.^{1, 17} These guidelines are developed by the National High Blood Pressure Education Program of the National Heart, Lung, and Blood Institute, along with a number of coordinating committee member organizations.¹

Therapy for hypertension is largely pharmaceutical-based, although nonpharmacologic therapies and lifestyle modifications such as exercise, sodium restriction, weight loss, and modification of alcohol intake are important contributors to blood pressure reduction. Evidence-based guidelines for management of hypertension recommend a wide variety of antihypertensive drugs, as well as targets for blood pressure control. The JNC 7 guidelines state “there are excellent clinical outcome trial data proving that lowering blood pressure with several classes of drugs, including angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor antagonists (ARBs), β -adrenergic receptor antagonists (β -blockers), calcium channel antagonists (CCBs), and thiazide-type diuretics, will all reduce the complications of hypertension.”¹ Equivalent blood pressure reduction with different antihypertensive agents, however, may not confer the same degree of risk reduction.²⁴ A recent analysis of data from 29 randomized trials studied the comparative benefits of several different antihypertensive drug classes on risk of cardiovascular events.²⁵ This analysis showed a reduction in major cardiovascular events with ACE inhibitors, angiotensin receptor antagonists, β -adrenergic receptor antagonists, calcium channel antagonists, and thiazide-type diuretics, while further determining that larger reductions in blood pressure (regardless of which of these medications was used) resulted in larger reductions in risk.²⁵ The JNC 7 guidelines further contend that “diuretics have been virtually unsurpassed in preventing the cardiovascular complications of hypertension,” and recommends

¹ National Heart, Lung, and Blood Institute, American Academy of Family Physicians, American Academy of Insurance Medicine, American Academy of Neurology, American Academy of Ophthalmology, American Academy of Physician Assistants, American Association of Occupational Health Nurses, American College of Cardiology, American College of Chest Physicians, American College of Occupational and Environmental Medicine, American College of Physicians - American Society of Internal Medicine, American College of Preventive Medicine, American Dental Association, American Diabetes Association, American Dietetic Association, American Heart Association, American Hospital Association, American Medical Association, American Nurses Association, American Optometric Association, American Osteopathic Association, American Pharmaceutical Association, American Podiatric Medical Association, American Public Health Association, American Red Cross, American Society of Health-System Pharmacists, American Society of Hypertension, American Society of Nephrology, Association of Black Cardiologists, Citizens for Public Action on High Blood Pressure and Cholesterol, Inc., Hypertension Education Foundation, International Society on Hypertension in Blacks, National Black Nurses Association, Inc., National Hypertension Association, Inc., National Kidney Foundation, Inc., National Medical Association, National Optometric Association, National Stroke Association, NHLBI Ad Hoc Committee on Minority Populations, Society of Geriatric Cardiology, Society for Nutrition Education, Federal Agency Representatives, Agency for Healthcare Research and Quality, Centers for Medicare and Medicaid Services, Department of Veterans Affairs, Health Resources and Services Administration, National Center for Health Statistics, National Institute of Diabetes and Digestive and Kidney Diseases

that “thiazide-type diuretics should be used as initial therapy for most patients with hypertension, either alone or in combination with one of the other classes (ACE inhibitors, ARBs, β -blockers, CCBs) demonstrated to be beneficial in randomized controlled outcome trials.”¹

A complete discussion of the different antihypertensive therapies is beyond the scope of this review of quality improvement strategies. Readers are directed to the JNC 7 guidelines and to other published resources. The World Health Organization and the Veterans Health Administration (VHA), for example, have undertaken independent reviews of the evidence, and have developed guidelines that closely resemble the JNC recommendations, with some areas of difference.^{26, 27}

Quality of Care Measures

The recent proliferation of quality measures for the assessment of medical outcomes has spawned multiple measures for particular conditions, including hypertension. Although there is no consensus regarding a single performance measure for determining hypertension quality of care, most national measures have focused on blood pressure control or screening. A multitude of blood pressure measures have been used over the years to assess the quality of care, frequently involving a percentage of patients with blood pressure exceeding a particular control threshold. The Institute of Medicine has stated that control of blood pressure is a valid quality measure, as it has been shown to reduce morbidity and mortality.²⁸ Few report cards have used measures other than blood pressure control or screening to evaluate quality of care (e.g., whether clinicians prescribed one of the recommended first-line antihypertensive medications).

Although blood pressure screening and control have emerged as the consensus choices for hypertension quality metrics, variations on these themes have been developed by different organizations to reflect their particular goals, purposes, or opinions. Developers of quality measures include government agencies, accreditation groups, voluntary health organizations, purchasers, health plans, and physician specialty organizations, among others.^{22, 29-33} Debate regarding the most appropriate measures is ongoing, despite a general agreement that ideal measures should be easy to obtain, reliable, and valid. A selection of the groups involved in the development and/or utilization of hypertension quality measures is described below.

The Agency for Healthcare Research and Quality (AHRQ) commissioned this report and maintains the National Quality Measures Clearinghouse. The Agency is mandated by the U.S. Congress to produce the National Healthcare Quality Report (NHQR), based on available quality measures.²⁹ AHRQ’s preliminary quality measures for hypertension include the percentage of people age 21 and over who have had their blood pressure checked within the past two years, and the percentage of people with hypertension who have their blood pressure under control.²⁹

The National Committee for Quality Assurance (NCQA) is the nonprofit accreditation organization that developed and maintains the Health Plan Employer Data and Information Set (HEDIS[®]), which contains quality performance measures for health care plans.³³ HEDIS is the most widely used performance measures set in the managed care industry, and also is used by purchasers of health care, regulators, consumers, and health plans. The current HEDIS quality measure for hypertension is the percentage of patients with hypertension, age 46 to 85, whose blood pressure is controlled (defined as SBP < 140 mmHg and DBP < 90 mmHg). In the year 2000, for example, 51.5 percent of patients participating in managed care plans that reported their HEDIS data had controlled blood pressure.³⁴ This figure represents a significant improvement over the 39 percent result obtained in 1999 for the same HEDIS measure.³⁴

Moreover, the year 2000 percentage is notably higher than the estimated percentage of known hypertensives in the general American population whose blood pressure is under control.³⁴

The Veterans Health Administration (VHA) utilizes quality measures to evaluate hypertension care within its delivery system. These measures include the percentage of patients with an active diagnosis of hypertension whose most recent blood pressure recording was less than 140/90 mmHg, and the percentage of patients with an active diagnosis of hypertension whose most recent blood pressure reading was \geq 160/100 mmHg, or for whom no blood pressure had been recorded during the previous year.³⁵

Key Questions

There are several important questions that warrant consideration in the realm of hypertension quality improvement. Some of these questions focus on prevention (screening) while others relate to the management of a chronic disease (blood pressure control). The reviewers have selected the following questions as important foci in the development of this report:

- Which QI strategies improve the process of screening for hypertension?
- Which QI strategies most effectively ensure that blood pressure goals are achieved and maintained?
- Which QI strategies improve provider adherence to recommended guidelines for hypertension management?
- Which QI strategies improve patient adherence to hypertension treatment?

Several features of hypertension pose challenges to the development and evaluation of quality improvement strategies. First and foremost, hypertension is generally asymptomatic; individuals afflicted with hypertension typically do not feel any differently from those who do not suffer the condition. In addition, medical treatment for hypertension may cause adverse side effects. These factors may make patients less likely to adhere to treatment. Additionally, hypertension is most often a chronic condition, requiring lifelong management. Patients whose blood pressure is controlled at one point in time may discover it is not well controlled at another time. This dilemma may present a challenge to those designing studies to evaluate the impact of QI interventions.

In addition, treatment must be individualized for each patient. While the different classes of antihypertensives are effective in lowering blood pressure on a population basis, any individual patient may be more or less responsive to a particular medication, and/or may develop particular adverse effects. If a patient's blood pressure already is well controlled through the use of a particular drug, changing to a different drug carries with it a possibility that the new drug will yield no benefit. The patient also could develop a drug-related adverse effect, requiring dose titration or other changes to the treatment regimen. Orthostatic hypotension is another concern, particularly in older adults with diminished autonomic responses to maintain blood pressure in the standing position. Many patients will require two, three, or more antihypertensive drugs to achieve the target blood pressure. Generally speaking, patients with hypertension tend to be older and often have other medical disorders requiring drug treatment. This patient population must be monitored closely for adverse drug effects and/or drug-drug interactions. Changing guideline recommendations and the wide variety of available therapies present further challenges to QI

development and evaluation, given the dynamic nature of physician knowledge and patient knowledge concerning hypertension.

Chapter 2: Methods

Methods common to the reviews of quality improvement strategies for the various topics and disorders are presented in first volume of the *Closing the Quality Gap* series. The authors provide additional detail in this section, as it pertains to the review of quality improvement strategies for hypertension.

Types of Quality Improvement Strategies

A variety of interventions have been tested with the goal of improving the quality of care for common clinical conditions. The conceptual framework developed for classifying quality improvement strategies has been on the scientific literature (See *Closing the Quality Gap*, Volume 1). These interventions can target organizations, providers, communities, or individual patients, and have been evaluated in a wide variety of formats. The reviewers have classified the range of interventions into nine broad strategies, according to the following taxonomy (also see, Volume 1):

- 1. Provider reminders**—Information tied to a specific clinical encounter, provided verbally, in writing, or by computer, and intended to prompt the clinician to recall information (e.g., to make medication adjustments or order appropriate screening tests), or to consider performing a specific process of care. The phrase “tied to a specific clinical encounter” serves to distinguish reminder systems from audit and feedback, where clinicians are typically presented with summaries of their performance relative to a process or outcome of care over multiple encounters.
- 2. Facilitated relay of clinical data to providers**—Clinical information collected directly from patients and relayed to the provider where the data are not generally collected during a patient visit, or using some format other than the existing local medical record system (e.g., transmission of a patient’s home blood pressure measurements). The researchers expected some overlap with provider reminder systems, but kept these strategies separate at the abstraction stage, to allow for the possibility that the data could be analyzed subsequently with and without collapsing the two strategies.
- 3. Audit and feedback**—Any summary of clinical performance of health care providers or institutions that is reported either publicly or confidentially, to or about the clinician or institution (e.g., the percentage of a provider's patients who have achieved or have not achieved some clinical target). Benchmarking refers to the provision of performance data from institutions or providers regarded as leaders in the field. The investigators included benchmarking as a type of audit and feedback, so long as local data were provided in addition to the benchmarks.
- 4. Provider education**—Any intervention that included one of the following three substrategies: educational workshops, meetings (e.g., traditional Continuing Medical Education [CME]), and lectures (live or computer-based); educational outreach visits (use of a trained person who met with providers in their practice settings to disseminate information intended to change the provider's practice); or distribution of educational

materials (e.g., published or printed recommendations for clinical care, including clinical practice guidelines, audio-visual materials and/or electronic publications).

5. **Patient education**—In-person patient education, either individually or as a part of a group or community; distribution of printed or audio-visual educational materials. The investigators evaluated those strategies that included patient education as part of a multifaceted strategy, but excluded those in which patient education was the sole strategy. A future volume in this series will review the topic of patient education with reference to its effect on a variety of chronic diseases, including hypertension.
6. **Promotion of self-management**—Distribution of materials (e.g., devices for blood pressure self-monitoring) or access to a resource that enhances the patients' ability to manage their condition, provision of clinical data back to the patient, or followup phone calls to make recommendations regarding adjustments to care. The reviewers expected some strategy overlap with patient education and patient reminders, but kept the strategies separate at the abstraction stage to allow for the possibility that the data could be analyzed subsequently with and without collapsing the strategies. Those strategies that included self-management as part of a multifaceted strategy were analyzed, but those in which self-management was the sole strategy were excluded. A future volume in this series will address the topic of self-management, along with patient education.
7. **Patient reminders**—Any effort directed at encouraging patients to keep appointments or adhere to other aspects of self-care.
8. **Organizational change**—Changes in the structure or delivery of clinical care designed to improve its efficiency or comprehensiveness. The investigators included changes such as the use of disease management or case management (coordination of assessment, treatment, and arrangement for referrals by a person or multidisciplinary team in collaboration with or supplementary to the primary care provider), other team or personnel changes, use of telemedicine (communication and case discussion between distant health professionals), Total Quality Management (TQM) or Continuous Quality Improvement (CQI) (i.e., cycles of measurement of quality problems, design of interventions, implementation, and re-measurement), and changes in medical records systems or hospital information systems. Among studies that included organization change as one of their QI strategies, three substrategies (disease/case management, team/staffing changes, and medical records changes) also were extracted for analysis.
9. **Financial, regulatory, or legislative incentives**—Interventions providing positive or negative financial incentives directed at providers (e.g., linked to adherence to some process of care or achievement of some target patient outcome), positive or negative financial incentives directed at patients, system-wide changes in reimbursement (e.g., capitation, prospective payment, shift from fee-for-service to salary), changes to provider licensure requirements, or changes to institutional accreditation requirements.

In addition to the aforementioned QI strategies, the reviewers planned initially to abstract data on intervention features, such as use of social influence (e.g., local opinion leaders^{36, 37}), involvement of top management, designing the intervention based on a theory of behavior or organizational change,³⁸⁻⁴⁰ and other potential “mediators” of intervention success.⁴¹ The identified studies, however, rarely explored these and other potentially relevant features of intervention design.⁴² Similarly, few studies considered organizational context⁴³ and local

attitudes and beliefs,⁴⁴ so these potential predictors of intervention success or failure were deleted from the structured questions on the abstraction forms and from the analysis.

The single “mediator” reported with sufficient frequency and detail was the use of clinical information systems, identified as a potential predictor of success in a previous review.^{45, 46} Reviewers were asked to indicate whether a clinical information system played a role in the design or implementation of the intervention (regardless of QI strategy type). The potential roles identified in structured form were: identification and/or group allocation of eligible patients or providers; reminders generated by an existing clinical information system; decision support at point of care; facilitated communication between providers (e.g., e-mail communications between members of a care team); and audit data gathered from a clinical information system to facilitate a QI strategy (e.g., audit and feedback, TQM, provider education, financial incentives).

Scope

In keeping with the goal of reviewing quality improvement strategies, numerous categories of studies were necessarily excluded or included. The investigators defined the scope of the project in terms of: hypertension type in the study population; targeted patient subpopulations; steps in the pathway to hypertension control; studies excluded for their failure to address QI; study design; and year of publication.

Hypertension type—To review studies that were most applicable to the general population, the researchers focused on primary hypertension in non-pregnant adults. Also known as “essential” hypertension, primary hypertension comprises at least 90 percent of all cases, and is of unknown etiology. Since identifiable secondary causes (such as renal artery stenosis) account for only a small number of cases (and management of these cases is less guideline-directed), this report focuses on primary hypertension. Studies that failed to specifically state that they omitted cases of secondary hypertension from the study population were not excluded. However, as management of hypertension in children and in pregnant women differs markedly from management of essential hypertension in non-pregnant adults, studies of these subpopulations of hypertensives were excluded from this review.

Targeted patient subpopulations—Many hypertensive patients have comorbidities such as diabetes mellitus and cardiovascular disease. These populations were included, as they are a sizable segment of the overall hypertensive population in the United States. Studies focused primarily on a smaller, specialized subpopulation (e.g., patients with alcoholism) were excluded.

Steps in the pathway to hypertension control—The causal pathway to hypertension control involves numerous steps. Studies that reported solely on interventions related to patient or provider knowledge at the earliest stages of the pathway were excluded. Patient and provider knowledge were considered only in conjunction with reports involving clinically relevant outcomes measures, such as blood pressure control.

Studies excluded for their failure to address QI—The primary QI targets were patient and provider adherence to recommendations, and the identification and effective control of hypertension (these will be described in full, later in this chapter). Equivalence studies (i.e., two patient groups that received either a physician-managed or a nurse-managed intervention to determine whether the two were equivalent) were excluded, as were studies that focused solely on patient satisfaction, costs, or resource use. In addition, studies of efficacy trials for particular

blood pressure control interventions, and studies designed primarily to assess the efficacy of certain medications in lowering blood pressure, particular life-style changes (e.g., salt restriction diets, stress reduction) and particular technical innovations (e.g., one home blood pressure monitor compared with another) were excluded. The same is true of studies that relied on provider self-report as a measure of provider adherence to recommendations.

Study design. Study designs other than randomized controlled trials (RCT), quasi-RCTs, controlled before–after (CBA), or interrupted time series (i.e., studies using a design below Level 2) were excluded. (For more on study designs, see in Table 2, in Volume 1 of this series.)

Year of publication—Studies published prior to 1980 were excluded.

Literature Search and Review Process

Our search strategy began with a broad electronic search of the MEDLINE® database from January 1966 to July 2003, which yielded a total of 3070 citations (Figure 1). The search strategy is shown in Appendix A. We supplemented these results with a search of the Cochrane Collaboration’s Effective Practice and Organisation of Care (EPOC) database,⁴⁷ which includes the results of EMBASE and CINAHL® searches in addition to MEDLINE and extensive hand searching. Searching the EPOC database produced an additional 82 articles deemed relevant for full abstraction. Manual review of reference lists from retrieved articles, including prior systematic reviews and seminal articles^{24, 48–70} in the field, yielded an additional 13 articles (Figure 1).^{48, 71–82} Core investigators reviewed all of the resulting abstracts. A total of 359 articles merited full-text review (performed by two independent reviewers); at this stage, we abstracted basic information on study design, quality improvement strategy, and types of outcomes (Figure 1, and Appendix B). To meet the criteria for full abstraction, articles were required to experimentally assess the effect of a quality improvement strategy on hypertension detection, hypertension control, provider adherence, or patient adherence in adults. Articles excluded at this review stage appear in Appendix C.

Terminology to Distinguish Studies, Interventions, and Comparisons

Because the articles we reviewed did not have a uniform structure in the presentation of study data, we adopted the following terminology to describe the quality improvement interventions we reviewed for this volume:

When a single *study* led to multiple *publications* (articles) describing different aspects of the study, (e.g., a methods article followed later by a results paper, or several results papers) each publication was separately identified, but we reviewed all articles for the same study together.

A single study may include several different *study arms* (groups of subjects), with different *QI interventions* provided to the subjects in each study arm. These are often reported in a single published article. For purposes of analysis, we considered *each* intervention that was

studied in comparison to a control group as a separate *comparison*. For example, a single study with one control group and three different QI intervention arms receiving different interventions (e.g., provider education and organizational change in one arm, patient reminder and organizational change in another arm, audit and feedback in a third arm), each compared with the control group, was considered (e.g., was listed in the Tables), as three comparisons. When an article reported several comparisons, we abstracted the data for each comparison separately.

The *intervention* described in a particular study may be multifaceted, that is, may involve more than one QI strategy. For example, the intervention may consist of a combination of provider education and provider reminders. A multifaceted intervention applied to a single study arm in comparison with control constituted a single comparison.

Outcome Measures

There are several important categories of outcomes relevant to the detection and management of hypertension. These include:

- measures of disease identification
- measures of disease control
- measures of provider adherence to recommendations
- measures of patient adherence to recommendations

Measures of Disease Identification and Initial Followup

We reviewed studies of screening for hypertension as a measure of disease identification. Screening for high blood pressure can occur in several settings. These include the community, the work place, and the clinician's office. Important outcomes with respect to disease identification include:

- percentage of individuals who had their blood pressure measured
- percentage of individuals found to have elevated blood pressure
- percentage of individuals with elevated blood pressure who received follow-up
- percentage of individuals screened who knew whether or not their blood pressure was elevated.

Measures of Disease Control

We reviewed several measures of disease control outcomes:

- all-cause mortality
- CVD or CHD mortality
- mean or median SBP
- mean or median change in SBP
- mean or median DBP

- mean or median change in DBP
- percentage of patients achieving blood pressure within a target blood pressure range
- percentage of patients with improved blood pressure control

We also abstracted a description of other measures of disease control used as outcomes in individual studies. We considered quality measures related to control of blood pressure to be the most important of the frequently used measures by which to evaluate quality improvement strategies for hypertension management. Morbidity and mortality measures represent the ideal measures, as they are the ultimate outcomes of interest; however, most studies did not report them.

Measures of Provider Adherence

Several measures of provider adherence were analyzed. We defined providers as the health professionals reported in the studies, including physicians, nurses, and pharmacists. We accepted the target or recommended practice as reported in the study. It must be noted, however, since recommendations have changed over time, some of the targets or recommendations no longer comport with current guidelines. Measures evaluated included:

- adherence to guideline-specified targets for blood pressure
- adherence to guidelines for the evaluation of patients with hypertension
- adherence to specific medication recommendations
- adherence to recommendations to improve patient medication adherence
- adherence to guidelines for checking and/or recording blood pressure
- adherence to guidelines for patient counseling or delivering patient education

Measures of Patient Adherence

We analyzed the following outcome measures of patient adherence to recommendations:

- medication adherence (determined by self-report, pill counts, or pharmacy records)
- adherence to follow-up appointments

Other Outcome Measures

Additional outcome measures reported in one or more studies that do not fit the categories above are shown in Appendix D.

Analysis

As described in Chapter 2 of this Volume, although we sought to conduct quantitative analysis of the included studies, many studies did not provide sufficient information to be analyzed in this fashion. Where feasible, we conducted a series of analyses, from descriptive summaries to comparative statistical analyses and exploratory regression analyses.

Median Effects Calculations

To take account of differences at baseline between intervention and control groups, we computed the outcomes for each study as the net change from pre-intervention to post-intervention between study and control groups:

$$\text{Net Change} = (\text{Post-intervention} - \text{Pre-intervention})_{\text{Study group}} - (\text{Post-intervention} - \text{Pre-intervention})_{\text{Control group}}$$

Following the method employed in a recent systematic review of strategies for guideline implementation,⁸³ the median of the calculated net change for studies reporting the same outcome was then reported for each analysis, and termed the “median effect.” For example, if a study reported the mean SBP for the control and intervention arms before and after the QI intervention, we calculated a net change in mmHg. We constructed each outcome measure so that a positive result indicated an improvement; for example, a lowering of SBP or an increase in the percentage of patients receiving guideline-recommended drugs were recorded as positive results. We report the median and inter-quartile (IQ) range for all studies reporting each outcome.

Because many different outcomes were used to measure provider adherence, we were unable to perform quantitative analysis of the effect of QI strategies on individual adherence outcomes. We therefore developed a summary measure of adherence for each study that reported more than one adherence outcome. For example, if a study reported three adherence outcomes that required (1) appropriate choice of medication (e.g., diuretics or β -blockers as first-line therapy for uncomplicated hypertension), (2) decrease in inappropriate choice of medication (e.g., calcium channel blocker for patients without specific indication), and (3) appropriate patient education (e.g., salt restriction, exercise counseling, smoking cessation), we calculated an effect size for each outcome, ranked the effect sizes, and used the outcome with the median effect size as the summary adherence measure for that study.

Study Sample Size and Publication Bias

Publication bias refers to the overestimation of effect size due to preferential reporting of positive studies, particularly with smaller, poor quality studies,^{84–90} and is of particular concern for quality improvement studies. Given the lack of a single, well-established analytic method for detecting or adjusting for the effects of publication bias,^{91–93} conducting a thorough search for unpublished research represents the preferred approach to avoiding this potentially large source of bias.^{84, 94, 95} However, in the area of quality improvement, relevant research may be more likely to be conducted by personnel charged with quality assurance activities as part of their job descriptions, with emphasis placed on measures of success rather than research dissemination. Consequently, the incentive to publish evaluations may be particularly low when the result is negative. Further, there is not an efficient means to find these studies.

The difficulty in obtaining unpublished QI trials and the accompanying susceptibility to publication bias led us to analyze the studies in terms of sample sizes. Focusing on median effects, as described above, rather than average effects, avoids skewing summary measures based on one or two outliers with particularly large or small effects. We then examined the median effect sizes by different strata of study sample size, e.g., comparing the median effect among studies with sample sizes in the lowest quartile versus those in the highest quartile, or the lower half compared with the upper half. Strata were defined for studies reporting SBP and DBP

outcomes separately, so that a study was assigned a study size quartile for comparisons with other studies reporting the same outcome.

For studies where the unit of analysis and unit of randomization differed, we also conducted analyses of “effective sample size.” Briefly, we adjusted for “clustering” (e.g., providers or clinics were randomized and patient outcomes for the providers or clinics used for ascertainment of the outcome). We performed this adjustment using estimated values for the intra-cluster coefficient (ICC).^{1, 96} We also addressed the possibility that studies of other sub-optimal design might contribute overly-optimistic outcomes by analyzing study design features, as described in the next section.

Study Design Quality

We reviewed studies for five aspects of study design quality. We considered studies to be of higher quality if the design included the following features: randomized allocation of intervention, providers blinded to study group assignment, patients blinded to study group assignment, unit of analysis same as unit of allocation to treatment, and concealment of allocation. We report pooled study outcomes for studies with and without each of these design features.

Statistical Analyses

Where possible, we performed a simple non-parametric test for differences between median effects— the Mann-Whitney rank-sum test.¹⁰⁴ Such analyses were possible only for mutually exclusive categories, such as randomized versus non-randomized trials, or for all interventions with a given QI strategy, compared with those without this strategy. We could not, however, compare one strategy to another because of the frequent overlap between types of strategies, with the same interventions contributing to multiple median effect sizes.

Chapter 3. Results

Search Yield and Results of Literature Review Process

Figure 1 depicts the article search and review process with the results at each step. From a literature search that resulted in 3070 citations, 110 articles merited full abstraction (Figure 1). Of these, 47 consisted solely of a patient education strategy (Appendix E), and are not reviewed here, as this topic will be reported in a future volume of this series. Our study sample consists of 63 articles^{73, 105–165} reporting a total of 82 comparisons of QI strategies (Appendix F). Forty-eight studies are randomized controlled trials (reporting on 64 different comparisons), six are quasi-randomized controlled studies (reporting on seven different comparisons), and nine are controlled before-after studies (reporting on 11 different comparisons) (see Table 1 and Appendix F).

The types of quality improvement strategies and substrategies assessed in the articles are shown in Tables 2a and 2b. Among individual strategies, organizational change (particularly team staffing changes) and patient education (in combination with other interventions) were most commonly utilized. Educational interventions for providers were common as well. Most articles described interventions consisting of more than one strategy; only 21 percent (17/82) described a single strategy (Table 3). The 82 comparisons reported 42 unique combinations of strategies, with most of these combinations occurring in only one or two comparisons (Table 4).

Studies analyzed a mix of outcomes. Ten studies reported disease identification outcomes. Most studies reported clinical and process outcomes (Appendix G). Among studies reporting clinical outcomes, 60 comparisons had sufficient information to calculate quantitative results. Among the 40 comparisons reporting SBP as a measure of disease control, 33 (83 percent) reported sufficient information to perform a quantitative analysis. Among the 49 comparisons reporting DBP as a measure of disease control, 43 (88 percent) reported sufficient information to calculate quantitative results. Among the 23 comparisons reporting proportion of patients achieving SBP within a certain range, 14 (61 percent) reported sufficient information to calculate quantitative results. Among the 28 comparisons reporting proportion of patients achieving DBP within a certain range, 16 (57 percent) supplied sufficient information for quantitative analysis. Among the 19 comparisons reporting process outcomes involving provider adherence to recommended care, 10 (53 percent) supplied sufficient information for quantitative analysis. Among the 28 comparisons reporting outcomes involving patient adherence, only 5 (18 percent) supplied sufficient information for quantitative analysis.

Analysis by Outcome Measures

Effect of Quality Improvement Strategies on Disease Identification and Initial Followup Measures

A total of 10 studies assessed disease identification and/or initial followup appointments.^{106, 109, 110, 124, 138, 141, 151, 158, 165, 166} Many of these studies also assessed other outcomes, most

commonly disease control. Table 5 summarizes the setting, interventions, and results of these studies. Studies of disease identification took place either in a medical setting, for example in a clinic, or in the community, for example at a work site, community center, or some other venue outside of the health care setting. The majority of these studies (6 of 10) were conducted at a clinic. Among the interventions in the clinic setting, the most common QI strategies were patient and/or provider reminders. Two studies reported a work site intervention, which included identification of hypertensives at the work site, and then a comparison of different followup treatment strategies.^{138, 166} The remaining studies of community-based screening often involved public education and appropriate followup of individuals identified as hypertensive.

Overall, in the studies of disease identification, outcomes measured were varied. Given the small number of studies and the heterogeneity of both the interventions and the outcomes, we were unable to perform meaningful analyses of pooled data, and therefore do not report summary data for screening studies. Most of the interventions led to some improvement in a screening related measure (Table 5).

Of the screening strategies evaluated, some strategies which demonstrated positive results included work site screening/followup, use of patient reminder letters, computer identification of patients with historically poor followup (combined with computer-generation of physician reminders), and the addition of a health promotion nurse to identify and followup with high-risk patients. One work site screening study involved 11,196 employees, and compared work site screening and referral of hypertensives to a physician (control group) with work site screening, referral, and more frequent followup or on-site treatment for hypertensives by a work site physician (three intervention groups).¹⁶⁶ The study reported higher rates of treatment at the end of the study in the intervention groups (96 percent or higher for intervention groups, compared with 84 percent for the control). Two studies found positive results with the use of patient letter reminders.^{141, 158} One of these studies involved 5744 patients and evaluated several interventions aimed at encouraging patients to have their BP checked, including letter reminders.¹⁴¹ In this study, 35.7 percent of patients who received letter reminders subsequently had their blood pressure measured, compared with 21.1 percent of patients in the control group.¹⁴¹ The other screening study evaluated patient reminder letters that encouraged patients with high blood pressure to receive followup, and found that 62 percent of the patients who received the reminder letter subsequently had followup, compared with 29 percent in the control group.¹⁵⁸ Another screening study evaluated the efficacy of an automated computer surveillance system to monitor patients with elevated BP and poor followup rates, and which generated reminders to providers for all patients not adhering to standard followup procedures.¹⁰⁹ This study involved 115 patients, and found, over a 6-24 month followup period, that 98 percent of the intervention group had followup over this period, and 70 percent had a repeat BP recorded, compared with a 46 percent followup rate in the control group, with a 52 percent repeat BP recorded rate.¹⁰⁹ One of the screening studies evaluated the efficacy of a health promotion nurse to identify and followup with high-risk patients (using a computer system to search for high-risk patients).¹⁵¹ This study involved 3117 patients, and found that over the course of the five-year study, patients in the intervention group increased the frequency with which their BP was recorded from 65 percent to 93 percent. The control group had a smaller increase in the same measure, from 62 percent to 73 percent, over the course of the study.

Effect of Quality Improvement Strategies on Measures of Disease Control

Effect of quality improvement strategies on mortality. Six studies reported mortality outcomes.^{20, 105, 110, 118, 131, 165} Two of these studies were large clinical trials, the Multiple Risk Factor Intervention Trial (MRFIT), and the Hypertension Detection and Follow-up Program (HDFP), a major clinical trial.^{20, 105} The MRFIT study was a primary prevention trial that tested the effect of a multifactor intervention program on coronary heart disease mortality in high-risk men aged 35-57 years. The “special intervention” (SI) included dietary advice for lowering blood cholesterol levels, counseling aimed at cessation for cigarette smokers, and “stepped care” treatment for hypertension for those with elevated BP. The SI was compared with usual care in the community. The trial included a planned initial followup in February, 1982; at that point, coronary heart disease and all-cause mortality rates were similar for SI and usual care. This finding was attributed, in part, to the substantially lower than expected death rate in the usual care group. After the initial results were reported in 1982, plans were made for additional analyses after ten-year followup of the participants. During ten-year followup, there were 317 deaths among 4019 SI participants (7.9 percent), and 353 deaths among 3993 usual care participants (8.8 percent). These rates were also reported as rates per 1000 person-years of 7.55 per 100 in the intervention group, and 8.48 per 1000 in the control group ($P = 0.13$). The data show a trend toward lower death rate in the SI group, but it was not statistically significant. It is not possible to distinguish the effect of the QI strategy components of the intervention from the effect of the specific drugs used, nor is it possible to distinguish the effects of blood-pressure-lowering from the effects of the cholesterol-lowering and smoking cessation components.

The HDFP examined a stepped care regimen in which participants were offered a free, standardized program of antihypertensive therapy in HDFP centers. Treatment approaches included the use of techniques believed to enhance patient adherence. Economic barriers to treatment were removed, to the extent possible, with provision of drugs, visits to the centers, laboratory tests, and transportation at no cost to the participant. Waiting times were minimized by use of additional allied health personnel, and appointments were available at convenient hours. Treatment included stepwise increases in medication to bring patients to or below their goal DBP. Patients were randomly assigned either to stepped care or usual care. Mortality from all causes was the primary endpoint of the study. During five-year followup, there were 349 deaths among 5485 stepped care participants (6.4 percent), and 419 deaths among 5455 usual care participants (7.9 percent). These rates were also reported as life table death rates per 100, of 6.4 per 100 in the intervention group, and 7.7 per 100 in the control group, representing a 16.9 percent relative risk reduction in mortality in the stepped care group ($P < 0.01$). The HDFP study also reported cardiovascular mortality as a secondary outcome: there were 195/5485 (3.6 percent) cardiovascular deaths in the stepped care group, and 240/5455 (4.4 percent) cardiovascular deaths in the control group (statistical comparison not reported). Because mortality was the primary endpoint of the study, and the difference in mortality was statistically significant, we can conclude that the stepped care approach, as implemented in the HDFP, was effective in lowering mortality risk. It is not possible to distinguish which component of stepped care, such as drug choice or QI strategies, was responsible for the benefit.

Another study reporting mortality rates used multiple QI strategies (provider reminders, patient education, patient reminders, and organizational change) in 34 family practices in Canada, involving 32,124 patients.¹¹⁰ This study reported similar all-cause and cardiovascular mortality in control (1.6 percent, and 0.7 percent, respectively) and intervention (1.5 percent, and

0.7 percent, respectively) groups. This study did not include outcome measures for disease control in a format that was quantifiable for inclusion in our disease control analyses.

The fourth study reporting mortality outcomes, which also reported disease control outcomes included in our pooled analyses, was a study of a nurse practitioner intervention in three specialist hypertension clinics in Scotland, involving 396 patients.¹¹⁸ The QI strategies included patient education, patient reminders, and organizational change. This study reported similar mortality rates in the control and intervention groups: 29/198 (15 percent) and 23/198 (12 percent) all-cause and cardiovascular mortality, respectively, in the control group, and 25/198 (13 percent) and 17/198 (9 percent) all-cause and cardiovascular mortality, respectively, in the intervention group.

A fifth study provided a special intervention for young, urban, African American men.¹³¹ The study included an educational intervention for both control and intervention study arms, including explanation of BP, goal BP, importance of remaining in care and adhering to treatment, referral to a physician if necessary, answers to questions, and a wallet card on which to record BP. In addition, men in the special intervention group also received individualized counseling, monthly telephone calls, and a home visit. This study reported mortality outcomes as one of several reasons for nonattendance at followup visits: 1/101 in usual care group, and 5/103 in the special intervention group. Mortality outcomes were not a primary outcome measure in this small study.

The sixth study reporting mortality outcomes was the Mayo three-community hypertension control program, which included two comparisons.^{165, 167} This study focused on individuals with BP at or above SBP 160 mmHg or DBP 95 mmHg in three different communities. The intervention included a special community hypertension clinic. Death rates at five-year followup were reported as 12/153 (6.2 percent) and 5/249 (1.8 percent) in the two different control areas, and 15/237 (5.4 percent) in the intervention area. Mortality outcomes were not a primary outcome measure in this small study.

Effect of Quality Improvement Strategies on Blood Pressure Control

A total of 33 comparisons assessed reduction in SBP, and 43 comparisons assessed reduction in DBP. The vast majority of studies showed improvements in these outcomes associated with the QI intervention (Appendix G). The median reduction in SBP was 4.5 mmHg (IQ range: 1.5, 11.0), and median reduction in DBP was 2.1 mmHg (IQ range: -0.2, 5.0) (Table 6a). Fourteen comparisons assessed the effect of the QI strategy on the proportion of patients with blood pressure in the target SBP range, and 16 comparisons assessed the effect of the QI strategy on the proportion of patients with blood pressure in the target DBP range (Appendix G and Table 6a). In these comparisons, the median increase in the proportion of patients in target SBP range and DBP range in these comparisons was 16.2 percent (IQ range: 10.3, 32.2), and 6.0 percent (IQ range: 1.5, 17.5), respectively. In these studies, QI strategies had a clinically meaningful effect on SBP, and on the proportion of patients achieving the target SBP range, and a more modest effect on DBP, and the proportion of patients achieving the target DBP range.

Effect of Quality Improvement Strategies on Provider Adherence

A total of 10 comparisons reported quantitative results of provider adherence to recommended practices (Appendix G and Table 6b). Overall, the median increase in percentage of providers adhering to recommendations was 3.0 percent (IQ range: 1.0, 5.5).

Effect of Quality Improvement Strategies on Patient Adherence

Four studies with five comparisons reported results for patient adherence to medications or followup appointments. Overall, there was a median increase in percent of patient adherence of 2.8 percent (IQ range: 1.9, 3.0) (Appendix G and Table 6b).

Analysis by Type of Quality Improvement Strategy

Table 2a lists the number of studies examining each major type of quality improvement strategy. For certain QI strategies, there were a large number of important substrategies for which meaningful outcomes were reported (Table 2b). Many studies used more than one QI strategy. The numbers of studies using each different combination of QI strategies is shown in Table 4. Table 6a shows the median effects of QI strategies on blood pressure outcomes, and Table 6b shows the effects of individual quality improvement strategies on provider and patient adherence outcomes. Since not all comparisons listed in Tables 2a and 2b had sufficient data to report all outcomes, the total number of comparisons in the median effect tables may be smaller than the total number listed in Tables 2a and 2b. When describing the results of each QI strategy, we do not differentiate those that used that particular QI strategy alone, from those that used it in conjunction with other strategies. This is because single QI strategies were seldom used alone (Table 4), especially in studies with adequate data for reporting median effects (Tables 7a and 7b). Mann-Whitney tests of significance are noted when *P*-values were less than 0.05 for analyses comparing results from studies with a particular QI strategy to studies without that particular strategy. This test of significance must be interpreted tentatively, as we conducted multiple sub-group analyses. Tables 8a and 8b show the effects of several quality improvement substrategies on outcomes.

Provider Reminders

Nine studies, including a total of 10 comparisons, used provider reminders alone (two comparisons), or in combination with other QI strategies (Table 2a and Table 4). Studies that used provider reminders, alone or in combination with other QI strategies, found a median reduction in SBP of 6.8 mmHg (IQ range: 3.0, 9.4) and a median reduction in DBP of 2.1 mmHg (IQ range: 0.9, 6.6). There were two comparisons using provider reminders as a QI strategy that reported outcomes for SBP in target range; both comparisons were from the same study, and reported a decrease in this outcome of 3.6 percent (IQ range: -5.7,-1.4) in the intervention group compared with the control group.¹²⁸ This study included three study arms: academic detailing, academic detailing plus Continuous Quality Improvement (CQI) teams, and

usual care. Patients whose mean BP measurements over six months were less than 160/90 mmHg were classified as controlled. In this study, all study groups showed improvements in percent of patients with BP in target range. The usual care control group had a greater improvement than the provider reminder (e.g., academic detailing) groups, producing the decrease in median effect size. The authors commented that either contamination or a Hawthorne effect may have contributed to their generally negative findings, by moving usual care behavior in the direction hypothesized by the interventions.

Three comparisons utilizing provider reminders reported outcomes for provider adherence to hypertension treatment recommendations, and had mixed results, with a median effect of 1.3 percent decrease (Table 6b). Two of these comparisons were in the same study described in the preceding paragraph.^{128, 168} The third study¹²³ used a clinical pharmacist program that included provider reminders as part of the QI strategy; this study found an improvement in provider adherence to recommended management. No studies using provider reminders reported effects on patient adherence outcomes.

Facilitated Relay of Clinical Data

Facilitated relay of clinical data was assessed as all (two comparisons), or part of the QI strategy in 23 studies, including a total of 31 comparisons (Table 2a and Table 4). Studies that used facilitated relay found a median reduction in SBP of 4.5 mmHg (IQ range: 2.2, 11.5), and a median increase in the percentage of patients with SBP in the target range of 15.3 percent (IQ range: 2.0, 28.4). The median effect for DBP was a reduction of 1 mmHg (IQ range: -1.0, 3.4) (Table 6a). There was a median increase in provider adherence of 2 percent (IQ range: -0.4, 3.7, seven comparisons), and a median increase in patient adherence of 2.4 percent (IQ range: 0.8, 5.0, four comparisons) (Table 6b).

Audit and Feedback

Ten studies (with 13 comparisons) included audit and feedback alone (one comparison), or in combination with other QI strategies (Table 2a and Table 4). In these studies, there were small improvements in median SBP of 1.3 mmHg (IQ range: 0.5, 1.6), median DBP of 0.6 mmHg (IQ range: 0.5, 1.0), percentage of patients with DBP under control (1.8 percent, IQ range: 0.1, 4.3) (Table 6a), and median improvement in provider adherence to recommended practice of 2.7 percent (IQ range: -0.4, 3.7) (Table 6b). There was a median reduction of 3.6 percent (IQ range: -5.7, -1.4) in patients in SBP target range. For SBP and proportion of patients in DBP range outcomes, studies with audit and feedback, alone or in combination, showed less of an improvement than studies without an audit and feedback component ($P = 0.039$ for SBP, and $P = 0.036$ for DBP range). Seven studies reported provider adherence outcomes with median improvement of 2.7 percent (IQ range: -0.4, 3.7) (Table 6b). Only one study reported an effect on patient adherence, and this was a net decrease of 2.7 percent (Table 6b).¹²⁹ This study used a multifaceted intervention with a goal of improving physician adherence by tailoring CME to deficiencies in physician performance identified by medical record review and a patient survey. The study included eight secondary hypotheses, of which one was that patients of physicians receiving the intervention were expected to show greater adherence to medication regimens.

Provider Education

A total of 18 studies (including 22 comparisons) utilized provider education as all (four comparisons), or part of the QI strategy (Table 2a and Table 4). Among our included studies, the most frequently used provider education strategies were educational workshops, meetings (e.g., traditional CME), and/or lectures (live or computer-based), (19 of 22; 86 percent), and distribution of educational materials (16 of 22; 73 percent). In studies examining provider education, alone or in combination with other QI strategies, there was a median reduction in SBP of 2.7 mmHg (IQ range: 1.1, 6.0). There was a median increase of 10.9 percent (IQ range: 1.4, 13.1) in proportion of patients achieving SBP in the target range (Table 6a). In these studies, the median reduction of DBP was 0.7 mmHg (IQ range: -0.3, 3.3), and median increase in percentage of patients achieving DBP in the target range was 3.5 percent (IQ range: 1.7, 11.3) (Table 6a). For SBP and proportion of patients in SBP range outcomes, studies with provider education, alone or in combination with other QI strategies, showed less of an improvement than studies without a provider education component ($P = 0.037$ for SBP and $P = 0.012$ for SBP range). Median improvement in provider adherence with hypertension treatment recommendations was 3.3 percent (IQ range: 0.7, 5.0) in these studies (Table 6b). Two studies reported the effect of QI strategies that included provider education on patient adherence: one reported a decrease in patient adherence of 2.7 percent, and the other an increase of 3.0 percent (Table 6b, Appendix G).

Substrategies of Provider Education

Because provider education includes so many types of QI strategies, we performed analyses of some educational substrategies, including CME, educational outreach, and distribution of printed materials (see Tables 8a and 8b). Most studies with provider education included CME, and therefore showed similar median effects in blood pressure outcomes as above. Studies involving CME as part of the quality improvement strategy also demonstrated similar improvements in provider adherence to recommended practices, and in patient adherence to medical regimen (see Table 8b). The few studies that included the substrategy of educational outreach generally showed improvements for these outcomes, but of lesser magnitude (see Tables 8a and 8b). Studies that used distribution of printed materials as part of the QI strategy showed a 1.7 mmHg improvement (IQ range: -0.2, 3.4) for SBP, and a 4.2 percent (IQ range: -2.5, 10.6) increase in the proportion of patients achieving SBP in the target range. However, the latter was based on only four studies (Table 8a). Results for DBP improvements were lesser in magnitude.

Patient Education

A total of 33 studies (including 41 comparisons) included patient education as part of the QI strategy (see Table 2a). Patient education was utilized more than any other QI strategy. As described above, we included only studies that used patient education in conjunction with at least one other QI strategy. Studies that included patient education as part of the QI intervention had a median improvement of 8.1 mmHg for SBP (IQ range: 3.3, 11.8) and 3.3 mmHg for DBP (IQ range: 0.4, 5.0). These studies also reported improvement in percentage of patients achieving both SBP and DBP in the target ranges (19.2 percent, IQ range: 10.3, 36.4; and 15.2 percent, IQ

range: 7.3, 21.8 respectively) (see Table 6a, Appendix G). Only two studies that included patient education resulted in an increase in patient adherence of 1.9 percent and 2.8 percent (see Table 6b, Appendix G). Only two studies with patient education QI strategies reported provider adherence outcomes; one showed a decrease of 1.3 percent and the other an increase of 2.0 percent in provider adherence outcomes (see Table 6b, Appendix G).^{114, 128}

Promotion of Self-management

A total of 18 studies (including 20 comparisons) (see Table 2a) included patient self-management as part of the QI strategy. As with patient education, this strategy was only included if used in conjunction with other strategies. Studies that used patient self-management, in combination with other strategies, showed a median improvement in SBP of 3.6 mmHg (IQ range: 2.1, 9.5) and a median improvement in DBP of 2.1 mmHg (IQ range: 0.4, 5.0), and an increase in percentage of patients with either SBP in the target range (13.4 percent, one study) or DBP in the target range (median improvement 9.4 percent; IQ range: 1.1, 13.4; five studies) (see Table 6a, Appendix G). Only one study assessed the effect of promotion of self-management on patient adherence, and this showed a positive effect (see Table 6b, Appendix G).

Patient Reminders

A total of 16 studies (including a total of 22 comparisons) included patient reminders as a component of the QI strategy, or alone (three comparisons). Studies that used patient reminders, alone or in combination, showed a median reduction in SBP of 2.8 mmHg (IQ range: -1.5, 5.1), virtually no reduction in DBP (median effect 0.5 mmHg; IQ range: -2.1, 3.4), and increases in the overall percentages of patients with SBP and DBP in the target ranges (7.0 percent and 9.4 percent, IQ range: 1.1, 19.0, respectively). However, only one study reported SBP target range results (see Table 6a). No studies using patient reminders reported provider or patient adherence outcomes.

Organizational Change

Organizational change was assessed in 36 studies (including a total of 45 comparisons), either alone (six comparisons), or in combination with other strategies. The most common types of organizational changes implemented were team staffing changes (e.g., addition of a new member to the health care team or a change in existing roles). Overall, studies including organizational change as part or all of the QI strategy demonstrated median improvement in SBP of 10.1 mmHg (IQ range: 3.9, 14.0), compared with a 2.3 mmHg median improvement for studies without an organizational change component ($P = 0.007$). Given the multiple comparisons for the Mann-Whitney significance test, even this low P -value may still be borderline. Studies including organizational change also showed median improvement in DBP of 4.4 mmHg (IQ range: -0.50, 6.9), at a potentially significant level, compared with studies that did not have an organizational change component (median improvement in DBP of 1.1 mmHg for studies without organizational change component; $P = 0.04$ for comparisons with, versus without, organizational change) (see Table 6a). The percentage of patients with SBP in the target range had a median improvement of 21.8 percent (IQ range: 9.0, 33.8), and DBP in the target

range had a median improvement of 17.0 percent (IQ range: 4.2, 24.5) (see Table 6a). Studies utilizing organizational change had a median improvement in patient adherence by 6.8 percent (IQ range: 1.9, 11.6), but provider adherence appeared unaffected (median effect 0.4 percent; IQ range: -1.6, 3.3) (see Table 6b).

Substrategies of Organizational Change

Because organizational change included several types of QI substrategies, we performed additional analyses for some of the commonly used substrategies. These included disease/case management, team staffing changes, use of telemedicine, and changes to medical record systems. Studies that included disease management/case management showed a median reduction of SBP of 14.1 mmHg (IQ range: 11.6, 16.4) and a median increase in the proportion of patients who achieved SBP in the target range of 4.2 percent (IQ range: -2.5, 10.3) (see Table 8a). Studies including the substrategy of team staffing change showed increases in the proportion of patients achieving SBP and DBP in target ranges of 21.8 percent (IQ range: 9.0, 33.8), and 19 percent (IQ range: 17.0, 30.0), respectively (see Table 8a). Studies including team staffing changes also showed a median increase in patient adherence of 6.8 percent (IQ range: 1.9, 11.6) (see Table 8b). Studies including telemedicine and changes to medical record systems had less of an effect. In these studies, none of the substrategies appeared to demonstrate an effect on provider adherence.

Financial Incentives

Only three studies (including a total of three comparisons) included financial incentives as part of the QI strategy. Quantitative analysis was limited due to the small number of studies. One study reported a better improvement in the control group, which had a reduction of 13 mmHg SBP, relative to the intervention group. In this study, the control group had a higher mean BP at baseline, and achieved a post-intervention BP similar to that achieved by the intervention group, for an overall greater decrease in SBP in the control group. Three studies assessed the impact of financial incentives on DBP reduction: the median effect was 0.0. Two studies assessed the impact of financial incentives on the proportion of patients achieving SBP in a certain range, and showed an improvement in one study but not the other (see Table 6a and 6b). No studies using financial incentives reported outcomes for DBP range, provider or patient adherence.

Other Analyses

Clinical Information Systems

Nineteen studies (reporting 25 comparisons) used information systems in some aspect of the quality improvement strategy. Eight studies (reporting 12 comparisons) used them to identify eligible participants for study enrollment, eight (reporting 12 comparisons) included a clinical reminder based on an existing information system, two (reporting two comparisons) included a clinical decision support system, four (reporting five comparisons) included the collection of

audit data based on an information system, and 14 (reporting 16 comparisons) included some other aspect of an information system. Tables 9a and 9b show the effect sizes of blood pressure and adherence outcomes for studies that included various uses of information systems, and reported quantitative results adequately for calculating median effects. Studies that included use of a clinical information system had a median effect on SBP reduction of 2.2 mmHg (IQ range: 1.1, 4.2), and on DBP reduction of 0.6 mmHg (IQ range: -1.3, 2.1). The median effect on proportion of patients in SBP target range was a decrease of 1.4 percent (IQ range: -3.6, 5.3), and in DBP target range was an increase of 1.8 percent (IQ: 0.1, 4.3). These effects were generally less than the effects seen in studies without information systems, particularly for the SBP in range outcome (Mann Whitney $P = 0.03$). There was a median effect increase of 2.7 percent (IQ range: -0.4, 5.0) in the proportion of providers adherent to recommended practice with the use of clinical information systems, and no apparent effect on the proportion of patients adherent to recommendations.

In a number of studies (see Table 9a and 9b), information systems were used only to identify eligible participants for the study, and may even have been used for both intervention and control groups. When information systems were used this way, they may have contributed to the feasibility of the study by facilitating the identification of potential participants, but would not have been expected to contribute to improvements in outcome.

A small numbers of studies reported outcomes for use of information systems to generate reminders either to patients or to providers, and results were mixed. Two comparisons (from a single study) using a clinical decision support system reported SBP and DBP outcomes, with reductions in SBP of 1.0 mmHg in one comparison, and 1.5 mmHg in the other, but an increase in DBP of 2.0 mmHg in the first, and a reduction of 0.6 mmHg in the second comparison (Table 9a). One study, including two comparisons reporting SBP and DBP outcomes used an information system to generate audit data. These comparisons also showed mixed results. Three studies with four comparisons reported the increase in proportion of patients achieving DBP in target range; the median effect was an increase of 3.5 percent (IQ range: 1.0, 5.5).

The small number of studies using information systems, and the variability in their roles with respect to QI strategies, limit the conclusions that can be drawn about this particular intervention.

Analysis of Number of Quality Improvement Strategies on Outcomes

The majority of studies employed a combination of QI strategies, rather than a single intervention (see Tables 3 and 4). The effect on blood pressure and adherence outcomes as a function of the number of QI strategies employed is shown in Tables 7a and 7b. For both SBP and DBP reductions, there was no clear pattern of increasing or decreasing effect as the number of QI strategies increased. For the SBP outcomes, the Mann-Whitney analysis comparing single QI strategies to multifaceted QI strategies (i.e., two or more QI strategies) had a P -value of 0.029 favoring single QI strategies, which has borderline significance given multiple comparisons. The results are likely confounded because the studies in the single QI strategy group use primarily organizational change strategy (i.e., three of five studies for SBP outcomes, and four of six studies for DBP outcomes). When assessing the percentage of patients with SBP in the target range, the largest increase was reported in studies employing two QI strategies, but this pattern was not present for DBP (Table 7a). There is no clear pattern of effect of number of QI strategies on adherence outcomes in our analysis, but again, there are few studies included in this analysis.

Effect of Methodologic Features

We critically reviewed studies to discern major features in study design or analysis that were likely to affect their results. The methodologic features that we considered were random allocation of subjects to the intervention, blinding of providers to the treatment status, blinding of patients to the treatment status, unit of analysis the same as unit of allocation, and concealment of the allocation. These desirable study design features, when present, improve the likelihood that the effects observed in the study represent true effects. We assessed the relationship between these methodologic features and outcomes, including reported decreases in blood pressure (systolic and diastolic), increased percentage of patients with blood pressure in target ranges, percentage of providers adhering to recommended practices, and patient adherence to recommended practices.

Effect of Methodologic Features on Blood Pressure Outcomes

As previously noted, 33 comparisons assessed reduction in SBP, and 43 comparisons assessed reduction in DBP. The majority of these were randomized controlled trials (25 of 33 (76 percent) of the comparisons assessing SBP; 33 of 43 (77 percent) of the comparisons assessing DBP (see Table 10a). Neither patients nor providers were blinded in the majority of studies. Unit of analysis was the same as the unit of allocation in two-thirds of the comparisons reporting SBP and DBP. However, in comparisons reporting target range outcomes, there were proportionally less studies with this design feature: only 29 percent of the SBP in target range comparisons, and 56 percent of the DBP in target range comparisons (see Table 10b). Concealment of allocation occurred in the minority of studies with SBP and DBP outcomes, but in the majority of studies with target range outcomes. With the exception of concealment of allocation, studies having positive design features had better median reduction in SBP; however, the inter-quartile ranges had substantial overlap, and Mann-Whitney tests did not show any significant differences by design feature. For other blood pressure outcomes, the comparative results by design feature were more mixed (e.g., RCT comparisons had lower values than non-RCTs for DBP and DBP in target range outcomes, while RCTs examining SBP in target range outcomes had higher values for this outcome than non-RCTs), with no design feature analysis showing significance.

After stratifying studies by study design (RCT versus non-RCT), we analyzed the effect of individual QI strategies on blood pressure outcomes, comparing studies that included a particular QI strategy with those that did not include that particular QI strategy (e.g., studies with provider education versus studies without a provider education component) (see Table 11). Overall, the median reduction in SBP in RCTs was 6.8 mmHg (compared with 4.5 mmHg when both CBAs and RCTs are included, or 4.3 mmHg for non-RCTs), and median reduction in DBP was 2.0 mmHg (compared with 2.1 mmHg when both CBA and RCTs are included, or 2.7 mmHg for non-RCTs). In general, analysis of categories of QI strategies according to study type revealed zero or minimal change in median reduction in SBP and DBP effects. For example, when analyzing RCT studies alone, the effect of organizational change on median reduction in SBP was 11.0 mmHg (IQ range: 5.2, 16.2), in contrast with a reduction of 10.1 mmHg (IQ range: 3.9, 14.0) seen with all study types (19 comparisons). The largest magnitude change for study type substratified by QI strategy was for RCT comparisons reporting provider reminders, with a median reduction in SBP of 3.0 mmHg (IQ range: -0.8, 6.8), in contrast to a reduction of 6.8

mmHg (IQ range: 3.0, 9.4) seen with all studies. However, there were very few studies (three comparisons overall, and two RCTs) reporting the effect of use of provider reminders on reduction of SBP.^{113, 122, 153}

Visual examination of Table 11 reveals that studies that included either organizational change (alone or in combination with other strategies) or patient education (in combination with other strategies) consistently report greater improvements in SBP and DBP, regardless of study design, as compared with studies without these particular strategies. Studies without patient reminders or provider audit and feedback (either alone or in combination) are similarly consistent in having greater improvements in SBP and DBP as compared with studies that included these strategies. For studies with other strategies, the results are less consistent by both outcome and study design.

Effect of Methodologic Features on Provider and Patient Adherence to Recommendations

Eight studies (10 comparisons) assessed provider adherence to some aspect of recommended care of hypertensive patients. The majority of these studies were RCTs (see Table 10c). Studies having positive design features had greater improvements in provider adherence to recommended practice, but the inter-quartile ranges had substantial overlap, and Mann-Whitney tests did not show any significant differences by design feature. Because of the limited number of studies, we did not assess QI strategies by design feature for provider adherence outcomes.

Only four studies (five comparisons) assessed patient adherence. Of these, three were RCTs and two were not (see Table 10c). Because of the small numbers of studies, the point estimates would have been imprecise, so we did not assess the impact of methodologic quality on patient adherence outcomes.

Effect of Study Size on Blood Pressure Outcomes

Table 12a reports the association of sample size with SBP outcomes. Results are shown for studies that include each QI strategy, followed by studies that do not include that QI strategy. The studies with the smaller sample sizes appear to report larger effects on reduction in SBP. The Spearman rank correlation of effect size with sample size is 0.43 for SBP ($P = 0.01$). Table 12b shows a similar analysis for reduction in DBP. Again, the smaller studies appear to report larger effects, although this is not as pronounced. The Spearman rank correlation of effect size with sample size for DBP is 0.23 ($P = 0.14$). To explore possible confounding of sample size with study design, we estimated the Spearman rank correlation separately for trials that had the desirable study design feature of unit of analysis equal to unit of randomization, and for studies that did not have this design feature. For studies without this desirable design feature, the Spearman rank correlation of effect size with sample size for SBP was 0.02 ($P = 0.53$, $N = 12$), indicating no correlation, and -0.36 ($P = 0.21$, $N = 14$) for DBP, indicating larger effects for larger sample size studies. Since these studies require adjustments to sample size to account for patient clustering, the more appropriate Spearman rank correlation comparison is between effect size and effective study sample size (Appendix H), which for SBP is 0.01 ($P = 0.97$), and for DBP is 0.07 ($P = 0.83$), indicating no correlation after adjustments to sample size. In contrast, for studies in which the unit of randomization is the same as the unit of analysis, the correlations

between sample size and effect size persisted, with a correlation of 0.58 ($P = 0.006$, $N = 21$) for SBP, and 0.40 ($P = 0.030$, $N = 29$) for DBP. Thus, the studies with differing unit of analysis and unit of randomization do not appear to be responsible for the correlations between study size and effect size for SBP and DBP; thus analysis by quartile of actual sample size is adequate. Also, non-RCT studies did not have a correlation between study size and effect size.

Correlation analysis for SBP and DBP in target range did not show any significant results, though the magnitude of the rank correlation for SBP range was -0.37 ($P = 0.21$), indicating a similar trend toward larger studies having less improvement (lower proportion of patients in range compared with smaller studies).

Visual inspection of Tables 12a and 12b reveal a somewhat consistent pattern for specific QI strategies across both blood pressure outcomes, when considering sample size. For example, as reported earlier, studies that include organizational change have improvements in SBP of 10.1 mmHg, and in DBP of 4.4 mmHg, as compared with 2.3 mmHg and 0.6 mmHg, respectively, for studies without an organizational change component. For studies reporting SBP outcomes that are in the bottom half of study sample size, those that include organizational change (12 comparisons) show improvements in SBP of 13.5 mmHg, while those that do not include organizational change (four comparisons, none of which would fall into the bottom quartile of study sample size) show effectively no improvement in SBP (0.1 mmHg). For studies reporting SBP outcomes that are in the top half of study sample size, those that include organizational change (seven comparisons, including five in the largest study size quartile,) and those that do not (10 comparisons, including four in the largest study size quartile), have similar magnitude improvements (3.3 mmHg versus 3.6 mmHg). A similar trend of effect sizes eroding with study size is seen for DBP, though perhaps to a less striking degree, as the studies with organizational change still appear to show greater improvements in DBP as compared with studies without organizational change (2.8 mmHg versus 1.6 mmHg). For the largest study size quartile, however, the relative magnitudes of DBP outcomes reverse, which occurs for SBP outcomes as well.

Chapter 4. Discussion

Hypertension is highly prevalent in the general population, and carries with it serious cardiovascular morbidity and mortality risks. The implementation of quality improvement strategies aimed at detection and management of this disease has the potential to improve the health of millions of Americans.

Our review of more than 3000 titles, which identified 82 core comparisons relating to the general areas of disease screening and management of hypertension, confirms some previous findings and extends them, with the addition of recent studies and further analyses.^{50, 52} Of the studies meeting our inclusion criteria, one-third were published in the past five years (1998–2003). The main questions we sought to answer were which QI strategies could most effectively result in improved detection of hypertension, blood pressure control, and improved patient and provider adherence. Our findings suggest that quality improvement strategies in general appear to be associated with improved detection and control of hypertension. Since most studies included more than one QI strategy, it is not possible to discern with complete confidence which QI strategies have the greatest effects. All of the strategies assessed—organizational change, patient education in combination with several other QI strategies, provider education, facilitated relay of clinical data, audit and feedback, promotion of self-management, provider reminders, patient reminders, and financial incentives—may be beneficial under some circumstances, and in varying combinations. Studies with organizational change had the largest effect on outcomes in general, a finding which persisted regardless of study design (e.g., RCTs versus CBAs or quasi-RCTs). However, after analysis of study sample size, which raised a concern about publication bias, these findings are less convincing. Studies including patient education as part of the QI strategy also appeared to have relatively larger effects, but these results are also confounded by study size, and are additionally uncertain because studies examining patient education alone were not reviewed in this report, but rather set aside for a subsequent review in the series. Finally, studies with audit and feedback did not show as much improvement in outcomes as studies without this strategy, but there were relatively few studies reporting multiple outcomes that included this strategy. Although conclusions about specific strategies require caveats, QI strategies in general appear beneficial for closing the quality gap in hypertension.

Which QI Strategies Improve Screening for Hypertension?

Increasing the percentage of individuals screened for hypertension is a critical national health goal. In general, most interventions led to some improvement in the intervention group, such as an increased number of individuals screened, an increased number of individuals who knew whether or not their blood pressure was elevated, or an increase in those identified as hypertensive who received appropriate followup. No single QI strategy had enough screening studies to provide pooled results, and therefore discussion of each strategy independently is not feasible.

Screening interventions were generally conducted in one of two environments: in the community (outside of medical settings), or at medical clinics. In the community, interventions at work sites appeared to be effective.^{138, 166} In the clinic, several strategies appeared effective.

These include patient reminder letters, computer identification of patients with historically poor followup along with computer-generation of provider reminders about these patients, and the addition of a health promotion nurse to identify and followup with high-risk patients (Table 5). Because there were few studies of screening (10), and because of the heterogeneity of the outcomes measured, we were unable to conduct quantitative analyses of the impact of screening.[†]

Which QI Strategies are Most Effective at Ensuring that Blood Pressure Goals are Achieved and Maintained?

Most of the quality improvement strategies we assessed had a positive impact on at least one of the blood pressure outcomes measured. The only outcome measures reported frequently enough for data analysis were reductions in SBP and DBP, and achieving SBP and DBP in target ranges. Most studies used more than one QI strategy. Thus, the following results, presented by type of QI strategy, must be interpreted with caution.

With this important caveat, the largest effect sizes for SBP and DBP reductions were observed in the strategies of organizational change, provider reminders (either alone or in combination with other QI strategies), and patient education (reviewed only in combination with other strategies, and often including organizational change).

For achieving SBP and DBP in target range, most of the strategies appeared to be effective, but were often used in combination. The strategies with larger effects include organizational change, patient education, promotion of self-management, and facilitated relay of clinical data (usually in combination with organizational change as well as other strategies). Audit and feedback, patient reminders, and financial incentives showed relatively more modest effects, although there were generally fewer studies of these interventions.

Effect of Specific QI Strategies on Achieving And Maintaining BP Goals

Studies that included *organizational change* tended to report larger effects on blood pressure outcomes than studies that did not include this QI strategy. Organizational change strategies are varied, and some substrategies of organizational change may work better than others. Case management and team staffing changes often appeared effective. The vast majority of studies of organizational change in hypertension included changes in team members' roles, additions of staff, or other re-organization of work flow for caring for hypertensive patients.

There are many possible explanations for the success of organizational change with respect to achieving blood pressure control. Organizational change typically requires administrative

[†] The MRFIT and the HDFP trials do not appear in our analysis of screening because these studies performed screening solely to identify individuals to be enrolled in the disease management portion of those studies, not as an outcome related to the intervention. We report results from these studies in Appendix F. Another large screening study, the North Karelia Project,¹⁶⁹ is omitted from our systematic review because it was conducted before our inclusion date of 1980.

support, which may itself be an important factor in the success of a QI strategy. Many studies of organizational change include designation of specific staff to address hypertension, which may represent either an increase in staffing or a re-allocation of staff effort to hypertension; in either case, it could represent an absolute increase in health professional time allocated to hypertension. However, it is also possible that an organizational change could achieve an effective increase in attention to hypertension by re-designing work flow without increasing the overall staffing devoted to hypertension management. Most studies did not report information that would allow us to make this distinction. The finding of the effect of organizational change is consistent with a report from an observational study of the Veterans Affairs Health Care System, which found moderate improvements in rates of blood pressure control after implementation of systemwide reengineering.^{170, 171} A randomized clinical trial published too recently to be included in our analysis confirms the major impact that organizational change may exert on blood pressure outcomes. Among 309 inner city African American men, comprehensive interventions in the community, by a multidisciplinary team, resulted in 44 percent of the subjects having controlled blood pressure (compared with 17 percent at baseline).¹⁷²

Patient education appeared to be a successful strategy for improving blood pressure control, but we evaluated it only when it was used in conjunction with other QI strategies. Therefore, the impact of patient education *per se* may be overestimated in the studies we included. Our findings that patient education may be effective in improving blood pressure comport with those of a previous meta-analysis.⁵⁰ However, although patient education produced the largest reduction in blood pressure of the various methods studied in one systematic review,⁵² one particular study (which combined a number of interventions along with patient education) accounted for most of this finding. Our analysis does not allow for an evaluation of the efficacy of patient education as a sole QI strategy for blood pressure control.

Our findings on provider education differ from the negative findings in one previous, smaller review of physician education interventions in the management of hypertension.⁶⁸ However, in our review, provider education was usually accompanied by other QI strategies, so the effect on outcomes attributable to provider education or its substrategies is not known.

Other strategies, such as provider reminders, promotion of patient self-management, and audit and feedback, all appear to have relatively modest effects, and, when positive, were often coupled with other strategies as part of a multifaceted intervention. Our findings regarding promotion of patient self-management on BP control are consistent with those of a previous meta-analysis, and a systematic review.^{50, 52}

Our findings regarding audit and feedback are consistent with the conclusions of a recent systematic review of that strategy, which states: “when it is effective, the effects are generally small to moderate.”¹⁷³ The studies of audit and feedback in hypertension are a small subset of the studies in this review, and highlight the difficulty of interpreting results of specific QI strategies for a selected clinical area. While a strategy may be more or less effective in one clinical area compared with another, the ability to detect such differences, or lack thereof, are hampered by the limited number of studies for any particular strategy, as well as the confounding due to multifaceted interventions and study quality.

Which QI Strategies Improve Provider Adherence with Recommendations for Management of Hypertension?

Surprisingly, the median increase in percentage of providers adhering to recommendations was relatively small, or even negative, for all QI strategies (median effects ranged from a 1.3 percent reduction to 3.3 percent improvement in adherence across the QI strategies). Only limited conclusions can be drawn, because we found mixed results among the 10 comparisons with data on this outcome, and there was significant overlap of studies across QI strategies. We also note that most of the studies reporting provider adherence outcomes are different from the studies that report blood pressure outcomes. Provider adherence included adherence with recommended medications, as well as adherence with other recommended practices, such as appropriately ordered laboratory tests. It is important to recognize that although guidelines recommending specific antihypertensives for treatment of particular comorbidities are evidence based,¹ there was not always an evidence base supporting the adherence outcomes we analyzed in the studies we reviewed.

There are a number of possible contributing factors that may explain the finding of the limited impact of QI strategies on provider adherence to recommended practice, if in fact this is a true effect. Past controversies in the medical literature about the relative importance of DBP versus SBP, as well as frequent change to overall targets for hypertension control, may have led to some provider confusion about appropriate targets for BP control. The large number of drugs available to treat hypertension, and the promotion of certain drugs for certain classes of patients, may also lead to some provider confusion. It is also possible that some providers do not agree with the guideline recommendations. For example, early trials using the thiazide class of diuretics used larger doses that were commonly associated with hypokalemia, a potentially serious problem. It is now known that much smaller doses, only rarely associated with hypokalemia, are effective in most patients; however, providers may still be reluctant to use them due to prior adverse effects on their patients. Because medical decision making is prone to “availability bias,” a single negative outcome may be remembered vividly, and may exert undue impact on future decisions.¹⁷⁴

A systematic review examining barriers to physician adherence to clinical practice guidelines identified a number of potential barriers (e.g., lack of awareness, inability to reconcile patient preferences with guideline recommendations, lack of resources).¹⁷⁵ This review noted that studies on improving physician guideline adherence may not be applicable across specialties or practice settings, as barriers in one setting may not be present in another.¹⁷⁵ Practice “inertia” may also be a barrier. The theme of “inertia” of previous practice has been attributed to at least three problems: overestimation of care provided; use of “soft” reasons to avoid intensifying therapy; and lack of education, training, and practice organization aimed at achieving therapeutic goals.¹⁷⁶

The apparently small effect of QI strategies on provider adherence outcomes is a finding that deserves future attention, because of the importance of provider behavior in attaining goals of improved hypertension outcomes. As described in a systematic review from the National Health Service in the United Kingdom,⁵² a greater health gain could theoretically be obtained by improving professional standards of detection of hypertension and the proportion of patients with hypertension receiving treatment, as compared with the expected health gains from improvements in patient adherence to treatment. Although the applicability of these data to the

United States may be limited, the analysis serves to emphasize the key role of provider adherence in improving hypertension outcomes.

Which QI Strategies Improve Patient Adherence with Treatment?

Use of patient education (in combination with other strategies), organizational change, facilitated relay of clinical data, and patient self-management as part of a QI strategy may have all improved patient adherence. However, relatively few studies assessed this outcome, and thus the evidence base is limited. Our findings that patient education may be effective in improving patient adherence are consistent with those of a previous meta-analysis, which found that patient education appeared to be effective in improving adherence with medications, and improving adherence with appointments.⁵⁰ We note again that the effect of patient education may be overestimated in the included studies, since patient education was never analyzed when it appeared as the sole component of an intervention, only when it was considered in combination with at least one other QI strategy.

Importance of Organizational Setting for Quality Improvement Interventions

Implementation of a QI strategy is essentially an attempt to change human behavior, either of health professionals or of patients. In studies of QI strategies, the organizational context of the study is very likely to have an impact on the effectiveness of the QI strategy. For example, if a QI strategy is implemented in a health care system despite objections from most of the professional staff, one would expect the likelihood of success to be lower than if the implementation enjoys the support of the staff, since it is staff who must carry out the strategy. Moreover, whether a given organizational strategy happens to mesh with existing features of an organization (such as its values or staffing patterns) may be a more important determinant of success than the QI strategy *per se*.

We also recognize that over the period of time—more than twenty years—of the studies we have included, there have been many changes in health care delivery systems that may affect the organizational context for QI implementation. We were not able in this evidence review to account for the impact of organizational context, because little information about it is presented in the published papers. We do report the setting of each study (see Table 1 and Appendix F), and readers who are contemplating implementation of a QI program may consider the similarity of the reported settings to their own, and the feasibility of implementation of the strategy in their own context. We also provide the actual results of each of the studies meeting the standards for inclusion, so that readers may consider the actual results of strategies that they may want to replicate.

Study Design Effects

Studies that are less methodologically rigorous may present more impressive-appearing findings, because less care was taken to correct for potential biases. Our analysis suggests that methodologic features affected some findings for QI strategies for hypertension. We found a fairly striking correlation between study size and effect size, particularly for SBP and DBP outcomes: larger studies reported less impressive reductions in blood pressures. This pattern did not hold for each individual QI strategy, but some individual strategies were used in very few studies. In further exploring possible confounding of study size with other study design features for the SBP and DBP outcomes, we found that studies in which the unit of randomization was the same as the unit of analysis appeared to account for the correlations between study size and effect size.

Our findings regarding the relationship between other study design features and effect size were mixed. For example, there was no clear relationship of RCT-study-design with effect size; findings differed for different outcomes.

Effect of Number of QI Strategies

We did not find a consistent pattern of improved outcomes with an increased number of QI strategies, and in fact, found that single QI strategy studies had larger effects compared with multifaceted QI strategies. However, our findings should be interpreted with caution because of the small number of studies, the large inter-quartile ranges, and possible confounding since most of the single QI strategies involved organizational change. Prior reviews have reached conflicting conclusions about the relative impact of adding more QI strategies, irrespective of their content.^{45, 83, 173, 177}

Additional Comments

Multiple risk factors. Many of the quality improvement strategies targeted hypertension as one of several risk factors to be controlled (e.g., for cardiovascular disease risk reduction). This confounded our ability to draw conclusions about the effect the specific QI strategy component had on hypertension, as distinct from the other risk factors.

Sources of variation in measurements of blood pressure. Many different blood pressure thresholds have been used to assess quality of care,¹⁷⁸ including percentage of patients with blood pressure exceeding a particular control threshold. Guidelines defining control have changed over time. This situation has implications with respect to the conclusions that can be drawn from studies reporting interventions that showed positive effects on achieving blood pressure control. For instance, some QI studies, particularly older studies, used control thresholds such as 160/95, whereas many recent studies define the control threshold at 140/90. Some hypertension quality of care studies used mean blood pressures for a particular patient over a number of visits, to determine whether they met control thresholds, whereas others used single visit blood pressure readings. The use of varied definitions of control, and different measurement techniques to determine control, may result in different judgments of quality of care.¹⁷⁸

Effect of QI interventions on mortality. Few studies reported mortality measures, perhaps because most quality improvement studies did not have a long enough study period or large enough study populations. For the six studies that did report mortality data, only two reported

mortality as a primary outcome measure. The MRFIT study reported a lower mortality rate at ten-year followup that was not statistically significant.¹⁰⁵ The HDFP study, however, showed reduced mortality of 16.9 percent with stepped care.²⁰ It is not possible to state what portion of the mortality benefit was due to the special components of the intervention that might be considered QI strategies, and what portion was due to the choices of drug therapy or other factors; however, overall, the application of the strategy was effective. With refinements to drug therapy since that time, for example the recognition that lower dose thiazide diuretics achieve reduction of blood pressure with fewer episodes of hypokalemia, it is possible that application of QI strategies such as those used in the stepped care program would be even more effective today. On the other hand, at the time that the HDFP study was conducted, the importance of treating systolic hypertension was not well-recognized, and the overall targets for BP control were higher. It is possible that application of the same strategies today would appear less effective in comparison to usual care, because current usual care includes treatments that were not then in use.

Relationship of reduction in average BP with improvements in percent of patients achieving BP in target range. For some QI strategies, the median effect on SBP or DBP does not correlate consistently with the median effect on improving the proportion of patients in SBP or DBP target range. For example, for some strategies, the decrease in BP was small, but resulted in a substantial increase in the percentage of patients in a target range, and vice versa. The relationship of reduction in the average BP with improvement in the percent of patients achieving BP in target range depends on several factors, including the baseline average BP, the variance in the BPs, and the baseline percent of patients in target range. Depending on the distribution of blood pressure and the range chosen as acceptable, a small change in mean BP can result in either small or large changes in the percentage of patients in the acceptable range. For a more detailed explanation, see Appendix I.

Potential benefits of clinical information systems. Studies that used a clinical information system had mixed effects, including some negative effects, in blood pressure outcomes and provider adherence. In light of the high expectations for information technology to improve health care, our findings from the studies published to date are disappointing. The potential for information technology to improve the quality of health care has been described by the Institute of Medicine as “enormous.”¹⁷⁹ A systematic review by Balas, et al, of 98 randomized clinical trials of computerized information services showed that about 75 percent reported substantial improvements.^{180, 181} Considerable evidence, summarized in systematic reviews, shows that automated reminder systems improve provider adherence to clinical practice guidelines.^{179, 180, 182, 183} Another systematic review of 68 controlled clinical trials assessing the effects of computer-based clinical decision support systems (CDSSs) on physician performance and patient outcomes found enhanced clinical performance for drug dosing, preventive care, and other aspects of medical care, but insufficient evidence regarding improvement in patient outcomes.¹⁸⁴ A 1998 systematic review of the use of computers in the management of hypertension showed that computers appeared to have a favorable effect on the uptake and followup of patients in hypertension management; however, the effect on blood pressure control was less conclusive.¹⁴⁵

We believe that it would be premature to draw conclusions based on the overall effects for clinical information systems. In many studies, the information systems used were only to identify eligible patients. Many medical centers and clinics are only now adopting electronic medical record systems that will permit smooth integration of clinical decision support with clinician work flow. In many cases, information technology that has been developed in academic research

centers has yet to be tested in large clinical trials. Decades of research have produced an infrastructure in medical informatics to support health care research and quality.¹⁸⁵ With further development of the infrastructure, new clinical trials will undoubtedly be conducted, and may yield different results from the few studies published to date.

Limitations in Interpretation of the Data

Conclusions based on pooled data are tentative, and must be interpreted cautiously. Each quality improvement study was conducted within a particular set of contexts, including practice type, era of guideline recommendations, local attitudes toward guideline implementation, and other potentially confounding factors. Nevertheless, although hypertension guidelines have changed over time, studies using older guidelines can provide useful evidence about whether or not quality improvement strategies work.

As with all systematic reviews, there is the possibility of missing relevant studies. For example, in this instance, studies that focus on a particular quality improvement strategy for broad application may have included hypertension, without specifying its inclusion in the title, abstract or subject headings, and would therefore be missed by our search strategy.¹⁸⁶

Recommendations for Future Research on Quality Improvement Implementations

Based on our review of published reports of QI strategies for hypertension, we offer several suggestions for future QI implementation research:

Clustering issues. The impact of the randomization choice should be discussed in published studies, and steps taken to account appropriately for clustering in the data analysis. Numbers of clusters and descriptive statistics of numbers of patients per cluster should be reported. An updated Consolidated Standards of Reporting Trials (CONSORT) statement specifically addressing cluster-randomized trials is in press.¹⁸⁷⁻¹⁸⁹

Blinding in measurement of study outcome. Providers performing clinical examinations may be unconsciously biased by prior expectation of a particular result.¹⁹⁰ In a study in which the provider who measures the patient's BP knows that a patient is receiving a QI intervention, the outcome measure may be unconsciously biased by an expectation of improvement. When the provider is also the individual who delivers the QI intervention, the prior expectation of benefit may be even more powerful, and the unconscious bias greater. Reports should specify whether the outcomes were measured by individuals who were blinded to the intervention status.

Pre- and post-intervention measures for both intervention and control group. Baseline differences between the intervention and control groups can have major effects on outcome measures. Reports should report both pre- and post-intervention measurements for both control and intervention groups, and should take account of baseline differences in statistical analyses, for example, by comparing change from baseline.

Organizational factors affecting QI interventions. Aspects of the organizational structure and setting of the providers' clinical practice may affect incentives to follow guidelines. For example, providers employed in a health care system would be expected to respond differently to recommended guidelines when a criterion of their performance standard includes adherence to such guidelines, as compared with independent providers, who may electively determine whether

or not to implement guidelines. As another example, when guidelines are recommended by a health insurance plan, adherence among providers with a large proportion of patients enrolled in that particular plan may differ as compared with providers whose patients are enrolled in many different plans. Further examples include extent of administrative support for the QI implementation. There is not, however, a clear consensus about how to define or measure such organizational factors. Possible factors to report in future studies include, among others:

- Descriptive information about organizational arrangements of providers in the study, for example, status as employees or independent practitioners.
- Descriptions of time constraints on clinical practice.
- Descriptive information about incentives for providers to follow recommended guidelines, for example, use of rates of guideline adherence in credentialing, performance review, or other processes.
- Description of the types and extent of administrative support and involvement of local clinical leadership; for instance, reports could include whether the QI strategy was implemented with research funds, administrative funds, or both, description of administrative support, and, if relevant, how this support was communicated to staff.

Number of QI activities concurrently implemented. The number of distinct QI implementations within a health care clinic or system may affect responses of both providers and patients. On one hand, providers or patients who receive many QI interventions may become less attentive to the interventions. On the other hand, providers or patients who become accustomed to QI interventions may incorporate a new approach to management of disease and may be more likely to adhere to guidelines. In order to evaluate the impact of such effects so that such questions may be addressed in future research, possible factors to report include:

- Number of programs in different areas being implemented concurrently in the study setting in which the QI strategy is being evaluated
- Information on the organizational culture regarding attitudes toward guideline implementation and QI strategies

Adverse effects of the QI intervention. As with all effective treatments, QI implementations have the potential for unintended adverse consequences. To date, these are rarely reported. Additionally, there is as yet no clear consensus as to methods for attributing adverse effects to a particular QI implementation, or which potential adverse effects to monitor and report. Because of this lack of consensus, studies of QI implementations rarely obtain information that would allow reporting of these factors. Candidate factors to consider include:

- Adverse effects on individual patients that are potentially due to aggressive implementation of particular guideline recommendations, for example, for hypertension, rates of syncope, falls, and morbidity related to falls (e.g., hip fracture) compared between study arms. Such factors might be particularly important to monitor in QI implementations that include strong incentives to providers to achieve certain targets for BP; and
- Adverse effects on populations of patients (e.g., the impact of guideline implementation for one disease on rates of guideline adherence for other diseases). Studies conducted in health care systems with clinical databases may be able to monitor database indicators of such rates. Another example might be the potential adverse effect of shifting staff resources from one area to another. It is well-recognized in cost-effectiveness analysis that it is essential to consider all the costs associated with an intervention, not merely the

immediate costs of providing the intervention initially. Similarly, it may be important to consider the effect on an entire health care system of shifting resources within the system.

Future QI reviews should consider adopting the CONSORT Statement, which provides a checklist of items to report in publications of randomized controlled trials.¹⁸⁷ The Statement is intended to improve the reporting of trials, to enable readers to understand how the trial was conducted, and to assess the validity of the results.

Chapter 5. Conclusions

Our review found that QI strategies result in increased detection of hypertension, and improved management, as measured by blood pressure. However, we found only small changes in provider and patient adherence due to QI interventions. Studies that included organizational change and patient education reported greater improvements in blood pressure control than did studies without these strategies, but the evidence is not sufficient to definitively establish the superiority of any individual QI strategy relative to others. The reported improvements in blood pressure control were smaller in larger studies than in smaller studies, raising a concern that our overall measures of the effectiveness of QI strategies may be overestimated because of publication bias.

Closing the quality gap will take sustained effort from the many parties with an interest in detection and management of hypertension. Our review documents the varied approaches to QI for hypertension that have received careful evaluation. The summary analyses provide a high level overview of these QI interventions. Perhaps as importantly, the details of individual studies offer a resource that may help guide further QI implementation and evaluation.

Despite the many studies documented here, the evidence about the usefulness of QI strategies in hypertension care is incomplete. There is a strong need for further and more detailed evaluation. Future studies will be more useful if they are designed rigorously, describe QI interventions carefully, and provide information about the organizational setting in which they are performed.

Each new attempt to close the quality gap in hypertension will likely need to be tailored to specific circumstances.⁴² We hope this report provides a useful starting point for individuals and organizations that are trying to improve the detection and management of hypertension, and for investigators attempting to further the field of quality improvement.

“Some observers have suggested that the answer to this problem is to produce a seventh version of the Joint National Committee Report on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC). Others counsel that what we need is not a new guideline but rather the will to implement what we already have, which is extensive. While JNC has been a valuable tool, it cannot be the only answer to controlling hypertension because it is an education tool, not an action tool. The application of the JNC... is what matters.”

— Claude Lenfant, Director, NHLBI, from *Reflections on Hypertension Control Rates. A Message From the Director of the National Heart, Lung, and Blood Institute*¹⁹¹

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Figure 1. Search strategy and article triage

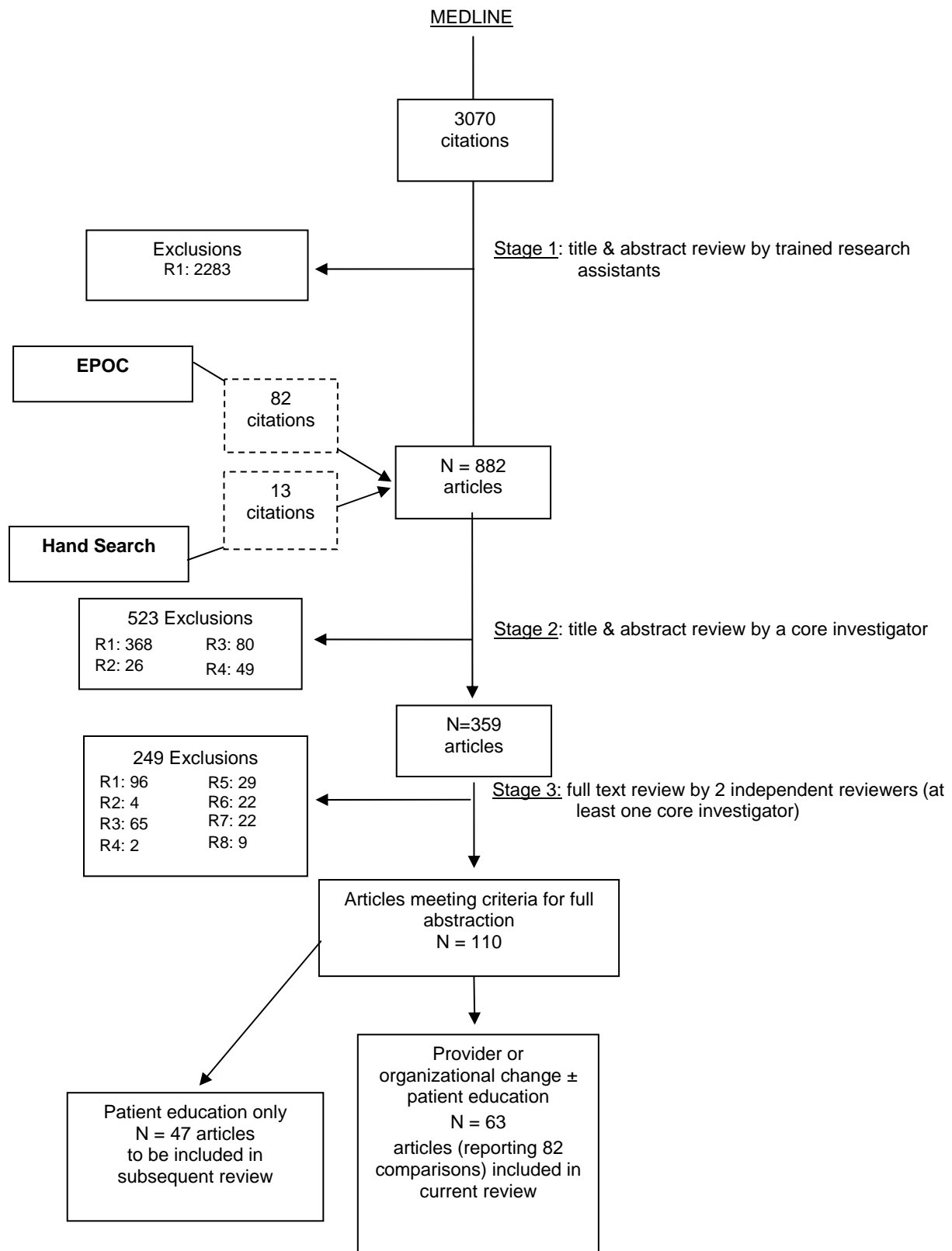


Figure 1 Legend

EPOC—Cochrane Effective Practice and Organization of Care database, which is described in Chapter 2, contains the results of extensive electronic searches of multiple large bibliographic databases, as well as hand searching of key journals. The 82 citations indicated above as contributed by EPOC do not include the 134 additional citations in EPOC already identified by the PubMed search.

Hand searching conducted for this project involved scanning bibliographies of all articles included at Stage 4 and the bibliographies of all systematic reviews and meta-analyses related to QI strategies in hypertension. When no systematic review existed for a given topic, we searched the bibliographies of traditional (narrative) review articles, editorials, and news items that appeared to describe QI studies involving outpatient hypertension care.

Reasons for Exclusion

R1—not QI or not an evaluation

R2—excluded topic: interventions restricted to HTN in pregnancy, Secondary HTN, HTN in children/adolescents, preventing HTN in high risk patients, hospital care

R3—study design below level 2 (i.e. does not meet criteria for RCT, CBA, or ITS)

R4—unrelated to HTN (e.g., QI article retrieved by broad search but related to a different chronic illness)

R5—no eligible outcomes

R6—duplicate article (in some cases the article may have only partially overlapped with another report of the same study; in general the earlier or smaller the two publications was excluded, but reviewed with the other article in case it contained any additional information). Please refer to Appendix C for a list of these articles.

R7—study published prior to 1980

R8—other (outcomes data not available for entire population studied, e.g., only presented in subgroups)

Table 1. Included studies

Setting	Study Period (Duration/months)	Study Design (Sample Size)	QI Strategies Employed *	Outcomes Reported † **
22 clinics (18 US cities) ¹	1973-1982 (99)	RCT (8012 patients)	Pt Ed, Org Change	Dz: SBP, DBP
2 hospital-based family medicine centers (Canada) ²	1983-1987 (60)	CBA (13 providers, 817 patients)	Pt Remind, Prvdr Ed, Audit & Fdbck, Org Change	DzID: BP Meas
Cleveland Veterans' Affairs Medical Center Ambulatory Clinic (Cleveland, OH) ³	1992 (2)	Quasi-RCT (2157 patients)	Prvdr Ed, Facil Relay, Audit & Fdbck	Prvdr Adhere: Med Rec
General practice and hospital-based ambulatory clinic (Italy) ⁴	1994-1996 (36)	CBA (121 providers, 2253 patients)	Prvdr Ed	Dz: SBP, DBP, BP Range Prvdr Adhere: Med Rec Pt Adhere: Meds
Kenmore Center of the Harvard Community Health Plan (Boston, MA) ⁵	1975-1977 (21)	RCT (115 patients)	Prvdr Remind, Info System	DzID: BP Elev FU Dz: Other Prvdr Adhere: Check BP
34 family practices (Canada) ⁶	1978-1982 (60)	RCT (34 practices, 32124 patients)	Pt Ed, Pt Remind, Prvdr Remind, Org Change	DzID: Other Dz: SBP, DBP Pt Adhere: Meds
1 ambulatory practice center, Temple University School of Medicine (Philadelphia, PA) ⁷	-- (3)	RCT (171 patients)	Pt Ed, Self-Mx, Pt Remind	Dz: DBP, BP Range Pt Adhere: Meds
20 community pharmacy sites (England) ⁸	1997-1998 (7)	Quasi-RCT (25 pharmacies, 282 patients)	Facil Relay, Org Change	Dz: BP Range Pt Adhere: Meds
1 primary care outpatient teaching clinic, The Queen's Medical Center (Honolulu, HI) ⁹	-- (6)	Quasi-RCT (100 patients)	Pt Ed, Prvdr Remind, Facil Relay, Org Change	Dz: SBP, DBP, BP Range
1 hypertension clinic (unspecified US city) ¹⁰	-- (12)	RCT (197 patients)	Pt Ed, Facil Relay, Org Change	Dz: SBP, DBP, BP Range Prvdr Adhere: Med Rec
6 community sites (Seattle, WA; Dayton, OH; Fitchburg or Franklin County, MA; and Charleston or Georgetown County, SC) ¹¹	1974-1982 (98)	RCT (3958 patients)	Org Change, Financial	DzID: BP Elev, BP Elev FU Dz: SBP, DBP, BP Range Prvdr Adhere: Med Rec, Eval HTN, Pt Counsel Pt Adhere: Other
19 general practices (Scotland) ¹²	-- (12)	RCT (1343 patients)	Pt Ed, Prvdr Ed, Org Change	Dz: BP Range
2 group medical practices (Taylorville, IL) ¹³	-- (6)	RCT (55 patients)	Pt Ed, Prvdr Ed, Facil Relay, Org Change, Info System	Dz: SBP, DBP, BP Range Pt Adhere: Meds

Table 1. Included studies (continued)

3 specialist hypertension clinics (Scotland) ¹⁴	-- (48)	CBA (396 patients)	Pt Ed, Pt Remind, Org Change	Dz: SBP, DBP, BP Range
Patient's residence/primary care clinic ¹⁵	-- (24)	RCT (218 patients)	Pt Ed, Self-Mx, Org Change	Dz: BP Range
2 manufacturing plants (unspecified cities, MI) ¹⁶	1985-1988 (36)	RCT (2 sites, 4341 patients)	Pt Ed, Org Change	Dz: BP Range
Urban university-affiliated internal medicine clinic (unspecified US city) ¹⁷	-- (5)	Quasi-RCT (80 patients)	Pt Ed, Self-Mx, Facil Relay, Org Change	Dz: SBP, DBP, BP Range
62 physician practice groups (Canada) ¹⁸	-- (12)	RCT (62 practices, 198 patients)	Prvdr Ed, Prvdr Remind	Dz: SBP, DBP, BP Range Prvdr Adhere: Check BP Pt Adhere: Meds
4 Ford Motor Company manufacturing plants (Southeastern Michigan) ¹⁹	1978-1981 (36)	RCT (4 worksites, 11196 patients)	Pt Ed, Org Change	DzID: BP Meas, BP Elev, BP Elev FU Dz: BP Range
HMO family practice clinic, Group Health Cooperative of Puget Sound (Seattle, WA) ²⁰	1986 (9)	CBA (8 providers, 326 patients)	Prvdr Remind, Org Change, Info System	Prvdr Adhere: Med Rec
4 communities (Northern California) ²¹	1978-1983 (64)	CBA (4 cities, 2364 patients)	Pt Ed, Self-Mx, Prvdr Ed	DzID: BP Elev, BP Elev FU, BP Knew Dz: SBP, DBP, BP Range
29 greater Boston communities (Boston, MA) ²²	-- (6)	RCT (301 patients)	Pt Ed, Self-Mx, Facil Relay, Info System	Dz: SBP, DBP Pt Adhere: Meds
1 pharmacy site (Portugal) ²³	2000 (6)	RCT (100 patients)	Pt Ed, Pt Remind, Facil Relay, Org Change	Dz: SBP, DBP
Patient's residence (Mexico) ²⁴	1998-1999 (6)	RCT (718 patients)	Pt Ed, Self-Mx, Prvdr Ed, Org Change, Info System	Dz: SBP, DBP, BP Range
15 small group practices at 4 primary care clinics (Seattle, WA) ²⁵	1993-1996 (30)	RCT (78 providers)	Pt Ed, Prvdr Ed, Prvdr Remind, Facil Relay, Audit & Fdbck, Org Change, Info System	Dz: BP Range Prvdr Adhere: Med Rec
MDs from 7 counties (San Francisco area, CA) ²⁶	-- (12)	RCT (82 providers)	Prvdr Ed, Facil Relay, Audit & Fdbck, Info System	Dz: BP Range Prvdr Adhere: Med Rec, Target BP
29 health centers (Norway) ²⁷	-- (21)	RCT (29 practices, 2239)	Prvdr Ed, Audit & Fdbck, Info System	Dz: SBP, DBP

Table 1. Included studies (continued)

Community site, Johns Hopkins Hospital catchment area (Maryland) ²⁸	-- (12)	RCT (204 patients)	Pt Ed, Self-Mx, Pt Remind, Org Change	Dz: SBP, DBP Pt Adhere: Appt
General Medical Outpatient Clinic at Duke University Medical Center (Durham, NC) ²⁹	-- (24)	CBA (391 patients)	Pt Ed, Pt Remind, Org Change	Dz: BP Range
10 VA medical centers, 1 academic center (unspecified US cities) ³⁰	-- (6)	RCT (133 patients)	Pt Ed, Self-Mx, Pt Remind, Facil Relay	Dz: SBP, DBP Pt Adhere: Meds
17 primary care clinics (Saskatchewan, Canada) ³¹	-- (12)	RCT (22 providers)	Prvdr Ed	Prvdr Adhere: Other
1 hypertension clinic, Aldermoor Health Centre (Southampton, UK) ³²	-- (12)	RCT (36 patients)	Org Change	Dz: BP Range
5 outpatient general medicine practices of a university-based internal medicine training program (unspecified US city) ³³	1998-2000 (30)	RCT (44 providers)	Audit & Fdbck	Prvdr Adhere: Eval HTN
Worksites (Toronto, Canada) ³⁴	1977 (12)	RCT (457 patients)	Org Change	Dz: DBP
38 business locations (Toronto, Canada) ³⁵	1979 (12)	RCT (194 patients)	Pt Ed, Self-Mx, Pt Remind, Facil Relay, Org Change	Dz: DBP, BP Range Pt Adhere: Appt, Meds
1 industrial worksite (Cheboksary, USSR) ³⁶	-- (60)	CBA (5563 patients)	Org Change	DzID: BP Elev
50 family practices (Toronto, Canada) ³⁷	-- (16)	RCT (60 providers, 2833 patients)	Pt Remind, Facil Relay, Info System	Dz: BP Range
1 general medical clinic (unspecified city, GA) ³⁸	-- (12)	RCT (103 patients)	Pt Ed, Self-Mx, Pt Remind, Org Change, Financial	Dz: SBP, DBP, BP Range
4 family practices Ottawa Civic Hospital (Ottawa, Canada) ³⁹	1985-1986 (18)	RCT (4247 families, 5744 patients)	Prvdr Remind, Info System	DzID: BP Meas, BP Elev
Hypertension clinic (UK) ⁴⁰	1986-1989 (48)	RCT (831 patients)	Pt Remind, Facil Relay, Org Change, Info System	Dz: SBP, DBP, BP Range Prvdr Adhere: Check BP
Patient's residence (unspecified city, CO) ⁴¹	-- (6)	RCT (36 patients)	Pt Ed, Self-Mx, Org Change	Dz: SBP, DBP, BP Range Pt Adhere: Meds
Patient's residence (Oakland, CA) ⁴²	-- (12)	RCT (204 patients)	Self-Mx, Facil Relay	Dz: SBP, DBP
27 general practices (New Zealand) ⁴³	1996-1998 (24)	Quasi-RCT (27 practices, 614 patients)	Prvdr Ed, Facil Relay, Info System	Dz: SBP, DBP

Table 1. Included studies (continued)

Health care centers (Sweden) ⁴⁴	1997-1998 (11)	RCT (40 providers, 46000 patients)	Prvdr Ed, Audit & Fdbck, Info System	Prvdr Adhere: Med Rec
2 pharmacy sites (Chicago, IL; Kenosha, WI) ⁴⁵	1993-1995 (20)	RCT (64 patients)	Pt Ed, Facil Relay, Org Change	Dz: SBP, DBP, BP Range Pt Adhere: Meds
University group general practice (Australia) ⁴⁶	1992-1994 (19)	RCT (97 patients)	Pt Ed, Prvdr Remind, Org Change	Dz: Other
Primary care practices (Canada) ⁴⁷	-- (18)	RCT (25 providers)	Prvdr Ed	Dz: Other
Hypertension clinic Cincinnati General Hospital (Cincinnati, OH) ⁴⁸	1974 (6)	RCT (100 patients)	Pt Ed, Org Change	Dz: SBP, DBP Pt Adhere: Appt, Meds
1 general practice (London, UK) ⁴⁹	1986-1988 (36)	RCT (3117 patients)	Pt Ed, Org Change, Info System	DzID: BP Meas
State University of New York Upstate Medical University primary care outpatient clinic (Syracuse, NY) ⁵⁰	-- (11 weeks)	RCT (121 patients)	Self-Mx, Facil Relay, Info System	Dz: Other
2 primary group practices, VA Medical Center (Richmond, VA) ⁵¹	-- (--)	RCT (2 practices, 320 patients)	Prvdr Ed, Prvdr Remind	Dz: SBP, DBP, BP Range Prvdr Adhere: Med Rec
1 primary care clinic (South Africa) ⁵²	-- (6)	RCT (224 patients)	Pt Ed, Self-Mx, Pt Remind	Dz: DBP, BP Range Pt Adhere: Meds
Medicine clinic University Hospitals Clinic, Ohio State University (Columbus, OH) ⁵³	-- (12)	RCT (40 patients)	Org Change	Dz: SBP, DBP, BP Range
Multi-specialty group practice (Edgecombe county, North Carolina) ⁵⁴	1981-1983 (21)	CBA (8 providers, 460 patients)	Pt Remind, Audit & Fdbck, Org Change, Info System	Dz: BP Range Pt Adhere: Appt
4 Kaiser Permanente Medical Centers (Alameda and Contra Costa counties, CA) ⁵⁵	1986 (12)	RCT (430 patients)	Pt Ed, Self-Mx, Pt Remind, Facil Relay	Dz: SBP, DBP, BP Range
VA medical center walk-in screening clinic (Durham, NC) ⁵⁶	1979 (3.5)	RCT (74 patients)	Pt Remind	DZID: BP Elev FU Dz: DBP Pt Adhere: Appt
1 hypertension clinic, VA Medical Center (Philadelphia, PA) ⁵⁷	-- (6)	RCT (56 patients)	Org Change	Dz: SBP, DBP, BP Range Pt Adhere: Meds

Table 1. Included studies (continued)

Kenmore Center Harvard Community Health Plan (Boston, MA) ⁵⁸	-- (15)	Quasi-RCT (16 providers)	Facil Relay, Info System	Dz: BP Range Prvdr Adhere: Eval HTN
Patient's residence (Ontario, Canada) ⁵⁹	-- (2)	RCT (31 patients)	Pt Ed, Self-Mx	Dz: Other Pt Adhere: Meds
Duke-Watts family medicine center (Durham, NC) ⁶⁰	-- (11)	RCT (41 providers, 250 patients)	Facil Relay, Audit & Fdbck, Info System	Dz: SBP, DBP, BP Range
14 communities (various US cities) ⁶¹	1974-1979 (60)	RCT (10940 patients)	Pt Ed, Self-Mx, Org Change, Financial	Dz: SBP, DBP, BP Range Pt Adhere: Meds
Patient's residence ⁶² (Detroit, MI)	-- (5)	RCT (26 patients)	Pt Ed, Self-Mx, Facil Relay, Org Change, Info System	Dz: SBP, DBP Pt Adhere: Other
3 rural regions (SE Minnesota) ⁶³	1974-1979 (72)	CBA (3 regions, 740 patients)	Pt Ed, Prvdr Ed	DZID: BP Elev, BP Elev FU Dz: SBP, DBP, BP Range

* Audit & Fdbck—audit and feedback to provider; Facil Relay—facilitated relay of information to provider; Financial—financial incentives; Info System—clinical information system; Org Change—organizational change; Pt Ed—patient education; Pt Remind—patient reminder; Prvdr Ed—provider education; Prvdr Remind—provider reminder; Self-Mx—resource for patient self-management.

† Dz: Measure of disease control; SBP—systolic blood pressure; DBP—diastolic blood pressure; BP Range—patients with blood pressure within a certain range; Other.

DzID: Measure of disease identification; BP Elev—patients with elevated blood pressure; BP Elev FU—patients with elevated blood pressure receiving follow-up; BP Knew—patients who knew blood pressure was elevated; BP Meas—patients who had blood pressure measured; Other.

Prvdr Adhere: provider adherence with recommendations for management of hypertension; Check BP—guidelines for checking or recording blood pressure; Eval HTN—guidelines for evaluation of hypertension; Med Rec—specific medication recommendations; Pt Counsel—guidelines for patient counseling or delivering patient education; Target BP—guidelines of targets for blood pressure; Other.

Pt Adhere: Patient adherence with treatment; Appt—appointment compliance; Meds—medication compliance; Other.

** Not all outcomes reported in Table 1 had sufficient information to use in quantitative analysis.

Table 2a. Quality improvement strategies

QI strategy	Randomized Controlled Trial	Non-Randomized Controlled Trial*	Total
Provider reminders	7 publications ^{5, 6, 18, 25, 39, 46, 51, 67} (8 comparisons)	2 publications ^{9, 20} (2 comparisons)	9 publications (10 comparisons)
Facilitated relay of clinical data	17 publications ^{10, 13, 22, 23, 25, 26, 30, 35, 37, 40, 42, 45, 50, 55, 60, 62, 67-73} (23 comparisons)	6 publications ^{3, 8, 9, 17, 43, 58, 64, 65} (8 comparisons)	23 publications (31 comparisons)
Audit and feedback	6 publications ^{25-27, 33, 44, 60, 67-69} (9 comparisons)	4 publications ^{2, 3, 54, 58} (4 comparisons)	10 publications (13 comparisons)
Provider education	12 publications ^{12, 13, 18, 24-27, 31, 44, 47, 51, 67-69, 74} (15 comparisons)	6 publications ^{2-4, 21, 43, 63, 66} (7 comparisons)	18 publications (22 comparisons)
Patient education[†]	27 publications ^{1, 6, 7, 10, 12, 13, 15, 16, 19, 22-25, 28, 30, 35, 38, 41, 45, 46, 48, 49, 52, 55, 59, 61, 62, 72, 73, 75-79} (34 comparisons)	6 publications ^{9, 14, 17, 21, 29, 63, 66} (7 comparisons)	33 publications (41 comparisons)
Promotion of self-management[†]	16 publications ^{7, 15, 22, 24, 28, 30, 35, 38, 41, 42, 50, 52, 55, 59, 61, 62, 73, 76} (18 comparisons)	2 publications ^{17, 21} (2 comparisons)	18 publications (20 comparisons)
Patient reminders	12 publications ^{6, 7, 23, 28, 30, 35, 37, 38, 40, 52, 55, 56, 70, 71, 76, 80, 81} (17 comparisons)	4 publications ^{2, 14, 29, 54, 65} (5 comparisons)	16 publications (22 comparisons)
Organizational change	27 publications ^{1, 6, 10-13, 15, 16, 19, 23-25, 28, 32, 34, 35, 38, 40, 41, 45, 46, 48, 49, 53, 57, 61, 62, 67, 72, 73, 75, 77-79, 82} (35 comparisons)	9 publications ^{2, 8, 9, 14, 17, 20, 29, 36, 54, 65} (10 comparisons)	36 publications (45 comparisons)
Financial incentives	3 publications ^{11, 38, 61} (3 comparisons)	0 publications	3 publications (3 comparisons)
Total	48 publications (64 comparisons)	15 publications (18 comparisons)	63 publications (82 comparisons)

* Includes 6 publications (with 7 comparisons) that are quasi-RCTs^{3, 8, 9, 17, 43, 58, 64} and 9 publications (with 11 comparisons) that are controlled before-after studies^{2, 4, 14, 20, 21, 29, 36, 54, 63, 65, 66}

† Studies designated as patient education, promotion of self-management, and patient reminders always included some other QI strategy involving providers or organizational change. The 46 additional studies reporting interventions consisting solely of patient education or promotion of self-management will be reviewed in a subsequent report.

Table 2b. Quality improvement sub-strategies

QI strategy	Randomized Controlled Trial	Non-Randomized Controlled Trial*	Total
CME[†]	9 publications ^{10, 12, 13, 26, 27, 31, 44, 47, 68, 69, 74} (11 comparisons)	6 publications ^{2, 3, 8, 21, 43, 63, 64, 66} (8 comparisons)	15 publications (19 comparisons)
Educational outreach	4 publications ^{25, 26, 44, 47, 67, 69} (6 comparisons)	2 publications ^{3, 21} (2 comparisons)	6 publications (8 comparisons)
Distribution of printed materials	10 publications ^{12, 18, 25-27, 31, 44, 47, 51, 67-69, 74} (13 comparisons)	3 publications ^{2, 3, 21} (3 comparisons)	13 publications (16 comparisons)
Disease/Case management	8 publications ^{6, 12, 13, 25, 32, 34, 57, 61, 67, 82} (10 comparisons)	1 publications ^{63, 66} (2 comparisons)	9 publications (12 comparisons)
Team/Staffing change	25 publications ^{6, 10, 12, 13, 15, 16, 19, 23-25, 28, 30, 32, 34, 35, 38, 40, 41, 45, 46, 48, 49, 53, 57, 62, 67, 72, 73, 75, 77-79, 82} (33 comparisons)	8 publications ^{3, 8, 9, 14, 17, 20, 29, 63, 65, 66} (10 comparisons)	33 publications (43 comparisons)
Telemedicine	1 publications ⁴⁰	1 publications ⁶⁵ (1 comparisons)	1 publications [‡] (1 comparisons)
Change in medical record system	5 publications ^{5, 6, 25, 32, 40, 67} (6 comparisons)	2 publications ^{2, 54, 65} (3 comparisons)	7 publications (9 comparisons)
Total	48 (64 comparisons)	15 publications (18 comparisons)	63 publications (82 comparisons)

* Includes 6 publications (with 7 comparisons) that are quasi-RCTs^{3, 8, 9, 17, 43, 58, 64} and 9 publications (with 11 comparisons) that are controlled before-after studies^{2, 4, 14, 20, 21, 29, 36, 54, 63, 65, 66}

[†] CME refers to traditional CME in the form of educational workshops or meetings.

[‡] The intervention group remained the same for both comparisons but the control group differed resulting in a difference in the study design; the first comparison for this study was a randomized control trial; the second comparison for this study had a controlled before-after design.

Table 3. Number of different quality improvement strategies included in articles

Number of QI types in intervention	Number of comparisons		
	RCTs	Non-RCTs*	Total
Single QI type	14 ^{5, 31–34, 39, 47, 53, 56, 57, 74, 80–82}	3 ^{4, 36, 64}	17
Multiple (total)	50	15	65
2 QI strategies	21 ^{1, 11, 16, 18, 19, 27, 37, 42, 44, 48–51, 56, 59, 60, 70, 71, 75, 77–79}	6 ^{8, 20, 43, 58, 63, 66}	27
3 QI strategies	15 ^{7, 10, 12, 15, 22, 26, 40, 41, 45, 46, 52, 68, 69, 72, 76}	6 ^{3, 14, 21, 29, 54, 65}	21
4 QI strategies	10 ^{6, 13, 23, 24, 28, 30, 55, 61, 62, 73}	3 ^{2, 9, 17}	13
5 QI strategies	3 ^{35, 38, 67}	0	3
6 QI strategies	1 ²⁵	0	1

* Includes 6 publications (with 7 comparisons) that are quasi-RCTs^{3, 8, 9, 17, 43, 58, 64} and 9 publications (with 11 comparisons) that are controlled before-after studies^{2, 4, 14, 20, 21, 29, 36, 54, 63, 65, 66}

Table 4. Quality improvement strategy combinations

IQ Strategy Combination*	Number of Comparisons	References
PtE, OC	9	1, 16, 19, 48, 49, 75, 77–79
FR, Aud, PvE	4	3, 26, 68, 69
OC	6	32, 34, 36, 53, 57, 82
FR, PtR	3	37, 70, 71
FR, PtE, SMx, OC	4	17, 35, 62, 73
PvE	4	4, 31, 47, 74
FR, PtE, OC	3	10, 45, 72
PtE, SMx, PtR	3	7, 52, 76
Aud, PvE	2	27, 44
PvE, PtE	2	63, 66
FR	2	58, 64
FR, PtR, OC	2	40, 65
FR, SMx	2	42, 50
FR, PtE, SMx, PtR	2	30, 55
PtR	3	56, 80, 81
PvR	2	5, 39
PvR, PvE	2	18, 51
PtE, PtR, OC	2	14, 29
PtE, SMx, OC	2	15, 41
Aud	1	33
Aud, FR	1	60
Aud, PvE, PtR, OC	1	2
Aud, PtR, OC	1	54
PvE, PtE, OC	1	12
PvE, PtE, SMx	1	21
PvE, PtE, SMx, OC	1	24
FR, PvE	1	43
FR, PvE, PtE, OC	1	13
FR, OC	1	8
FR, PtE, PtR, OC	1	23
FR, PtE, SMx	1	22
OC, Fin	1	11
PvR, FR, Aud, PvE, OC	1	67

Table 4. Quality improvement strategy combinations (continued)

PvR, FR, Aud, PvE, PtE, OC	1	25
PvR, FR, PtE, OC	1	9
PvR, OC	1	20
PvR, PtE, PtR, OC	1	6
PvR, PtE, OC	1	46
PtE, SMx	1	59
PtE, SMx, PtR, OC	1	28
PtE, SMx, PtR, OC, Fin	1	38
PtE, SMx, OC, Fin	1	61
	82	

* Aud—audit and feedback to provider; FR—facilitated relay of information to provider; Fin—financial incentives; OC—organizational change; PtE—patient education; PtR—patient reminder; PvE—provider education; PvR—provider reminder; SMx—resource for patient self-management.

Table 5. Screening studies

Author	Screening Intervention	Screening Setting	Results	Type of Screening Measure(s)
<p>Aubin, 1994² non-RCT (CBA)</p>	<p>“Operational incentives to increase hypertension screening”: Reference guide, placed in physician’s offices Chart aids for the recording of BP measurements Follow up system and protocol Control group: Usual care</p>	<p>Clinic N = 13 providers, 817 patients</p>	<p><u>Control group:</u> Screening rates decreased from 71.9% to 59.8%</p> <p><u>Intervention group:</u> Screening rates increased from 59.8% to 78.7%</p> <p><i>Note: Control group had high screening rate to start with. Authors noted that there was a medical audit of practices in this group at baseline.</i></p>	<p><u>Screening Rate:</u> Percent of individuals who had blood pressure measured.</p> <p>Control vs. Intervention: <i>P</i> < 0.001 at baseline; <i>P</i> < 0.001 at end of study</p>
<p>Barnett, 1983⁵ RCT</p>	<p>Automated computer surveillance system used to monitor patient population with elevated diastolic BP and poor follow-up rates. Providers received automatic computer-generated reminders for all patients not adhering to standard follow-up procedures. Control group: Usual care</p>	<p>Clinic N = 115 patients</p>	<p>6–12 month follow-up period: <u>Control group:</u> 25% follow-up rate; 31% had Repeat BP recorded <u>Intervention group:</u> 49% follow-up rate; 49% had Repeat BP recorded</p> <p>6–24 month follow-up period: <u>Control group:</u> 46% follow-up rate; 52% had Repeat BP recorded <u>Intervention group:</u> 98% follow-up rate; 70% had Repeat BP recorded</p>	<p><u>Follow-up Rate</u> (attempted or accomplished): Percent of patients with elevated blood pressure who had follow-up <i>P</i> < 0.01 (6–12 months) <i>P</i> < 0.01 (6–24 months)</p> <p><u>Repeat BP recorded:</u> <i>P</i> < 0.05 (6–12 months) <i>P</i> < 0.05 (6–24 months)</p>

Table 5. Screening studies (continued)

<p>Bass, 1986⁶ RCT</p>	<p>Medical assistant administered hypertension screening, education, compliance, and follow-up activities in family practice setting. Medical charts were tagged to remind providers to measure patient's BP. A "tickler" file system tracked patients due for follow-up. Patient appointments were filed on an index card by month of visit; the card was removed from the file when the patient attended the appointment. Cards remaining at the end of the month received follow-up.</p> <p>Patients received post card reminders to have BP checked.</p> <p>Control group: Usual care</p>	<p>Clinic</p> <p>N = 34 practices, 32,124 patients</p>	<p><u>Control group:</u> 80% screened at least once; 57% screened at least twice</p> <p><u>Intervention group:</u> 90.8% screened at least once; 70.3% screened at least twice</p> <p><i>Note: Authors concluded that the higher rates of screening did not influence outcomes, probably because the family doctors were identifying higher risk groups regardless of screening practice.</i></p>	<p><u>Screening Rate:</u> Percent of patients who had blood pressure measured;</p> <p><u>Followup Rate:</u> Percent of patients with elevated blood pressure who had follow-up</p> <p>Intervention versus control group patients were: more likely to have lower SBP ($P < 0.02$) more likely to be more compliant ($P < 0.05$) more likely to be very satisfied with care ($P < 0.01$)</p>
<p>Foote, 1983¹⁹ RCT</p>	<p>Worksite hypertension screening conducted at 4 sites.</p> <p>Site 1: Screening and referral to a physician only (Control)</p> <p>Site 2: Screening, referral to a physician, and semiannual follow-up visits</p> <p>Site 3: Screening, referral to a physician, and more frequent follow-ups as needed</p> <p>Site 4: Screening and on-site treatment by a physician.</p>	<p>Community (Work site)</p> <p>N = 4 worksites, 11,196 patients</p>	<p>Screening rates reported for Sites 1, 2, 3, and 4 (83%, 75%, 77%, 66%)</p> <p>Percent of employees identified as hypertensive being treated before versus after study:</p> <p>Site 1: 49% to 84%</p> <p>Site 2: 49% to 96%</p> <p>Site 3: 33% to 96%</p> <p>Site 4: 40% to 98%</p>	<p><u>Screening Rate:</u> Percent of patients who had blood pressure measured;</p> <p>Percent of patient with hypertension who are treated (and identified as hypertensive)</p> <p>Site 1: Significant increase in proportion under treatment ($P < 0.001$), but not in proportion with adequate blood pressure control.</p> <p>Sites 2, 3, and 4: Significant increase in proportion under treatment ($P < 0.001$) and in proportion with adequate blood pressure control ($P < 0.001$).</p> <p>No statistical comparison between control and intervention</p>

Table 5. Screening studies (continued)

<p>Markov, 1986³⁶ non RCT (CBA)</p>	<p>Work site hypertension screening. Active prevention group screened annually and referred to cardiovascular outpatient department for further testing and treatment.</p> <p>Control group: Annual screenings; individuals with elevated blood pressure referred to routine care.</p>	<p>Community (Work site)</p> <p>N = 5,563 patients</p>	<p><u>Control group:</u> Effectively treated patients increased from 4% to 11.9% within 5 years.</p> <p><u>Intervention group:</u> Effectively treated patients increased from 7.3% to 25.2% within 5 years.</p>	<p><u>Percent of Effectively Treated Patients</u> (i.e., stable decrease in DBP below 90 mmHg, or DBP decrease by 10-15% from initial screening to final 5th year of screening):</p> <p><i>P</i> < 0.01 for change in proportion of effectively treated patients in intervention group</p> <p><i>P</i> < 0.01 for change in proportion of effectively treated patients in control group</p> <p>No statistical comparison between control and intervention</p>
<p>Robson, 1989⁴⁹ RCT</p>	<p>Health promotion nurse assisted physicians in recording BP during regular appointments. Computer system allocated patients into groups, depending on their risk score (based on BP measure). Nurse ran monthly computer searches and followed up with high risk patients and those without any record of risk factors.</p> <p>Control group: General practitioners managed patients; recorded blood pressure and history of smoking in computerized record.</p>	<p>Clinic</p> <p>3,117 patients</p>	<p>Percent patients with BP recorded within 5 years: <u>Control group:</u> Increased from 62% to 73%. <u>Intervention group:</u> Increased from 65% to 93%.</p> <p>Percent hypertensives with BP recorded within 1 year at end of study: <u>Control group:</u> 69% <u>Intervention group:</u> 97%</p>	<p><u>Screening rate</u> (Percent of patients with BP checked initially) Control versus intervention: <i>P</i> < 0.001 for proportion of patients who had BP recorded within preceding 5 years.</p> <p><u>BP recorded at a follow-up time in patients identified as hypertensive</u> <i>P</i> < 0.001 for proportion of patients with HTN or who had fewer than 3 readings in the HTN range but had not had BP recorded within the preceding year.</p>

Table 5. Screening studies (continued)

<p>Fortmann, 1990²¹ non RCT (CBA)</p>	<p>Annual cross-sectional surveys of randomly selected households, and 4 repeated surveys of a cohort. Mass media and education programs for public and health professionals in the study cities.</p> <p>Control group: Usual care included 2 cities where no mass media education was provided.</p>	<p>Community</p> <p>N = 4 cities, 2,364 patients</p>	<p>For cohort study –</p> <p>Percent of hypertensives aware: <u>Control</u>: 58.8% to 64.3% <u>Intervention</u>: 42.2% to 55.9%</p> <p>Percent of hypertensives under treatment: <u>Control</u>: 41% to 44.9% <u>Intervention</u>: 27.7% to 32.5%</p>	<p><u>Percent of hypertensives aware of HTN</u> Control versus intervention: $P < 0.01$ at baseline. Results at end of study not significant.</p> <p><u>Percent of hypertensives under treatment</u>: $P < 0.05$ at baseline. Results at end of study not significant.</p>
<p>McDowell, 1989³⁹ RCT</p>	<p>Patients in 4 family practices received one of the following interventions aimed at encouraging patients to have their BP checked:</p> <ol style="list-style-type: none"> 1. Letter reminder 2. Telephone reminder 3. Physician reminder 4. Randomized control group 5. Two additional control practices did not participate in the trial and patients were not issued reminders 	<p>Clinic</p> <p>N = 4,247 families, 5,744 patients</p>	<p>Percent of individuals who had blood pressure measured: <u>Control group</u>: 21.1% <u>Letter reminder</u>: 35.7% <u>Telephone reminder</u>: 24.1% <u>Physician reminder</u>: 30.7% <u>Control Practices</u> (not randomized): 18.6%</p>	<p><u>Screening rate</u> Percent of patients without BP checked in last year who have BP reading within the study year: $P < 0.001$ for difference between the 3 intervention groups and the control group. $P < 0.001$ for differences among the 3 groups. $P < 0.001$ for difference between physician intervention and control.</p>
<p>Velez, 1985⁵⁶ RCT</p>	<p>Patient and providers were randomized to receive reminders:</p> <ol style="list-style-type: none"> 1. Patient Letter only 2. Provider Letter only 3. Both Patient and Provider Letter <p>Control Group: Patients informed of their elevated blood pressure and the need to follow-up with their local physician</p>	<p>Clinic</p> <p>N = 74 patients</p>	<p>Percent of patients with elevated blood pressure who had follow-up: <u>Control Group</u>: 29% <u>Patient Letter</u>: 62% <u>Provider Letter</u>: 39% <u>Both Letters</u>: 64%</p> <p><i>Note: 60% of patients were previously treated for HTN, and there were significant differences in this rate between intervention groups, but stratification did not change the results significantly.</i></p>	<p><u>Percent of patients returning to physician after high blood pressure reading</u>: $P = 0.012$ for main effects of patient letter. $P = 0.334$ for main effects of physician letter $P = 0.72$ for interaction effects of patient letter X physician letter</p>

Table 5. Screening studies (continued)

<p>Krishan, 1981⁶³</p> <p>non-RCT (CBA)</p>	<p>Public education via local radio and newspapers. Providers offered educational outreach program.</p> <p>Community screening. Those identified with high blood pressure were offered a stepped care approach for the treatment of HTN in a special community hypertension clinic; patients could also follow-up with their own physicians.</p> <p>Control group: Usual care</p>	<p>Community</p> <p>N = 3 regions, 740 patients</p>	<p>2 Control communities were compared with Intervention community:</p> <p>The percentage of patients receiving hypertensive medications reported at baseline and 1st year had no significant differences between communities in first two periods, but the intervention group had a higher rate in the final 5th year (61.4% and 55.4% in control communities versus 68.4% in intervention community)</p> <p><i>Note: Only patients who participated in 5-year follow-up survey had data reported.</i></p>	<p><u>Percent of hypertensives on medications:</u></p> <p>Insignificant difference at baseline and 1st year</p> <p><i>P</i> = 0.01 for intervention community versus control communities at 5 years</p>
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Table 6a. Effect of quality improvement strategies on blood pressure outcomes*

Type of QI	Median reduction in SBP (mmHg) [inter-quartile range] [†] N = number of comparisons	Median reduction in DBP (mmHg) [inter-quartile range] [†] N = number of comparisons	Median increase in proportion of patients achieving SBP in a certain range [inter-quartile range] [†] N = number of comparisons	Median increase in proportion of patients achieving DBP in a certain range [inter-quartile range] [†] N = number of comparisons
All comparisons	4.5 [1.5, 11.0] N = 33 ^{1, 4, 9, 10, 13, 14, 17, 18, 21-24, 27, 28, 30, 38, 40-43, 45, 51, 53, 55, 57, 60, 62, 64, 65, 68, 73, 74, 82}	2.1 [-0.2, 5.0] N = 43 ^{1, 4, 7, 9-11, 13, 14, 17, 18, 21-24, 26-28, 30, 34, 35, 38, 40-43, 45, 51-53, 55, 57, 60-66, 68, 73, 74, 76, 82}	16.2 [10.3, 32.2] N = 14 ^{4, 8, 12-14, 16, 19, 21, 25, 45, 53, 67, 72, 78}	6.0 [1.5, 17.5] N = 16 ^{4, 7, 14, 15, 21, 26, 29, 38, 54, 58, 60, 61, 68, 69, 74, 79}
Provider reminders	6.8 [3.0, 9.4] N = 3 ^{9, 18, 51}	2.1 [0.9, 6.6] N = 3 ^{9, 18, 51}	-3.6 [-5.7, -1.4] N = 2 ^{25, 67}	NA N = 0
Facilitated relay of clinical data	4.5 [2.2, 11.5] N = 19 ^{9, 10, 13, 17, 22, 23, 30, 40, 42, 43, 45, 55, 60, 62, 64, 65, 68, 73, 74}	1.1 [-1.0, 3.4] N = 20 ^{9, 10, 13, 17, 22, 23, 26, 30, 35, 40, 42, 43, 45, 55, 60, 62, 64, 65, 68, 73}	15.3 [2.0, 28.4] N = 6 ^{8, 13, 25, 45, 67, 72}	2.0 [1.6, 5.0] N = 5 ^{26, 58, 60, 68, 69}
Audit and feedback	1.3 [0.5, 1.6] N = 4 ^{27, 60, 68, 74}	0.6 [0.5, 1.0] N = 4 ^{26, 27, 60, 68}	-3.6 [-5.7, -1.4] N = 2 ^{25, 67}	1.8 [0.1, 4.3] N = 6 ^{26, 54, 58, 60, 68, 69}
Provider education	2.7 [1.1, 6.0] N = 10 ^{4, 13, 18, 21, 24, 27, 43, 51, 68, 74}	0.7 [-0.3, 3.3] N = 13 ^{4, 13, 18, 21, 24, 26, 27, 43, 51, 63, 66, 68, 74}	10.9 [1.4, 13.1] N = 6 ^{4, 12, 13, 21, 25, 67}	3.5 [1.7, 11.3] N = 6 ^{4, 21, 26, 60, 68, 69}
Patient education	8.1 [3.3, 11.8] N = 18 ^{1, 9, 10, 13, 14, 17, 21-24, 28, 30, 38, 41, 45, 55, 62, 73}	3.3 [0.4, 5.0] N = 25 ^{1, 7, 9, 10, 13, 14, 17, 21-24, 28, 30, 35, 38, 41, 45, 52, 55, 61-63, 66, 73, 76}	19.2 [10.3, 36.4] N = 10 ^{12-14, 16, 19, 21, 25, 45, 72, 78}	15.2 [7.3, 21.8] N = 8 ^{7, 14, 15, 21, 29, 38, 61, 79}
Promotion of self-management	3.6 [2.1, 9.5] N = 12 ^{17, 21, 22, 24, 28, 30, 38, 41, 42, 55, 62, 73}	2.1 [0.4, 5.0] N = 17 ^{7, 17, 21, 22, 24, 28, 30, 35, 38, 41, 42, 52, 55, 61, 62, 73, 76}	13.4 N = 1 ²¹	9.4 [1.1, 13.4] N = 5 ^{7, 15, 21, 38, 61}
Patient reminders	2.8 [-1.5, 5.1] N = 8 ^{14, 23, 28, 30, 38, 40, 55, 65}	0.5 [-2.1, 3.4] N = 12 ^{7, 14, 23, 28, 30, 35, 38, 40, 52, 55, 65, 76}	7.0 N = 1 ¹⁴	9.4 [1.1, 19.0] N = 5 ^{7, 14, 29, 38, 54}

Table 6a. Effect of quality improvement strategies on blood pressure outcomes* (continued)

Organizational change	10.1 [3.9, 14.0] N = 19 ^{1, 9, 10, 13, 14, 17, 23, 24, 28, 38, 40, 41, 45, 53, 57, 62, 65, 73, 82}	4.4 [-0.5, 6.9] N = 23 ^{1, 9-11, 13, 14, 17, 23, 24, 28, 34, 35, 38, 40, 41, 45, 53, 57, 61, 62, 65, 73, 82}	21.8 [9.0, 33.8] N = 12 ^{8, 12-14, 16, 19, 25, 45, 53, 67, 72, 78}	17.0 [4.2, 24.5] N = 7 ^{14, 15, 29, 38, 54, 61, 69}
Financial incentives	-13.3 N = 1 ³⁸	0.0 [-2.0, 2.5] N = 3 ^{11, 38, 61}	NA N = 0	4.2 [-1.1, 9.4] N = 2 ^{38, 61}

* For reference 25, nurses were given training about ageing, clinical aspects of hypertension, personal interviews, health behavior change models, process of negotiation, and ethical aspects of home visits.

† When N=2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 6b. Effect of quality improvement strategies on summary adherence outcomes

Type of QI	Median improvement in proportion of provider adherence to recommended practice [inter-quartile range] [†] N = number of comparisons	Median improvement in proportion of patient adherence [inter-quartile range] [†] N = number of comparisons
All comparisons	3.0 [1.0, 5.5] N = 10 ^{3, 4, 10, 20, 25, 26, 44, 58, 67, 69}	2.8 [1.9, 3.0] N = 5 ^{4, 8, 22, 45, 69}
Provider reminders	-1.3 [-2.0, 2.9] N = 3 ^{20, 25, 67}	NA N = 0
Facilitated relay of clinical data	2.0 [-0.4, 3.7] N = 7 ^{3, 10, 25, 26, 58, 67, 69}	2.4 [0.8, 5.0] N = 4 ^{8, 22, 45, 69}
Audit and feedback	2.7 [-0.4, 3.7] N = 7 ^{3, 25, 26, 44, 58, 67, 69}	-2.7 N = 1 ⁶⁹
Provider education	3.3 [0.7, 5.0] N = 7 ^{3, 4, 25, 26, 44, 67, 69}	0.2 [-2.7, 3.0] N = 2 ^{4, 69}
Patient education	0.4 [-1.3, 2.0] N = 2 ^{10, 25}	2.4 [1.9, 2.8] N = 2 ^{22, 45}
Promotion of self-management	NA N = 0	2.8 N = 1 ²²
Patient reminder	NA N = 0	NA N = 0
Organizational change	0.4 [-1.6, 3.3] N = 4 ^{10, 20, 25, 67}	6.8 [1.9, 11.6] N = 2 ^{8, 45}
Financial incentives	NA N = 0	NA N = 0

[†] When N=2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 7a. Effect of number of quality improvement strategies on blood pressure outcomes

Number of QI strategies employed in intervention	Median reduction in SBP (mmHg) [inter-quartile range]* N = Number of comparisons	Median reduction in DBP (mmHg) [inter-quartile range]* N = Number of comparisons	Median increase in proportion of patients in target SBP range [inter-quartile range]* N = Number of comparisons	Median increase in proportion of patients in target DBP range [inter-quartile range]* N = Number of comparisons
Single QI strategy	10.9 [4.9, 17.6] N = 6 ^{4, 53, 57, 64, 74, 82}	4.8 [2.5, 10.2] N = 7 ^{4, 34, 53, 57, 64, 74, 82}	23.1 [13.8, 32.4] N = 2 ^{4, 53}	14.6 [5.0, 24.2] N = 2 ^{4, 74}
Two QI strategies	1.5 [1.0, 4.7] N = 7 ^{1, 18, 27, 42, 43, 51, 60}	0.3 [-0.3, 2.1] N = 10 ^{1, 11, 18, 27, 42, 43, 51, 60, 63, 66}	31.5 [23.4, 38.5] N = 4 ^{8, 16, 19, 78}	7.0 [6.0, 12.0] N = 3 ^{58, 60, 79}
Three QI strategies	3.8 [2.0, 10.1] N = 9 ^{10, 14, 21, 22, 40, 41, 45, 65, 68}	0.7 [-1.0, 5.0] N = 13 ^{7, 10, 14, 21, 22, 26, 40, 41, 45, 52, 65, 68, 76}	13.4 [9.7, 31.6] N = 5 ^{12, 14, 21, 45, 72}	2.0 [1.1, 19.0] N = 9 ^{7, 14, 15, 21, 26, 29, 54, 68, 69}
Four QI strategies	9.2 [4.2, 13.4] N = 10 ^{9, 13, 17, 23, 24, 28, 30, 55, 62, 73}	3.7 [1.1, 8.0] N = 11 ^{9, 13, 17, 23, 24, 28, 30, 55, 61, 62, 73}	12.0 N = 1 ¹³	-1.1 N = 1 ⁶¹
Five QI strategies	-13.3 N = 1 ³⁸	-0.6 [-2.2, 1.1] N = 2 ^{35, 38}	-5.7 N = 1 ⁶⁷	9.4 N = 1 ³⁸
Six QI strategies	NA N = 0	NA N = 0	-1.4 N = 1 ²⁵	NA N = 0
All comparisons	4.5 [1.5, 11.0] N = 33 ^{1, 4, 9, 10, 13, 14, 17, 18, 21-24, 27, 28, 30, 38, 40-43, 45, 51, 53, 55, 57, 60, 62, 64, 65, 68, 73, 74, 82}	2.1 [-0.2, 5.0] N = 43 ^{1, 4, 7, 9-11, 13, 14, 17, 18, 21-24, 26-28, 30, 34, 35, 38, 40-43, 45, 51-53, 55, 57, 60-66, 68, 73, 74, 76, 82}	16.2 [10.3, 32.2] N = 14 ^{4, 8, 12-14, 16, 19, 21, 25, 45, 53, 67, 72, 78}	6.0 [1.5, 17.5] N = 16 ^{4, 7, 14, 15, 21, 26, 29, 38, 54, 58, 60, 61, 68, 69, 74, 79}

* When N=2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 7b. Effect of number of quality improvement strategies on summary adherence outcomes

Number of QI strategies employed in intervention	Median improvement in proportion of provider adherence to recommended practice [inter-quartile range]* N = Number of comparisons	Median improvement in proportion of patient adherence [inter-quartile range]* N = Number of comparisons
Single QI strategy	6.7 N = 1 ⁴	3.0 N = 1 ⁴
Two QI strategies	2.7 [1.6, 4.8] N = 3 ^{20, 44, 58}	11.6 N = 1 ⁸
Three QI strategies	3.7 [3.0, 4.5] N = 4 ^{3, 10, 26, 69}	1.9 [-0.38, 2.35] N = 3 ^{22, 45, 69}
Four QI strategies	NA N = 0	NA N = 0
Five QI strategies	-2.6 N = 1 ⁶⁷	NA N = 0
Six QI strategies	-1.3 N = 1 ²⁵	NA N = 0
All comparisons	3.0 [1.0, 5.5] N = 10 ^{3, 4, 10, 20, 25, 26, 44, 58, 67, 69}	2.8 [1.9, 3.0] N = 5 ^{4, 8, 22, 45, 69}

* When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 8a. Effect of specific quality improvement sub-strategies on blood pressure outcomes

Type of QI Sub-Strategy	Median reduction in SBP (mmHg) [inter-quartile range]* N = number of comparisons	Median reduction in DBP (mmHg) [inter-quartile range]* N = number of comparisons	Median increase in proportion of patients achieving SBP in a certain range [inter-quartile range] N = number of comparisons	Median increase in proportion of patients achieving DBP in a certain range [inter-quartile range] N = number of comparisons
Provider education	2.7 [1.1, 6.0] N = 10 ^{4, 13, 18, 21, 24, 27, 43, 51, 68, 74}	0.7 [-0.3, 3.3] N = 13 ^{4, 13, 18, 21, 24, 26, 27, 43, 51, 63, 66, 68, 74}	10.9 [1.4, 13.1] N = 5 ^{4, 12, 13, 21, 25, 67}	3.5 [1.7, 11.3] N = 6 ^{4, 21, 26, 68, 69, 74}
CME [†]	2.9 [1.4, 5.3] N = 8 ^{10, 13, 21, 27, 43, 64, 68, 74}	0.0 [-1.0, 0.8] N = 11 ^{10, 13, 21, 26, 27, 43, 63, 64, 66, 68, 74}	12.7 [11.4, 14.7] N = 4 ^{8, 12, 13, 21}	2.0 [1.6, 5.0] N = 5 ^{21, 26, 68, 69, 74}
Educational outreach	3.8 N = 1 ²¹	2.2 [0.7, 3.8] N = 2 ^{21, 26}	-1.4 [-3.6, 6.0] N = 3 ^{21, 25, 67}	1.6 [0.6, 7.5] N = 3 ^{21, 26, 69}
Distribution of printed materials	1.7 [-0.2, 3.4] N = 6 ^{18, 21, 27, 51, 68, 74}	0.7 [0.3, 1.6] N = 7 ^{18, 21, 26, 27, 51, 68, 74}	4.2 [-2.5, 10.6] N = 4 ^{12, 21, 25, 67}	2.0 [1.6, 5.0] N = 5 ^{21, 26, 68, 69, 74}
Organizational change	10.1 [3.9, 14.0] N = 19 ^{1, 9, 10, 13, 14, 17, 23, 24, 28, 38, 40, 41, 45, 53, 57, 62, 65, 73, 82}	4.4 [-0.5, 6.9] N = 23 ^{1, 9-11, 13, 14, 17, 23, 24, 28, 34, 35, 38, 40, 41, 45, 53, 57, 61, 62, 65, 73, 82}	21.8 [9.0, 33.8] N = 12 ^{8, 12-14, 16, 19, 25, 45, 53, 67, 72, 78}	17.0 [4.2, 24.5] N = 7 ^{14, 15, 29, 38, 54, 61, 69}
Disease/Case management	14.1 [11.6, 16.4] N = 3 ^{13, 57, 82}	5.0 [1.4, 10.2] N = 7 ^{13, 34, 57, 61, 63, 66, 82}	4.2 [-2.5, 10.3] N = 4 ^{12, 13, 25, 67}	-1.1 N = 1 ⁶¹
Team/Staffing change	10.1 [3.9, 14.0] N = 19 ^{9, 10, 13, 14, 17, 23, 24, 28, 30, 38, 40, 41, 45, 53, 57, 62, 65, 73, 82}	3.7 [-0.8, 6.9] N = 23 ^{9, 10, 13, 14, 17, 23, 24, 28, 30, 34, 35, 38, 40, 41, 45, 53, 57, 62, 63, 65, 66, 73, 82}	21.8 [9.0, 33.8] N = 11 ^{8, 12-14, 16, 19, 25, 45, 53, 67, 72, 78}	19.0 [17.0, 30.0] N = 5 ^{14, 15, 29, 38, 79}
Telemedicine	3.4 [2.3, 4.5] N = 2 ^{40, 65}	-2.0 [-1.6, -2.4] N = 2 ^{40, 65}	NA N = 0	NA N = 0
Change in medical record system	3.4 [2.3, 4.5] N = 2 ^{40, 65}	-2.0 [-1.6, -2.4] N = 2 ^{40, 65}	-3.6 [-5.7, -1.4] N = 2 ^{25, 67}	-2.0 N = 1 ⁵⁴

* When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

† CME refers to traditional CME in the form of educational workshops or meetings.

Table 8b. Effect of specific quality improvement sub-strategies on summary adherence outcomes

Type of QI Sub-Strategy	Median improvement in proportion of provider adherence to recommended practice [inter-quartile range]* N = number of comparisons	Median improvement in proportion of patient adherence [inter-quartile range]* N = number of comparisons
Provider education	3.3 [0.7, 5.0] N = 7 ^{3, 4, 25, 26, 44, 67, 69}	0.2 [-2.7, 3.0] N = 2 ^{4, 69}
CME [†]	3.3 [2.7, 4.0] N = 5 ^{3, 10, 26, 44, 69}	4.5 [-2.7, 11.6] N = 2 ^{8, 69}
Educational outreach	3.0 [-0.3, 3.8] N = 6 ^{3, 25, 26, 44, 67, 69}	-2.66 N = 1 ⁶⁹
Distribution of printed materials	3.0 [-0.3, 3.8] N = 6 ^{3, 25, 26, 44, 67, 69}	-2.66 N = 1 ⁶⁹
Organizational change	0.4 [-1.6, 3.3] N = 3 ^{10, 20, 25, 67}	6.8 [1.9, 11.6] N = 2 ^{8, 45}
Disease/Case management	-2.0 [-2.6, -1.3] N = 2 ^{25, 67}	NA N = 0
Team/Staffing change	2.0 [-1.3, 3.3] N = 5 ^{3, 10, 20, 25, 67}	6.8 [1.9, 11.6] N = 2 ^{8, 45}
Telemedicine	NA N = 0	NA N = 0
Change in medical record system	-2.0 [-2.6, -1.3] N = 2 ^{25, 67}	NA N = 0

* When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

† CME refers to traditional CME in the form of educational workshops or meetings.

Table 9a. Effect of information systems on blood pressure outcomes*

Type of Information System	Median reduction in SBP (mmHg) [inter-quartile range] [†] N = number of comparisons	Median reduction in DBP (mmHg) [inter-quartile range] [†] N = number of comparisons	Median increase in proportion of patients achieving SBP in a certain range [inter-quartile range] [†] N = number of comparisons	Median increase in proportion of patients achieving DBP in a certain range [inter-quartile range] [†] N = number of comparisons
All information systems	2.2 [1.1, 4.2] N = 10 ^{13, 22, 24, 27, 40, 43, 60, 62, 65, 68}	0.6 [-1.3, 2.1] N = 11 ^{13, 22, 24, 26, 27, 40, 43, 60, 62, 65, 68}	-1.4 [-3.6, 5.3] N = 3 ^{13, 25, 67}	1.8 [0.1, 4.3] N = 6 ^{26, 54, 58, 60, 68, 69}
Identification of eligible participants using information systems	1.2 [1.0, 1.6] N = 4 ^{27, 43, 60, 68}	0.6 [0, 0.7] N = 5 ^{26, 27, 43, 60, 68}	NA N=0	2.0 [1.6, 5.0] N = 5 ^{26, 58, 60, 68, 69}
Reminders generated by existing clinical information system	2.3 [1.7, 3.4] N = 3 ^{40, 60, 65}	-1.6 [-2.0, 0.2] N = 3 ^{40, 60, 65}	-3.6 [-5.7, -1.4] N = 2 ^{25, 67}	6.0 [5.0, 7.0] N = 2 ^{58, 60}
Decision Support System	1.2 [1.0, 1.5] N = 2 ^{27, 43}	-0.7 [-2.0, 0.6] N = 2 ^{27, 43}	NA N = 0	NA N = 0
Audit data gathered from clinical information systems	1.5 [1.3, 1.8] N = 2 ^{60, 68}	1.0 [0.5, 1.5] N = 2 ^{60, 68}	NA N = 0	3.5 [1.0, 5.5] N = 4 ^{54, 58, 60, 68}

* Some subcategories of information systems strategies are not included in this table.

† When N=2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 9b. Effect of information systems on summary adherence outcomes*

Type of Information System	Median improvement in proportion of provider adherence to recommended practice [inter-quartile range] [†] N = number of comparisons	Median improvement in proportion of patient adherence [inter-quartile range] [†] N = number of comparisons
All Information Systems	2.7 [-0.4, 5.0] N = 7 ^{20, 25, 26, 44, 58, 67, 69}	0.07 [-2.66, 2.8] N = 2 ^{22, 69}
Identification of eligible participants using information systems	4.0 [2.3, 5.0] N = 3 ^{26, 58, 69}	-2.66 N = 1 ⁶⁹
Reminders generated by existing clinical information system	-1.3 [-2.0, -0.4] N = 3 ^{25, 58, 67}	NA N = 0
DSS	NA N = 0	NA N = 0
Audit data gathered from clinical information systems	1.7 [0.6, 2.7] N = 2 ^{44, 58}	NA N = 0

* Some subcategories of information systems strategies are not included in this table.

† When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 10a. Association of methodologic features* with decreased blood pressures

	Median reduction in SBP (mmHg) [inter-quartile range] [†] N = Number of comparisons		Median reduction in DBP (mmHg) [inter-quartile range] [†] N = Number of comparisons	
	Design feature present	Design feature absent	Design feature present	Design feature absent
RCT	6.8 [1.5, 13.0] N = 25 ^{1, 10, 13, 18, 22-24, 27, 28, 30, 38, 40-42, 45, 51, 53, 55, 57, 60, 62, 68, 73, 74, 82}	4.3 [3.1, 8.1] N = 8 ^{4, 9, 14, 17, 21, 43, 64, 65}	2.0 [0.0, 5.0] N = 33 ^{1, 7, 10, 11, 13, 18, 22-24, 26-28, 30, 34, 35, 38, 40-42, 45, 51-53, 55, 57, 60-62, 68, 73, 74, 76, 82}	2.7 [-0.9, 4.6] N = 10 ^{4, 9, 14, 17, 21, 43, 63-66}
Providers blinded	5.1 [3.3, 6.8] N = 2 ^{24, 51}	4.5 [1.3, 11.5] N = 31 ^{1, 4, 9, 10, 13, 14, 17, 18, 21-23, 27, 28, 30, 38, 40-43, 45, 53, 55, 57, 60, 62, 64, 65, 68, 73, 74, 82}	2.9 [2.1, 3.7] N = 2 ^{24, 51}	2.0 [-0.3, 5.0] N = 41 ^{1, 4, 7, 9-11, 13, 14, 17, 18, 21-23, 27, 28, 30, 34, 35, 38, 40-43, 45, 52, 53, 55, 57, 60-66, 68, 73, 74, 76, 82}
Patients blinded	6.8 [1.5, 7.3] N = 7 ^{4, 9, 30, 51, 60, 68, 74}	4.3 [1.7, 12.5] N = 26 ^{1, 10, 13, 14, 17, 18, 21-24, 27, 28, 38, 40-43, 45, 53, 55, 57, 62, 64, 65, 73, 82}	1.5 [0.7, 2.8] N = 8 ^{4, 9, 26, 30, 51, 60, 68, 74}	2.1 [-0.8, 5.0] N = 35 ^{1, 7, 10, 11, 13, 14, 17, 18, 21-24, 27, 28, 34, 35, 38, 40-43, 45, 52, 53, 55, 57, 61-66, 73, 76, 82}
Unit of analysis same as unit of allocation	7.1 [2.6, 13.9] N = 21 ^{1, 9, 10, 14, 22-24, 28, 30, 38, 40-42, 45, 53, 55, 57, 62, 65, 73, 82}	2.9 [1.0, 7.0] N = 12 ^{4, 13, 17, 18, 21, 27, 43, 51, 60, 64, 68, 74}	3.7 [0.0, 6.7] N = 29 ^{1, 7, 9-11, 14, 22-24, 26, 28, 30, 34, 35, 38, 40-42, 45, 52, 53, 55, 57, 61, 62, 65, 73, 76, 82}	0.8 [-0.5, 2.1] N = 14 ^{4, 13, 17, 18, 21, 27, 43, 51, 60, 63, 64, 66, 68, 74}
Concealment allocation	3.8 [1.5, 9.6] N = 11 ^{13, 21, 24, 41, 43, 60, 62, 64, 68, 73, 74}	6.8 [1.7, 11.8] N = 22 ^{1, 4, 9, 10, 14, 17, 18, 22, 23, 27, 28, 30, 38, 40, 42, 45, 51, 53, 55, 57, 65, 82}	1.5 [0.0, 4.7] N = 14 ^{11, 13, 21, 24, 26, 41, 43, 60-62, 64, 68, 73, 74}	2.1 [-0.3, 5.0] N = 29 ^{1, 4, 7, 9, 10, 14, 17, 18, 22, 23, 27, 28, 30, 34, 35, 38, 40, 42, 45, 51-53, 55, 57, 63, 65, 66, 76, 82}
Total (i.e., irrespective of design feature presence or absence)	4.5 [1.5, 11.0] N = 33 ^{1, 4, 9, 10, 13, 14, 17, 18, 21-24, 27, 28, 30, 38, 40-43, 45, 51, 53, 55, 57, 60, 62, 64, 65, 68, 73, 74, 82}		2.1 [-0.2, 5.0] N = 43 ^{1, 4, 7, 9-11, 13, 14, 17, 18, 21-24, 26-28, 30, 34, 35, 38, 40-43, 45, 51-53, 55, 57, 60-66, 68, 73, 74, 76, 82}	

* In this table, all design features whose presence was judged as “unclear” were coded as absent.

† When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 10b. Association of methodologic features* with increased percentage of patients in blood pressure target range

	Median increase in proportion of patients in target SBP range [inter-quartile range] [†] N = Number of comparisons		Median increase in proportion of patients in target DBP range [inter-quartile range] [†] N = Number of comparisons	
	Design feature present	Design feature absent	Design feature present	Design feature absent
RCT	28.3 [10.3, 36.6] N = 10 ^{12, 13, 16, 19, 25, 45, 53, 67, 72, 78}	13.6 [11.8, 15.0] N = 4 ^{4, 8, 14, 21}	3.5 [1.2, 8.8] N = 10 ^{7, 15, 26, 38, 60, 61, 68, 69, 74, 79}	16.2 [7.1, 22.9] N = 6 ^{4, 14, 21, 29, 54, 58}
Providers blinded	NA N = 0	16.2 [10.3, 32.2] N = 14 ^{4, 8, 12-14, 16, 19, 21, 25, 45, 53, 67, 72, 78}	NA N = 0	6.0 [1.5, 17.5] N = 16 ^{4, 7, 14, 15, 21, 26, 29, 38, 54, 58, 60, 61, 68, 69, 74, 79}
Patients blinded	-1.4 [-3.6, 6.3] N = 3 ^{4, 25, 67}	25.0 [12.7, 35.2] N = 11 ^{8, 12-14, 16, 19, 21, 45, 53, 72, 78}	5.0 [1.8, 6.0] N = 7 ^{4, 25, 58, 60, 68, 69, 74}	13.4 [1.1, 19.0] N = 9 ^{7, 14, 15, 21, 29, 38, 54, 61, 79}
Unit of analysis same as unit of allocation	20.7 [9.0, 31.8] N = 4 ^{12, 14, 45, 53}	16.2 [12.4, 34.8] N = 10 ^{4, 8, 13, 16, 19, 21, 25, 67, 72, 78}	9.4 [1.1, 19.0] N = 9 ^{7, 14, 15, 26, 29, 38, 61, 69, 79}	5.0 [3.5, 10.2] N = 7 ^{4, 21, 54, 58, 60, 68, 74}
Concealment allocation	13.4 [9.7, 38.0] N = 9 ^{12, 13, 16, 19, 21, 25, 67, 72, 78}	18.6 [13.8, 31.6] N = 5 ^{4, 8, 14, 45, 53}	5.0 [1.6, 13.4] N = 9 ^{15, 21, 26, 60, 61, 68, 69, 74, 79}	9.4 [3.1, 21.6] N = 7 ^{4, 7, 14, 29, 38, 54, 58}
Total (i.e., irrespective of design feature presence or absence)	16.2 [10.3, 32.2] N = 14 ^{4, 8, 12-14, 16, 19, 21, 25, 45, 53, 67, 72, 78}		6.0 [1.5, 17.5] N = 16 ^{4, 7, 14, 15, 21, 26, 29, 38, 54, 58, 60, 61, 68, 69, 74, 79}	

* In this table, all design features whose presence was judged as “unclear” were coded as absent.

† When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 10c. Association of methodologic features* with summary adherence outcomes

	Median improvement in proportion of provider adherence to recommended practice [inter-quartile range] [†] N = Number of comparisons		Median improvement in proportion of patient adherence [inter-quartile range] [†] N = Number of comparisons	
	Design feature present	Design feature absent	Design feature present	Design feature absent
RCT	2.3 [-0.5, 3.7] N = 6 ^{10, 25, 26, 44, 67, 69}	5.0 [2.6, 6.8] N = 4 ^{3, 4, 20, 58}	1.90 [-0.38, 2.35] N = 3 ^{22, 45, 69}	7.3 [5.15, 9.45] N = 2 ^{4, 8}
Providers blinded	NA N = 0	3.0 [1.0, 5.5] N = 10 ^{3, 4, 10, 20, 25, 26, 44, 58, 67, 69}	NA N = 0	2.8 [1.9, 3.0] N = 5 ^{4, 8, 22, 45, 69}
Patients blinded	3.3 [0.6, 6.0] N = 9 ^{3, 4, 20, 25, 26, 44, 58, 67, 69}	2.0 N = 1 ¹⁰	0.17 [-1.25, 1.59] N = 2 ^{4, 69}	2.8 [2.35, 7.2] N = 3 ^{8, 22, 45}
Unit of analysis same as unit of allocation	4.0 [3.0, 5.0] N = 3 ^{10, 26, 69}	2.7 [-0.4, 5.0] N = 7 ^{3, 4, 20, 25, 44, 58, 67}	1.9 [-0.38, 2.35] N = 3 ^{22, 45, 69}	7.3 [5.15, 9.45] N = 2 ^{4, 8}
Concealment allocation	3.3 [-1.3, 4.0] N = 5 ^{3, 25, 26, 67, 69}	2.7 [2.0, 6.7] N = 5 ^{4, 10, 20, 44, 58}	-2.66 N = 1 ⁶⁹	2.9 [2.58, 5.15] N = 4 ^{4, 8, 22, 45}
Total (i.e., irrespective of design feature presence or absence)	3.0 [1.0, 5.5] N = 10 ^{3, 4, 10, 20, 25, 26, 44, 58, 67, 69}		2.8 [1.9, 3.0] N = 5 ^{4, 8, 22, 45, 69}	

* In this table, all design features whose presence was judged as “unclear” were coded as absent.

[†] When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 11. Comparison of study design by quality improvement strategy on blood pressure outcomes

	Median Reduction in SBP (mmHg) [inter-quartile range*] N = Number of comparisons			Median Improvement in DBP (mmHg) [inter-quartile range*] N = Number of comparisons		
	All Comparisons	RCT	Non-RCT [†]	All Comparisons	RCT	Non-RCT [†]
All QI types	4.5 [1.5, 11.0] N = 33	6.8 [1.5, 13.0] N = 25	4.3 [3.1, 8.1] N = 8	2.1 [-0.2, 5.0] N = 43	2.0 [0.0, 5.0] N = 33	2.7 [-0.9, 4.6] N = 10
Provider education	2.7 [1.1, 6.0] N = 10	2.0 [0.3, 5.1] N = 7	3.8 [2.4, 5.8] N = 3	0.7 [-0.3, 3.3] N = 13	0.6 [0.1, 1.3] N = 8	3.3 [-0.6, 3.8] N = 5
No provider education	8.2 [2.8, 13.7] N = 22	10.1 [2.6, 14.1] N = 17	4.5 [4.0, 9.3] N = 5	2.5 [-0.1, 6.4] N = 30	2.8 [0.0, 6.7] N = 25	2.1 [-1.0, 5.0] N = 5
Provider reminders	6.8 [3.0, 9.4] N = 3	3.0 [-0.8, 6.8] N = 2	12.0 N = 1	2.1 [0.9, 6.6] N = 3	0.9 [-0.3, 2.1] N = 2	11.0 N = 1
No provider reminders	4.3 [1.6, 10.8] N = 30	6.9 [1.8, 13.5] N = 23	4.0 [2.4, 6.1] N = 7	2.1 [-0.2, 5.0] N = 40	2.0 [0.0, 5.3] N = 31	2.1 [-1.0, 3.8] N = 9
Facilitated relay	5.7 [2.4, 11.8] N = 18	6.9 [2.3, 13.0] N = 13	4.5 [4.0, 9.3] N = 5	1.1 [-1.0, 3.4] N = 20	1.6 [-0.1, 3.9] N = 15	-1.0 [-1.6, 2.1] N = 5
No facilitated relay	3.8 [-0.9, 8.9] N = 15	5.1 [-0.8, 11.1] N = 12	3.8 [1.4, 5.8] N = 3	3.7 [0.2, 5.0] N = 23	2.9 [0.1, 5.5] N = 18	3.8 [3.3, 4.8] N = 5
Patient education	8.1 [3.3, 11.8] N = 18	8.1 [3.3, 12.5] N = 14	6.6 [2.6, 10.0] N = 4	3.3 [0.4, 5.0] N = 25	2.8 [-0.3, 5.9] N = 19	3.5 [2.4, 4.7] N = 6
No patient education	2.6 [1.2, 7.3] N = 15	2.3 [1.2, 10.5] N = 11	4.3 [3.3, 5.3] N = 4	0.6 [-0.3, 3.5] N = 18	0.8 [0.0, 3.5] N = 14	-1.3 [-1.7, 0.5] N = 4
Self-management	3.6 [2.1, 9.5] N = 12	3.3 [1.0, 9.3] N = 10	6.6 [3.8, 9.3] N = 2	2.1 [0.4, 5.0] N = 17	2.1 [0.1, 5.9] N = 15	2.9 [2.1, 3.8] N = 2
No self-management	6.8 [1.5, 12.0] N = 21	7.1 [1.7, 13.6] N = 15	4.3 [1.8, 6.9] N = 6	1.5 [-0.5, 5.0] N = 26	1.5 [0.0, 4.9] N = 18	1.3 [-1.2, 4.9] N = 8
Patient reminders	2.8 [-1.5, 5.1] N = 8	2.8 [-1.7, 6.0] N = 6	1.8 [-1.0, 4.5] N = 2	0.5 [-2.1, 3.4] N = 12	0.5 [-2.3, 2.5] N = 10	1.7 [-1.6, 5.0] N = 2
No patient reminders	7.1 [2.0, 12.0] N = 25	7.1 [1.7, 13.5] N = 19	5.9 [3.9, 8.9] N = 6	2.1 [0.0, 5.0] N = 31	2.1 [0.3, 5.3] N = 23	2.7 [-0.7, 4.1] N = 8
Audit and feedback	1.5 [1.3, 1.8] N = 3	1.5 [1.3, 1.8] N = 3	---- ---- N = 0	0.5 [0.5, 1.0] N = 4	0.5 [0.5, 1.0] N = 4	---- ---- N = 0

Table 11. Comparison of study design by quality improvement strategy on blood pressure outcomes (continued)

No audit and feedback	6.9 [2.4, 11.8] N = 30	7.0 [2.4, 13.7] N = 22	4.3 [3.1, 8.1] N = 8	2.1 [-0.5, 5.0] N = 39	2.1 [-0.1, 5.6] N = 29	2.7 [-0.9, 4.6] N = 10
Organizational change	10.1 [3.9, 14.0] N = 19	11.0 [5.2, 16.2] N = 15	6.9 [3.1, 10.0] N = 4	4.4 [-0.5, 6.9] N = 23	4.4 [-0.5, 6.9] N = 19	3.6 [1.2, 6.5] N = 4
No organizational change	2.3 [1.0, 4.0] N = 14	1.8 [0.6, 3.1] N = 10	3.9 [3.1, 4.9] N = 4	0.6 [-0.2, 2.1] N = 20	0.6 [0.1, 1.9] N = 14	1.4 [-0.9, 3.7] N = 6
Financial incentives	-13.3 N = 1	-13.3 N = 1	---- ---- ----	0.0 [-2.0, 2.5] N = 3	0.0 [-2.0, 2.5] N = 3	---- ---- N = 0
No financial incentives	5.6 [1.9, 11.3] N = 32	6.8 [1.9, 13.2] N = 24	4.3 [3.1, 8.1] N = 8	2.1 [-0.2, 5.0] N = 40	2.1 [0.1, 5.5] N = 30	2.7 [-0.9, 4.6] N = 10
Information systems	2.2 [1.1, 4.2] N = 10	2.2 [1.4, 4.7] N = 8	2.8 [1.9, 3.6] N = 2	0.6 [-1.3, 2.1] N = 11	0.7 [0.0, 2.1] N = 9	-1.8 [-1.6, -2.0] N = 2
No information systems	7.1 [3.0, 12.5] N = 23	7.1 [2.6, 13.9] N = 17	5.9 [3.9, 8.9] N = 6	3.0 [0.0, 5.2] N = 32	2.5 [0.0, 5.9] N = 24	3.5 [1.4, 4.9] N = 8

* When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

† Includes 6 publications (with 7 comparisons) that are quasi-RCTs^{3, 8, 9, 17, 43, 58, 64} and 9 publications (with 11 comparisons) that are controlled before-after studies.^{2, 4, 14, 20, 21, 29, 36, 54, 63, 65, 66}

Table 12a. Association of study size with systolic blood pressure outcomes

	Median Reduction in SBP (mmHg) [inter-quartile range]* N = Number of comparisons				
	All Comparisons	Comparisons with sample size in lowest quartile	Comparisons with sample size in lower 2 quartiles	Comparisons with sample size in upper 2 quartiles	Comparisons with sample size in highest quartile
All QI types	4.5 [1.5, 11.0] N = 33	14.0 [12.3, 19.2] N = 8	11.1 [5.7, 15.2] N = 16	3.3 [1.0, 4.5] N = 17	3.3 [2.3, 4.5] N = 9
Provider education	2.7 [1.1, 6.0] N = 10	9.0 N = 1	2.0 [0.5, 5.5] N = 3	3.3 [1.2, 5.3] N = 7	3.6 [2.9, 4.8] N = 4
No provider education	7.1 [2.5, 13.5] N = 23	14.1 [13.5, 19.8] N = 7	13.0 [9.3, 18.3] N = 13	3.0 [0.9, 4.4] N = 10	3.3 [2.3, 4.5] N = 5
Provider reminders	6.8 [3.0, 9.4] N = 3	---- ---- N = 0	12.0 N = 1	3.0 [-0.8, 6.8] N = 2	---- ---- N = 0
No provider reminders	4.3 [1.6, 10.8] N = 30	14.0 [12.3, 19.2] N = 8	10.1 [4.5, 16.2] N = 15	3.3 [1.3, 4.3] N = 15	3.3 [2.3, 4.5] N = 9
Facilitated relay	5.7 [2.4, 11.8] N = 18	13.5 [12.0, 16.8] N = 4	10.7 [7.4, 13.7] N = 10	3.0 [2.0, 4.1] N = 8	3.3 [2.8, 3.9] N = 3
No facilitated relay	3.8 [-0.9, 8.9] N = 15	16.4 [13.1, 19.2] N = 4	12.1 [1.8, 17.5] N = 6	3.3 [-0.8, 6.8] N = 9	3.6 [1.9, 6.3] N = 6
Patient education	8.1 [3.3, 11.8] N = 18	13.0 [10.1, 13.9] N = 5	11.1 [9.1, 13.7] N = 10	3.3 [0.1, 4.6] N = 8	3.3 [3.3, 3.8] N = 5
No patient education	2.6 [1.2, 7.3] N = 15	18.6 [16.4, 19.8] N = 3	8.1 [1.3, 17.5] N = 6	2.6 [1.5, 4.5] N = 9	3.4 [2.1, 5.3] N = 4
Self-management	3.6 [2.1, 9.5] N = 12	13.9 [12.0, 19.8] N = 3	9.7 [7.5, 13.0] N = 6	3.0 [1.0, 3.3] N = 6	3.3 [3.3, 3.6] N = 3
No self-management	6.8 [1.5, 12.0] N = 21	14.1 [13.0, 18.6] N = 5	12.5 [3.8, 17.3] N = 10	4.0 [1.2, 7.0] N = 11	3.4 [1.7, 6.5] N = 6
Patient reminders	2.8 [-1.5, 5.1] N = 8	---- ---- N = 0	6.9 [-3.2, 12.6] N = 3	2.3 [-1.0, 3.3] N = 5	2.8 [1.5, 3.6] N = 4
No patient reminders	7.1 [2.0, 12.0] N = 25	14.0 [12.3, 19.2] N = 8	12.0 [9.0, 14.1] N = 13	3.6 [1.4, 6.9] N = 12	3.8 [3.3, 7.1] N = 5

Table 12a. Association of study size with systolic blood pressure outcomes (continued)

Audit and feedback	1.5 [1.3, 1.8] N = 3	---- ---- N = 0	1.5 [1.0, 2.0] N = 2	1.5 N = 1	1.5 N = 1
No audit and feedback	6.9 [2.4, 11.8] N = 30	14.0 [12.3, 19.2] N = 8	12.5 [9.1, 17.3] N = 14	3.3 [0.9, 5.1] N = 16	3.6 [3.1, 5.2] N = 8
Organizational change	10.1 [3.9, 14.0] N = 19	14.0 [12.3, 19.2] N = 8	13.5 [9.9, 18.4] N = 12	3.3 [0.7, 5.8] N = 7	3.3 [2.3, 4.5] N = 5
No organizational change	2.3 [1.0, 4.0] N = 14	---- ---- N = 0	1.5 [0.5, 3.2] N = 4	3.0 [1.1, 4.0] N = 10	3.6 [2.9, 4.8] N = 4
Financial incentives	-13.3 N = 1	---- ---- N = 0	-13.3 N = 1	---- ---- N = 0	---- ---- N = 0
No financial incentives	5.6 [1.9, 11.3] N = 32	14.0 [12.3, 19.2] N = 8	12.0 [8.0, 16.2] N = 15	3.3 [1.0, 4.5] N = 17	3.3 [2.3, 4.5] N = 9
Information systems	2.2 [1.1, 4.2] N=10	17.3 [9.0, 25.7] N=2	5.5 [1.8, 13.2] N=4	1.9 [1.1, 3.1] N=6	2.8 [2.1, 3.6] N=4
No information systems	7.1 [3.0, 12.5] N=23	14.0 [13.2, 17.5] N=6	12.5 [8.7, 15.2] N=12	3.8 [0.9, 7.0] N=11	3.8 [3.3, 7.1] N=5

* When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table 12b. Association of study size with diastolic blood pressure outcomes

	Median Reduction in DBP (mmHg) [inter-quartile range]* N = Number of comparisons				
	All Comparisons	Comparisons with sample size in lowest quartile	Comparisons with sample size in lower 2 quartiles	Comparisons with sample size in upper 2 quartiles	Comparisons with sample size in highest quartile
All QI types	2.1 [-0.2, 5.0] N = 43	5.0 [1.4, 10.7] N = 11	2.1 [0.0, 7.0] N = 21	1.9 [-0.9, 3.8] N = 22	3.3 [-0.3, 4.1] N = 11
Provider education	0.7 [-0.3, 3.3] N = 13	-0.2 [-0.6, 0.3] N = 2	0.3 [-0.3, 0.8] N = 4	2.1 [-0.3, 3.7] N = 9	3.5 [1.3, 3.8] N = 6
No provider education	2.5 [-0.1, 6.4] N = 30	6.7 [4.0, 12.5] N = 9	5.0 [0.6, 9.0] N = 17	1.6 [-1.0, 4.4] N = 13	0.0 [-1.6, 4.4] N = 5
Provider reminders	2.1 [0.9, 6.6] N = 3	----- ----- N = 0	11.0 N = 1	0.9 [-0.3, 2.1] N = 2	---- ---- N = 0
No provider reminders	2.1 [-0.2, 5.0] N = 40	5.0 [2.1, 10.7] N = 11	2.1 [0.3, 7.0] N = 20	1.9 [-1.0, 4.0] N = 20	3.3 [0.3, 4.1] N = 11
Facilitated relay	1.1 [-1.0, 3.4] N = 20	2.1 [1.3, 7.0] N = 7	2.0 [0.4, 7.5] N = 12	-1.0 [-1.7, 1.7] N = 8	-2.0 [-2.4, -1.6] N = 2
No facilitated relay	3.7 [0.2, 5.0] N = 23	10.8 [6.0, 15.5] N = 4	4.0 [0.4, 7.0] N = 9	3.5 [0.1, 4.7] N = 14	3.7 [0.6, 4.4] N = 9
Patient education	3.3 [0.4, 5.0] N = 25	5.9 [2.8, 8.4] N = 6	5.0 [0.4, 7.0] N = 13	3.0 [1.0, 4.0] N = 12	3.7 [3.4, 4.3] N = 6
No patient education	0.6 [-0.3, 3.5] N = 18	4.0 [2.0, 14.8] N = 5	1.5 [0.5, 6.7] N = 8	0.1 [-1.5, 1.8] N = 10	0.0 [-1.6, 0.6] N = 5
Self-management	2.1 [0.4, 5.0] N = 17	7.9 [5.6, 9.9] N = 4	1.3 [0.0, 6.9] N = 10	2.8 [1.8, 3.7] N = 7	3.8 [3.7, 4.4] N = 3
No self-management	1.5 [-0.5, 5.0] N = 26	4.0 [1.3, 9.9] N = 7	4.0 [0.8, 9.0] N = 11	0.0 [-1.0, 3.8] N = 15	0.3 [-0.9, 3.6] N = 8
Patient reminders	0.5 [-2.1, 3.4] N = 12	---- N = 0	0.5 [-2.8, 5.4] N = 6	0.0 [-1.9, 2.5] N = 6	-2.0 [-2.4, -1.6] N = 2
No patient reminders	2.1 [0.0, 5.0] N = 31	5.0 [2.0, 10.7] N = 11	4.0 [0.8, 10.0] N = 15	2.1 [-0.4, 4.0] N = 16	3.7 [0.6, 4.4] N = 9

Table 12b. Association of study size with diastolic blood pressure outcomes (continued)

Audit and feedback	0.6 [0.5, 1.0] N = 4	1.3 [0.7, 2.0] N = 2	0.7 [0.3, 1.3] N = 3	0.6 N = 1	0.6 N = 1
No audit and feedback	2.1 [-0.5, 5.0] N = 39	6.7 [4.0, 12.0] N = 9	4.5 [0.5, 8.5] N = 18	2.1 [-1.0, 3.8] N = 21	3.5 [-0.5, 4.3] N = 10
Organizational change	4.4 [-0.5, 6.9] N = 23	6.7 [4.0, 12.5] N = 9	6.9 [3.5, 11.4] N = 12	2.8 [-1.3, 4.7] N = 11	1.9 [-1.2, 4.2] N = 6
No organizational change	0.6 [-0.2, 2.1] N = 20	1.3 [0.7, 2.0] N = 2	0.6 [0.0, 1.0] N = 9	1.6 [-0.5, 2.7] N = 11	3.3 [0.6, 3.8] N = 5
Financial incentives	0.0 [-2.0, 2.5] N = 3	---- ---- N = 0	-3.9 N = 1	2.5 [0, 5.0] N = 2	2.5 [0, 5.0] N = 2
No financial incentives	2.1 [-0.2, 5.0] N = 40	5.0 [2.0, 10.7] N = 11	3.0 [0.5, 7.5] N = 20	1.8 [-1.0, 3.7] N = 20	3.3 [-0.6, 3.8] N = 9
Information systems	0.6 [-1.3, 2.1] N = 11	1.3 [0.3, 4.6] N = 4	0.7 [0.0, 2.0] N = 5	-0.5 [-1.9, 1.7] N = 6	-0.5 [-1.8, 1.4] N = 4
No information systems	3.0 [0.0, 5.2] N = 32	6.7 [4.5, 11.9] N = 7	4.5 [0.5, 7.5] N = 16	2.5 [-0.4, 4.5] N = 16	3.8 [1.6, 4.6] N = 7

* When N = 2, square brackets show the actual results of each study rather than interpolated inter-quartile range.

Table References

Note: Some articles are listed more than once because they report multiple comparisons. Article records were repeated and data for each comparison were abstracted into separate files. These references are noted as an “additional comparison.”

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