

A Multimethod Quality Improvement Intervention To Improve Preventive Cardiovascular Care

A Cluster Randomized Trial

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Background: Research is needed to validate effective and practical strategies for improving the provision of evidence-based medicine in primary care.

Objective: To determine whether a multimethod quality improvement intervention was more effective than a less intensive intervention for improving adherence to 21 quality indicators for primary and secondary prevention of cardiovascular disease and stroke.

Design: 2-year randomized, controlled clinical trial with the practice as the unit of randomization.

Setting: 20 community-based family or general internal medicine practices in 14 states. All used the same electronic medical record.

Participants: 44 physicians, 17 midlevel providers, and approximately 200 staff members; data from the electronic medical records of 87 291 patients.

Interventions: All practices received copies of practice guidelines and quarterly performance reports. Intervention practices also hosted quarterly site visits to help them adopt quality improvement approaches and participated in 2 network meetings to share "best practice" approaches.

Measurements: The percentage of indicators at or above pre-

defined targets and the percentage of patients who had achieved each clinical indicator.

Results: Intervention practices improved 22.4 percentage points (from 11.3% to 33.7%) in the percentage of indicators at or above the target; control practices improved 16.4 percentage points (from 6.3% to 22.7%). The 6.0–percentage point absolute difference between the intervention and control group was not statistically significant ($P > 0.2$). Patients in intervention practices had greater improvements than those in control practices for diagnoses of hypertension (improvement difference, 15.7 percentage points [95% CI, 5.2 to 26.3 percentage points]) and blood pressure control in patients with hypertension (improvement difference, 8.0 percentage points [CI, 0.0 to 16.0 percentage points]).

Limitations: The study involved a small number of practices and lacked a pure control group.

Conclusions: Primary care practices that use electronic medical records and receive regular performance reports can improve their adherence to clinical practice guidelines for cardiovascular disease and stroke prevention.

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Widespread evidence reveals inadequate implementation of evidence-based clinical practice guidelines for prevention and management of cardiovascular disease and stroke in primary care settings (1–3). Primary prevention deficiencies exist in the screening and management of dyslipidemia (4) and hypertension (5). Secondary prevention deficiencies include inadequate treatment of dyslipidemia in patients with coronary heart disease (CHD) (6) and inadequate use of antiplatelet therapy in patients with CHD or cerebrovascular disease (7), inadequate use of β -blockers after myocardial infarction (8), inadequate use of angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers in patients with heart failure (9), and inadequate use of oral anticoagulant therapy in patients with atrial fibrillation (10). Finally, patients with diabetes mellitus who are at high risk for cardiovascular disease as well as microvascular disease infrequently receive recommended screening and adequate treatment for elevated glycosylated hemoglobin levels, hypertension, and dyslipidemia (11).

Published systematic reviews point to the importance of multifaceted interventions in increasing adherence to practice guidelines and improving disease control (12, 13). Little is known, however, about the relative effectiveness of different implementation strategies. More research is needed to develop and validate effective, theoretically sound, and practical strategies for improving the provision of evidence-based medicine in primary care. Particularly important are studies that address multiple common, chronic conditions, which together reflect a large proportion of the work of primary care providers (14).

This study was designed as a pragmatic clinical trial (15), intended to assess whether a multimethod quality improvement intervention was more effective than a less intensive intervention for improving adherence to 21 quality indicators relevant to the primary and secondary prevention of cardiovascular disease and stroke. The multimethod quality improvement intervention added practice site visits (for academic detailing and quality improvement facilitation) and network meetings (for sharing best prac-

Context

Interventions to promote guideline-recommended care have met with limited success. Quality improvement experts believe that multicomponent interventions are more effective than simpler strategies, but this belief rests on limited evidence.

Contribution

In this randomized trial of 20 primary care practices, intervention practices received quarterly site visits and 2 network meetings about quality improvement in addition to copies of practice guidelines and quarterly performance reports. Intervention practices had greater improvement in providing guideline-recommended care for cardiovascular disease prevention and treatment than practices that received only the guidelines and performance reports.

Cautions

The study involved a small number of practices.

—The Editors

tices) to the approach of guideline dissemination and audit and feedback used in the less intensive intervention. The study was conducted in a practice-based research network (PPRNet) among users of a common electronic medical record (Practice Partner Patient Records, Seattle, Washington), which historically provided audit and feedback to its practice members. Audit and feedback have already been shown to improve the practice of health care professionals, particularly in prescribing and test ordering (16). Additional research is needed to assess the effect of audit and feedback in combination with other interventions.

METHODS**Design**

The design was a cluster randomized, controlled clinical trial, with the practice as the unit of randomization. Twenty-three office-based primary care practices in 15 states agreed to participate. The institutional review board at the Medical University of South Carolina approved the study.

Study Indicators

We derived the study indicators (Table 1) from published sources (17–22). Fourteen were process measures, which reflected whether recommended tests were done, appropriate diagnoses made, or appropriate medication prescribed. Seven were outcome measures, which reflected whether patients achieved recommended treatment goals. Some of the measures represented primary prevention, for example, screening for hypertension or dyslipidemia. Others represented secondary prevention, for example, reaching treatment goals for glycosylated hemoglobin levels, low-density lipoprotein (LDL) cholesterol levels, and blood

pressure in patients with diabetes. An additional indicator, hormone replacement therapy for postmenopausal women, was included at the beginning of the study but was withdrawn in July 2002 when the results from the Women's Health Initiative trial were published (23).

We determined practice performance for each study indicator at baseline and quarterly throughout the study. To determine performance, participating practices ran a computer program to extract patient activity during the previous quarter from their electronic medical record. To protect patient confidentiality, the extract program assigned a unique, anonymous numerical identifier to each patient. The extract program obtained demographic information, such as age, race, and sex; diagnoses; medications; laboratory data; and vital signs. Text of progress notes, consultation reports, and discharge summaries were not extracted. The data were copied to a diskette and mailed to PPRNet or sent electronically via a secure server. In the PPRNet offices, the data were bridged to standard data dictionaries and converted to SAS data sets (SAS Institute, Inc., Cary, North Carolina) on standard microcomputers for analyses.

Interventions

The intervention began on 1 January 2001 and was completed on 1 January 2003. During the first quarter of 2001, the medical director of each practice was sent printed copies of each practice guideline referenced in the study. Beginning in the first quarter of 2001, the medical director was sent quarterly performance reports documenting the practice's adherence to each of the 21 study indicators. Each report contained the practice's current performance, calculated as the percentage of eligible patients who had received the recommended service, the number of patients who were receiving the recommended medication, or the number of patients who had achieved the treatment goal. The report also presented data on the practice's previous performance since the beginning of the study and the performance target, calculated as the 90th percentile at baseline among all practices. In practices with more than 1 clinician, individual provider data were not given because the study emphasized improvement at the practice level. The medical director was encouraged to share the reports with others in the practice in order to stimulate motivation for improvement. The 90th percentile was selected as the performance target because it reflected a bold but achievable goal (at least 2 practices were at this level of performance at baseline). Practices in the control group received no other interventions during the study. An example of 1 page of a practice report is available in the Appendix Figure (available at www.annals.org).

Practices in the intervention group also participated in practice site visits and network meetings. Six or seven 1- or 2-day site visits were held at each practice approximately every 3 months during 2001 and 2002. The practice site visit was led by 1 of the physician coauthors, assisted dur-

ing the first few visits in 2001 by a clinical pharmacist with expertise in academic detailing (24), and at later visits by other coauthors with expertise in quality improvement. Initial site visits focused on engaging clinicians and staff members in the project, through a formal presentation by the site visitors and group discussion with all members of the practice team, including providers, nurses, medical assistants, and reception and administrative personnel. Because of vacation or hospital coverage responsibilities, 1 or 2 providers were occasionally absent in the multiprovider practices, and 1 practice involved only a few members of their staff. We placed detailed attention on the scientific justification for the chosen study indicators and on published frameworks for clinician behavior change (25, 26). Baseline practice performance on each study indicator was discussed, and previous evidence of the ability of PPRNet practices to improve care was presented (27). Practices were encouraged to increase the use of quality improvement tools available in the electronic medical record, such as note templates with embedded practice guidelines, query functions, prompts, reminders, and messaging. At each visit, a participatory planning session was held in which practice members identified specific clinical indicators they wished to work on and improvement activities to conduct before the next site visit. Lessons from complexity theory were used in this exercise—the influence of each practice member on the system, the importance of replicating successful approaches and focusing on motivators for patients and staff, and the notion that simple changes are easiest to adopt and can have profound effects. In subsequent site visits, we focused on discussing the practice's success in adopting its planned improvement activities, presenting updated performance data, and planning additional practice-level interventions. The site visitors presented results from recently published studies relevant to the study indicators. Successful and unsuccessful approaches to improvement by other intervention sites were also presented.

Two-day network meetings were held in Charleston, South Carolina, in May 2001 and May 2002. The lead clinician from each intervention practice and the research team attended the first meeting. At this meeting, “best practice” presentations were made by 5 participating clinicians whose practices were performing well on specific indicators relative to other practices. Clinicians and clinical and administrative staff from each practice attended the second network meeting. This meeting provided an opportunity for clinicians and nonclinicians to interact with peers from other practices and share “best practice” approaches.

Outcomes

The primary practice-level outcome was the percentage of performance targets achieved. The primary patient-level outcome was the percentage of patients for whom the recommended process measures had occurred or the recommended outcome measure had been achieved.

Table 1. Study Indicators*

Condition (References)	Measures
Hypertension (17)	<p>Process measures</p> <ul style="list-style-type: none"> BP measurement in previous 12 mo Diagnosis of hypertension for 3 BP measurements $\geq 140/90$ mm Hg in previous 12 mo BP measurement in previous 3 mo for patients with diagnosis of hypertension <p>Outcome measures</p> <ul style="list-style-type: none"> Most recent BP measurement $< 140/90$ mm Hg for all patients Most recent BP measurement $< 140/90$ mm Hg for patients with diagnosis of hypertension
Hyperlipidemia (general population screening) (18)	<p>Process measures</p> <ul style="list-style-type: none"> Measurement of total cholesterol level in previous 60 mo Measurement of HDL cholesterol level in previous 60 mo
Coronary heart disease (17–19)	<p>Process measures</p> <ul style="list-style-type: none"> Measurement of LDL cholesterol level in previous 12 mo Recorded diagnosis of hyperlipidemia for LDL cholesterol level > 3.37 mmol/L (> 130 mg/dL) Medication for hyperlipidemia for LDL cholesterol level > 3.37 mmol/L (> 130 mg/dL) Prescription for β-blocker in patients with history of myocardial infarction <p>Outcome measures</p> <ul style="list-style-type: none"> Most recent LDL cholesterol level < 2.59 mmol/L (< 100 mg/dL) Most recent BP measurement $< 140/90$ mm Hg
Heart failure (20)	<p>Process measure</p> <ul style="list-style-type: none"> Prescription for angiotensin-converting enzyme inhibitor or angiotensin-receptor blocker
Atrial fibrillation (21)	<p>Process measure</p> <ul style="list-style-type: none"> Prescription for oral anticoagulant
Diabetes mellitus (22)	<p>Process measures</p> <ul style="list-style-type: none"> Measurement of HbA_{1c} in previous 12 mo Measurement of LDL cholesterol level in previous 24 mo BP measurement in previous 3 mo <p>Outcome measures</p> <ul style="list-style-type: none"> Most recent HbA_{1c} level $< 7\%$ Most recent LDL cholesterol level < 2.59 mmol/L (< 100 mg/dL) Most recent BP measurement $< 130/85$ mm Hg

* BP = blood pressure; HbA_{1c} = hemoglobin A_{1c}; HDL = high-density lipoprotein; LDL = low-density lipoprotein.

Sample Size

The original sample size of 23 practices was chosen on the basis of feasibility in PPRNet at the time and budget constraints. It provided greater than 75% (range, 78% to 99%) statistical power to detect improvements in all of the 7 primary patient-level outcome indicators over time to performance targets and 70% or greater power (range,

71% to 99%) to detect similar improvement in 13 of the 15 process indicators. The power to detect improvement in the remaining 2 process indicators was 51% or lower. The sample size estimation, which assumed 2-sided hypothesis testing ($\alpha = 0.05$) and that complete data would be available from all 20 practices, used the Donner and Klar method of calculating the intraclass correlation coefficient for binary outcomes (28) and the Murray sample size estimation formula for cluster randomized trials (29). Using this approach allowed us to account for the cluster randomization scheme. The power to detect differences in improvement in practice-level outcomes over the course of the study was low (62%) given the relatively small number of practices enrolled. This estimate was based on an assumption that intervention practices would improve from 10% to 50% in the percentage of targets reached and that control practices would improve from 10% to 20% in the percentage of targets reached.

Randomization

We used a baseline adaptive randomization scheme to allocate practices to an intervention or control group (30). This method ensured that the practices would be as balanced as possible across 3 characteristics that a priori were thought to be associated with the outcomes of interest. The characteristics were practice specialty (general internal medicine or family practice), practice size (solo practice, 2 or 3 health care providers, ≥ 4 health care providers), and geographic location (South, Northeast, Midwest, and Northwest). Because of the nature of the project, neither the sites nor the investigators were blinded to the group assignment after randomization.

Statistical Analysis

All statistical analyses were performed by using SAS, version 9.0 (SAS Institute, Inc.). We made baseline comparisons between characteristics of patients in intervention and control practices by using a combination of mixed-effects regression models and generalized mixed-effects regression models, depending on whether the characteristic was categorical or continuous. Random effects for physician practice were used in the mixed models because the unit of randomization was the practice rather than the individual patient. Changes in performance at the practice and patient level were assessed over the 2-year study period, from 1 January 2001 (baseline) to 1 January 2003 (follow-up).

The primary practice-level analysis compared the improvement in the percentage of targets reached by the end of the study between intervention and control practices by using a randomization test (31), in which the observed data on whether the targets were achieved were compared against all possible combinations of the ways in which the practices could have been randomly assigned. For these analyses, data from a particular practice were not included for any indicator if the practice did not provide complete data for the study period or if fewer than 10 patients were

eligible for the indicator. This prespecified cutoff was chosen to balance the need to allow as many practices as possible to contribute to the analysis without the analysis being unduly weighted by a practice with a small number of eligible patients. Several secondary analyses were also performed. Wilcoxon signed-rank tests (the nonparametric test analogous to paired *t*-tests) were used to assess whether the percentage of targets achieved over time improved significantly; this was assessed separately for the intervention and control practices. In addition, a randomization test was used to determine whether the number of measures for which intervention practices showed greater improvement was significantly higher than would be expected by chance. This test ignored the magnitude of the difference in improvement and was affected only by whether improvement was better or worse in the intervention practices than in control practices. Exploratory analyses focused on process measures and outcome measures separately and on analyses that examined which of the targets were easier to achieve, defined as those achieved by at least 40% of control and intervention practices. By considering only the measures for which at least 7 practices per group had complete and sufficient data, we also performed sensitivity analyses to examine whether the findings were biased by incomplete data for certain indicators within practices.

For the primary patient-level analysis, a series of generalized mixed-regression models were used to determine whether improvement was greater in study outcomes among patients in intervention practices compared with patients in control practices. Again, these models incorporated random practice effects; however, unlike in the baseline comparisons, we adjusted for several patient characteristics: age, sex, and the presence of any of the clinical conditions studied. The models included data from baseline and the end of the study, thus accounting for any practice-level baseline differences in the outcome of interest. Data from intervention and control practices were combined, and the main independent variable of interest was the time \times treatment group interaction term. We also analyzed change over time for patients in intervention practices and control practices separately by using the generalized mixed-regression model approach, which adjusted for the previously described patient characteristics.

Although many significance tests were performed in these analyses, we did not adjust for multiple comparisons. With the exception of the exploratory hypotheses, all comparisons were stated a priori in the study protocol. The randomization tests used in these analyses incorporate all indicators at once and thus do not suffer from the issue of multiple hypothesis testing.

Role of the Funding Source

The funding agency had no role in the design, conduct, or reporting of the study or in the decision to submit the manuscript for publication.

Table 2. Characteristics of Study Practices*

Characteristic	Intervention Group (n = 10)	Control Group (n = 10)
Specialty		
Family medicine	6	8
Internal medicine	3	2
Joint practice (family medicine and internal medicine)	1	0
Providers, n		
1	3	3
2 or 3	4	5
4–9	3	2
Type of providers		
Physicians	23	21
Midlevel providers	9	8
Location		
South (FL, NC, SC, TN, TX, VA)	3	5
Northeast (CT, PA)	2	1
Midwest (MI, MO, WI)	2	2
Northwest (OR, ID, WA)	3	2

* CT = Connecticut; FL = Florida; ID = Idaho; MI = Michigan; MO = Missouri; NC = North Carolina; OR = Oregon; PA = Pennsylvania; SC = South Carolina; TN = Tennessee; TX = Texas; VA = Virginia; WA = Washington; WI = Wisconsin.

RESULTS

Characteristics of Practices and Patients

Twelve practices were randomly allocated to the intervention group and 11 to the control group. Before any site visits, 2 practices randomly assigned to the intervention group withdrew from the study because of logistic issues related to hosting site visits. One control practice could not provide data throughout the study period. All analyses were performed on the remaining 20 practices.

Table 2 presents the characteristics of the 20 practices. Distribution of specialty and the number and type of providers were similar in intervention and control practices. Table 3 presents characteristics of the patients in the study practices. Patients in the intervention group ($n = 45\,571$) and control group ($n = 41\,720$) practices were statistically similar in terms of age, sex, and prevalence of study conditions.

Changes in Practice-Level Performance

Table 4 summarizes the proportion of practices in the intervention and control groups at or above the target for each indicator at baseline and follow-up. The Appendix Table (available at www.annals.org) provides more detailed data at the level of the individual practice and includes the baseline and end-of-study intraclass correlations for each measure, which are necessary for estimating sample sizes for cluster randomized trials such as this. During the study period, intervention group practices improved from an average of 11.3% to 33.7% in the percentage of indicators that were at or above the target. Control group practices improved from an average of 6.3% to 22.7% of indicators at target. The primary analysis found that the absolute difference between the 22.4–percentage point improve-

ment in the intervention group and the 16.4–percentage point improvement in the control group was not statistically significant ($P > 0.2$, randomization test). However, secondary analyses, which considered changes in each group separately, indicated that the 22.4–percentage point improvement in the intervention group and 16.4–percentage point improvement in the control group were statistically significant ($P = 0.020$ and $P = 0.027$, respectively, Wilcoxon signed-rank test). In addition, intervention practices had greater actual improvements (not considering whether specific targets were reached) than control practices for 18 of the 21 indicators (86%), a percentage that is significantly higher than expected by chance ($P = 0.035$, randomization test). In the practice-level analyses of several indicators, some practices had incomplete data (Table 4, footnotes); this occurred more often at baseline. One reason for incomplete data was use of the electronic medical record for a shorter interval than the period for which the specific measure was assessed. This was a particular problem for cholesterol and high-density lipoprotein cholesterol measurements, which are recommended every 60 months. Another reason was a problem with a laboratory interface, which caused incomplete data recording in the sections of the electronic medical record extracted for the project. Sensitivity analyses demonstrated that the primary and secondary comparisons between the 2 groups were not biased because of inadequate data for certain indicators within practices, as the results were similar to those originally observed. The percentages of targets for the reduced number of indicators achieved by the intervention and control groups were 32.8% and 24.5%, respectively ($P > 0.2$, randomization test); improvement was greater in the intervention practices for 14 of 15 indicators ($P = 0.054$, randomization test), for which at least 7 practices in each group had adequate data.

Exploratory analyses revealed that in both intervention and control practices, the improvement over time among process measures was greater than among outcome measures. The improvement over time among the 14 process measures was significant for both intervention (from

Table 3. Characteristics of Adult Patients in Study Practices

Characteristic	Intervention Group (n = 45 571)	Control Group (n = 41 720)	P Value*
Demographic characteristics			
Mean age \pm SD, y	44.8 \pm 22.4	39.5 \pm 22.3	>0.2
Men, %	44.4	43.5	>0.2
Study conditions, n (%)			
Hypertension	7644 (16.8)	6202 (14.9)	>0.2
Hyperlipidemia	4877 (10.7)	3807 (9.1)	>0.2
Diabetes mellitus	2892 (6.3)	1954 (4.9)	>0.2
Coronary heart disease	1422 (3.1)	1166 (2.8)	>0.2
Heart failure	810 (1.8)	630 (1.5)	>0.2
Atrial fibrillation	573 (1.3)	338 (0.8)	>0.2

* P values derived from mixed-effects models, including random practice effects.

Table 4. Performance Targets Achieved at Baseline (01/01/2001) and Follow-up (01/01/2003): Control and Intervention Practices for 21 Indicators*

Indicator	Target, %†	Practices at Target (Eligible Practices), % (n)‡			
		Intervention Group–Baseline	Intervention Group–Follow-up	Control Group–Baseline	Control Group–Follow-up
Hypertension					
BP measurement in previous 12 mo	69	10.0 (10)	10.0 (10)	10.0 (10)	0.0 (10)
Diagnosis of hypertension for 3 BP measurements ≥140/90 mm Hg	93	0.0 (10)	20.0 (10)	0.0 (10)	0.0 (10)
BP measurement in 3 previous mo in patients with hypertension	64	10.0 (10)	20.0 (10)	10.0 (10)	10.0 (10)
Last BP measurement <140/90 mm Hg for all patients	80	10.0 (10)	40.0 (10)	0.0 (10)	20.0 (10)
Last BP measurement <140/90 mm Hg in patients with hypertension	52	10.0 (10)	60.0 (10)	0.0 (10)	40.0 (10)
Hyperlipidemia					
Cholesterol level in previous 60 mo	58	40.0 (5)§	30.0 (10)	16.7 (6)§	11.1 (9)§
HDL cholesterol level in previous 60 mo	51	40.0 (5)§	60.0 (10)	16.7 (6)§	22.2 (9)§
Coronary heart disease					
LDL cholesterol level in previous 12 mo	65	25.0 (8)	40.0 (10)	0.0 (10)	50.0 (8)§,
Diagnosis of hyperlipidemia for LDL cholesterol level >3.37 mmol/L (>130 mg/dL)	94	0.0 (7)§,	42.9 (7)	0.0 (4)	0.0 (6)§,
Medication for LDL cholesterol level >3.37 mmol/L (>130 mg/dL)	90	0.0 (7)§,	28.6 (7)	0.0 (4)	0.0 (6)§,
Prescription for β-blocker in patients with history of MI	53	33.3 (6)	42.9 (7)	20.0 (5)	25.0 (4)
Last LDL cholesterol level <2.59 mmol/L (<100 mg/dL)	57	12.5 (8)§,	12.5 (8)	11.1 (9)	25.0 (8)§,
Last BP measurement <140/90 mm Hg	68	0.0 (8)	44.4 (9)	11.1 (9)	22.2 (9)
Heart failure					
Prescription for ACE inhibitor or ARB	60	0.0 (9)	22.2 (9)	0.0 (9)	22.2 (9)
Atrial fibrillation					
Prescription for oral anticoagulant	58	14.3 (7)	12.5 (8)	12.5 (8)	12.5 (8)
Diabetes mellitus					
HbA _{1c} measurement in previous 12 mo	67	12.5 (8)§	30.0 (10)	10.0 (10)	44.4 (9)§
LDL cholesterol level in previous 24 mo	72	12.5 (8)§	70.0 (10)	20.0 (10)	55.6 (9)§
BP measurement in previous 3 mo	69	10.0 (10)	0.0 (10)	10.0 (10)	0.0 (10)
Last HbA _{1c} level <7%	56	16.7 (6)§,	40.0 (10)	0.0 (10)	22.2 (9)§
Last LDL cholesterol level <2.59 mmol/L (<100 mg/dL)	46	0.0 (8)§,	30.0 (10)	0.0 (10)	55.6 (9)§,
Last BP measurement <130/85 mm Hg	41	10.0 (10)	40.0 (10)	0.0 (10)	40.0 (10)
Mean indicators at or above target, %		11.3	33.7¶	6.3	22.7**

* ACE = angiotensin-converting enzyme; ARB = angiotensin-receptor blocker; BP = blood pressure; HbA_{1c} = hemoglobin A_{1c}; HDL = high-density lipoprotein; LDL = low-density lipoprotein; MI = myocardial infarction.

† Target defined at the 90th percentile at baseline among all study practices.

‡ Practices were eligible if they had complete data for this indicator during the study period and at least 10 patients eligible for the indicator.

§ One or more practices were ineligible for this indicator because they had incomplete data.

|| One or more practices were ineligible for this indicator because they had <10 eligible patients.

¶ The increase from 11.3% to 33.7% was statistically significant ($P = 0.02$, Wilcoxon signed-rank test).

** The increase from 6.3% to 22.7% was statistically significant ($P = 0.027$, Wilcoxon signed-rank test).

10.7% to 36.8%; $P = 0.027$) and control practices (from 6.3% to 23.9%; $P = 0.020$). The improvement over time among the 7 outcome measures was not significant in either the intervention practices (from 12.1% to 26.8%; $P = 0.094$) or the control practices (from 6.4% to 20.4%; $P = 0.188$). Targets achieved by 40% of intervention group practices were all 4 targets for blood pressure control, total cholesterol and high-density lipoprotein cholesterol screening, LDL cholesterol screening, diagnosis of hyperlipidemia in patients with CHD and elevated LDL cholesterol level, use of β-blockers in patients with a history of myo-

cardial infarction, LDL cholesterol measurement, and hemoglobin A_{1c} control in diabetic patients. Targets achieved by 40% of control group practices were blood pressure control for patients with hypertension or diabetes, LDL cholesterol measurement in patients with CHD, and LDL cholesterol and hemoglobin A_{1c} measurement and LDL cholesterol control in diabetic patients.

Changes in Patient-Level Performance

Table 5 shows the proportion of patients in the intervention and control group practices that had achieved each

Table 5. Clinical Targets Achieved at Baseline (01/01/2001) and Follow-up (01/01/2003): Control and Intervention Patients for 21 Indicators*

Indicator	Patients at Target (Eligible Patients), % (n)				Adjusted Difference in Improvement (95% CI), percentage point [†]	P Value
	Intervention Group—Baseline	Intervention Group—Follow-up	Control Group—Baseline	Control Group—Follow-up		
Hypertension						
BP measurement in previous 12 mo	58.0 (39 495)	58.7 (42 935)	62.0 (33 670)	56.8 (38 690)	3.2 (−4.2 to 10.7)	>0.2
Diagnosis of hypertension for 3 BP measurements ≥140/90 mm Hg	71.6 (3063)	83.6 (3208)	69.6 (3235)	70.9 (3145)	15.7 (5.2 to 26.3)	<0.001
BP measurement in 3 previous mo in patients with hypertension	48.0 (7644)	51.9 (10 166)	54.1 (6202)	50.9 (7353)	6.7 (−1.0 to 14.4)	0.084
Last BP measurement <140/90 mm Hg for all patients	64.1 (14 676)	72.2 (14 676)	68.7 (12 681)	70.6 (12 681)	5.9 (−0.3 to 12.2)	0.063
Last BP measurement <140/90 mm Hg in patients with hypertension	40.0 (4446)	58.4 (4446)	43.7 (3326)	51.9 (3326)	8.0 (0.0 to 16.0)	0.047
Hyperlipidemia						
Cholesterol level in previous 60 mo	50.2 (20 909)	53.5 (42 935)	45.3 (23 322)	43.1 (37 158)	0.2 (−12.0 to 12.4)	0.2
HDL cholesterol level in previous 60 mo	47.9 (20 909)	52.6 (42 935)	38.2 (23 322)	41.3 (37 158)	−1.9 (−8.4 to 12.2)	0.875
Coronary heart disease						
LDL cholesterol level in previous 12 mo	52.8 (1416)	61.4 (1613)	46.2 (1166)	61.3 (1105)	−11.0 (−23.0 to 1.0)	0.076
Diagnosis of hyperlipidemia for LDL cholesterol level >3.37 mmol/L (>130 mg/dL)	66.0 (203)	76.1 (247)	73.4 (139)	72.4 (174)	11.3 (−5.9 to 28.5)	>0.2
Medication for LDL cholesterol level >3.37 mmol/L (>130 mg/dL)	64.5 (203)	72.1 (247)	73.4 (139)	77.0 (174)	1.6 (−12.4 to 15.5)	>0.2
Prescription for β-blocker in patients with history of MI	39.2 (166)	42.8 (194)	39.5 (129)	40.0 (110)	6.5 (−17.1 to 30.0)	>0.2
Last LDL cholesterol level <2.59 mmol/L (<100 mg/dL)	45.2 (438)	57.3 (438)	49.5 (273)	59.3 (273)	2.3 (−8.6 to 13.2)	>0.2
Last BP measurement <140/90 mm Hg	55.3 (711)	67.9 (711)	61.8 (477)	64.4 (477)	7.8 (−2.7 to 18.3)	0.076
Heart failure						
Prescription for ACE inhibitor or ARB	38.2 (810)	47.3 (903)	47.5 (630)	52.0 (612)	2.0 (−8.2 to 12.3)	>0.2
Atrial fibrillation						
Prescription for oral anticoagulant	42.1 (573)	38.6 (725)	40.8 (338)	44.0 (364)	−7.1 (−17.7 to 3.6)	0.171
Diabetes mellitus						
HbA _{1c} measurement in previous 12 mo	42.8 (2706)	53.2 (3345)	61.9 (1954)	63.5 (2290)	5.8 (−10.0 to 21.6)	0.181
LDL cholesterol level in previous 24 mo	61.6 (2706)	75.9 (3345)	62.4 (1954)	72.5 (2290)	−1.9 (−13.8 to 9.9)	>0.2
BP measurement in previous 3 mo	47.7 (2892)	51.9 (3345)	57.8 (1954)	53.8 (2428)	5.0 (−4.6 to 14.7)	>0.2
Last HbA _{1c} level <7%	49.2 (828)	53.9 (828)	43.4 (730)	53.7 (730)	−3.8 (−12.9 to 5.4)	>0.2
Last LDL cholesterol level <2.59 mmol/L (<100 mg/dL)	36.4 (929)	48.4 (929)	36.5 (575)	49.2 (575)	3.9 (−9.0 to 16.9)	>0.2
Last BP measurement <130/85 mm Hg	52.1 (1568)	65.9 (1568)	50.3 (1067)	58.2 (1067)	7.7 (−1.7 to 17.1)	0.089

* ACE = angiotensin-converting enzyme; ARB = angiotensin-receptor blocker; BP = blood pressure; HbA_{1c} = hemoglobin A_{1c}; HDL = high-density lipoprotein; LDL = low-density lipoprotein; MI = myocardial infarction.

† The adjusted difference in improvement was the change (follow-up minus baseline) among intervention practices minus the change among control practices. With use of generalized mixed regression models, these differences and the associated 95% CIs and *P* values reflect adjustment for patient-level covariates (age, sex, and indicators for each of the following medical conditions: hypertension, hyperlipidemia, coronary heart disease, MI, atrial fibrillation, congestive heart failure, and diabetes mellitus) and random practice effects (to account for correlation of patient measures within individual practices). A positive difference reflects greater improvement among intervention practices.

clinical indicator at baseline and follow-up. **Table 5** also lists the adjusted difference in improvement (change from baseline to follow-up among intervention practices minus the change from baseline to follow-up among control practices) for each of the measures, the 95% CIs for these adjusted differences, and the *P* values associated with the time \times group interaction from the generalized mixed models. The primary analyses indicated that for 2 of the 21 measures (diagnosis of hypertension for 3 elevated measurements and blood pressure control among patients with hypertension), improvement was significantly greater among intervention group patients than control group patients ($P = 0.001$ and $P = 0.047$, respectively, generalized mixed regression models).

Secondary analyses showed that 8 indicators statistically significantly improved among intervention group patients: the diagnosis of hypertension for 3 elevated measurements, blood pressure control for all patients and patients with hypertension, LDL cholesterol and blood pressure control in patients with CHD, and LDL cholesterol control and blood pressure control in patients with diabetes. A small but statistically significant decline in the use of oral anticoagulants occurred for patients with atrial fibrillation. The secondary analyses also indicated that control group patients had statistically significant improvements for 6 indicators: blood pressure control in patients with hypertension, high-density lipoprotein cholesterol screening, LDL cholesterol measurement and control in patients with CHD, and LDL cholesterol control and blood pressure control in patients with diabetes. Statistically significant declines occurred in 3 indicators: blood pressure measurement in all patients, blood pressure measurement in patients with hypertension, and blood pressure measurement in patients with diabetes.

DISCUSSION

Our primary finding is that a multimethod quality improvement intervention—adding practice site visits and network meetings—was only marginally more effective than performance reports alone for improving adherence to 21 quality indicators for primary and secondary prevention of cardiovascular disease and stroke in primary care practices that use an electronic medical record. However, equally important is our finding that substantial improvement occurred in both groups in analyses at the practice and patient level.

Interviews conducted with participants revealed 5 key components to successful improvement: prioritizing performance, involving all staff, redesigning delivery systems, activating patients, and using electronic medical record tools. Prioritization of performance reflected a willingness to accept the practice guidelines supporting the study indicators and the use of PPRNet performance reports to guide improvement efforts. Involving all staff meant that clinicians, nursing staff, and administrative personnel

shared responsibility for improvement efforts. Delivery system redesign largely involved systematizing approaches to laboratory testing, patient scheduling and follow-up, and care responsibilities for those with chronic illness. Patient activation meant sharing clinical practice guidelines with patients so that they would be able to set more informed goals, be motivated toward self-management, and help ensure that routine monitoring was done and treatment goals reached. Electronic medical record tools included more systematic use of point-of-care note templates with embedded practice guidelines and reminders, flagging records of patients needing attention, internal messaging to coordinate care, and providing customized results letters with specific education for patients. The key components identified in this study are similar to those identified recently by the Institute of Medicine (14) and articulated in the Chronic Care Model (32). They are also consistent with a Cochrane review of interventions to improve diabetes care (13) and a meta-analysis of disease management studies (12). Practices in the intervention group were more likely to adopt these components than were those in the control group, which may account for the marginally better improvements. Site visit evaluation surveys revealed that practices found the visits motivating; they provided a focus to improvement efforts and a natural deadline to overcome competing priorities and stimulate attention to improvement. In addition, practice members expressed that the site visits and network meetings helped practices become more efficient in their improvement activities. However, regardless of group assignment, practices that adopted more of these components had greater improvement in study indicators than those that did not.

Some performance targets were easier for practices to reach than others. More than 40% of control and intervention practices achieved targets for LDL cholesterol measurement in patients with CHD and diabetes and for blood pressure control in patients with hypertension and diabetes.

Feedback from participants suggested that better awareness of the practice guideline and increased use of office-based instruments for lipid measurements facilitated LDL cholesterol measurement. More frequent use of multiple-agent antihypertensive therapy, recommended in recent practice guidelines (33), was cited as an explanation for better blood pressure control. In contrast, fewer than 15% of control and intervention practices achieved targets for blood pressure measurement among all patients or those with diabetes and targets for oral anticoagulant use for patients with atrial fibrillation. Participants reported busy schedules as disincentives to outreach to patients not receiving regular blood pressure screening. Patients with atrial fibrillation were often managed with aspirin, which is appropriate in many cases (10); however, as an over-the-counter medication, aspirin was not recorded reliably in the electronic medical record. Patient-level measures had similar findings. In addition, LDL cholesterol control for

patients with CHD and diabetes also improved in both intervention and control groups. Participants cited the ease of reaching therapy targets with statin medication for many patients, as well as the ability to make point-of-care decisions by using office-based lipid measurements as reasons for these improvements.

Our study has several important limitations. The relatively small sample size of 20 practices and variability among practices in performance on the study indicators limited our ability to detect differences between the intervention and control groups. Although 87 291 patients participated in the study, the primary unit of randomization was the practice, a design that significantly reduced the effective sample size. Incomplete practice data had the effect of further reducing the statistical power to detect differences between the 2 groups. Also, baseline and end-of-study indicators varied substantially among practices. For example, practice-level blood pressure control among hypertensive patients ranged from 27.8% to 64.3% at baseline and from 33.2% to 73.7% at the end of the study. Baseline intraclass correlation coefficients ranged from 0.008 to 0.176, and end-of-study intraclass correlation coefficients ranged from 0.008 to 0.158 (Appendix Table), indicating that there is more variability among certain indicators than others.

The absence of a pure control group (in which performance would be measured without interventions) was another limitation. Given the nature of PPRNet, having a pure control group was not feasible because practices expected a benefit from sharing their data. Also, given previous research, which showed the benefits, albeit limited, of audit and feedback (16), we did not think it would be ethical to withhold information that might improve patient care. The absence of a pure control group is problematic in analyzing the study findings because improvements in the group that received practice reports alone may have occurred for reasons other than the receipt of these reports. Interviews with control group practices after completion of the study suggest otherwise, as most of the practices used the reports to remind them of the guidelines, encourage better performance, and, in some practices, organize specific systemic improvement approaches.

Another limitation is that participants were aware of the study hypotheses and could have altered their data entry habits to produce better reports. For instance, physicians could repeat blood pressures initially obtained by nurses and record lower measurements. We do not believe that this potential bias dramatically affected the study findings. Most participating clinicians indicated that, although they may have occasionally repeated an abnormal blood pressure measurement and recorded a subsequent normal result, much more often they were stimulated to modify therapy. In addition, a recording bias could not explain improvements in LDL cholesterol control because these results are obtained from automated instruments and often are electronically transferred to the electronic medical record.

Another possible limitation of the study is potential underestimation of performance because data were not extracted from text sections of the records. However, this factor would affect control and intervention practices equally and should not have affected comparisons between them or changes over time in either group.

The improved performance on clinical indicators observed in this study could have a substantial effect on morbidity and mortality. The initial systolic blood pressure was 130 mm Hg or greater in 10 871 patients in the intervention group and 9033 patients in the control group. The last systolic blood pressure during the 2-year study was at least 12 mm Hg less in 29.8% of intervention group patients and 26.7% of control group patients. On the basis of published estimates of the effect of blood pressure lowering, these improvements, if maintained for 10 years, might prevent 302 cardiovascular disease events and 209 deaths in the intervention group and 224 cardiovascular disease events and 154 deaths in the control group (34). Increasing national emphasis on office-based quality initiatives and electronic medical records (35) suggests that the improvements found in this study can be extended to most Americans.

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References

1. Braunwald E. Shattuck lecture—cardiovascular medicine at the turn of the millennium: triumphs, concerns, and opportunities. *N Engl J Med.* 1997;337:1360-9. [PMID: 9358131]
2. Lenfant C. Shattuck lecture—clinical research to clinical practice—lost in translation? *N Engl J Med.* 2003;349:868-74. [PMID: 12944573]
3. McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of health care delivered to adults in the United States. *N Engl J Med.* 2003;348:2635-45. [PMID: 12826639]
4. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). National Cholesterol Education Program. Washington, DC: National Heart, Lung, and Blood Institute; 2002. NIH publication no. 02-5215.
5. Hajjar I, Kotchen TA. Trends in prevalence, awareness, treatment, and control of hypertension in the United States, 1988-2000. *JAMA.* 2003;290:199-206. [PMID: 12851274]

6. **Stafford RS, Blumenthal D, Pasternak RC.** Variations in cholesterol management practices of U.S. physicians. *J Am Coll Cardiol.* 1997;29:139-46. [PMID: 8996306]
7. **Pearson TA, Blair SN, Daniels SR, Eckel RH, Fair JM, Fortmann SP, et al.** AHA Guidelines for Primary Prevention of Cardiovascular Disease and Stroke: 2002 Update: Consensus Panel Guide to Comprehensive Risk Reduction for Adult Patients Without Coronary or Other Atherosclerotic Vascular Diseases. American Heart Association Science Advisory and Coordinating Committee. *Circulation.* 2002;106:388-91. [PMID: 12119259]
8. **Wang TJ, Stafford RS.** National patterns and predictors of beta-blocker use in patients with coronary artery disease. *Arch Intern Med.* 1998;158:1901-6. [PMID: 9759686]
9. **Hunt SA, Baker DW, Chin MH, Cinquegrani MP, Feldman AM, Francis GS, et al.** ACC/AHA guidelines for the evaluation and management of chronic heart failure in the adult: executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to revise the 1995 Guidelines for the Evaluation and Management of Heart Failure). *J Am Coll Cardiol.* 2001;38:2101-13. [PMID: 11738322]
10. **McNamara RL, Bass EB, Miller MR, Segal JB, Goodman SN, Kim NL, et al.** Management of new onset atrial fibrillation. Evidence Report/Technology Assessment No. 12 (prepared by the Johns Hopkins University Evidence-based Practice Center in Baltimore, MD, under contract no. 290-97-0006). Rockville, MD: Agency for Healthcare Research and Quality; 2001. AHRQ publication no. 01-E026.
11. Standards of medical care for patients with diabetes mellitus. *Diabetes Care.* 2003;26 Suppl 1:S33-50. [PMID: 12502618]
12. **Weingarten SR, Henning JM, Badamgarav E, Knight K, Hasselblad V, Gano A Jr, et al.** Interventions used in disease management programmes for patients with chronic illness—which ones work? Meta-analysis of published reports. *BMJ.* 2002;325:925. [PMID: 12399340]
13. **Rothman AA, Wagner EH.** Chronic illness management: what is the role of primary care? *Ann Intern Med.* 2003;138:256-61. [PMID: 12558376]
14. **Institute of Medicine.** Crossing the Quality Chasm: A New Health System for the 21st Century. Washington, DC: National Academy Pr; 2001.
15. **Tunis SR, Stryer DB, Clancy CM.** Practical clinical trials: increasing the value of clinical research for decision making in clinical and health policy. *JAMA.* 2003;290:1624-32. [PMID: 14506122]
16. **O'Brien T, Oxman AD, Davis DA, Haynes RB, Freemantle N, Harvey EL.** Audit and feedback: effects on professional practice and health care outcomes (Cochrane Review). In: *The Cochrane Library.* Oxford: Update Software; 2003.
17. **The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VI).** Bethesda, MD: National Institutes of Health; 1997. NIH publication no. 98-4080.
18. **Summary of the second report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel II).** *JAMA.* 1993;269:3015-23. [PMID: 8501844]
19. **Smith SC Jr, Blair SN, Criqui MH, Fletcher GF, Fuster V, Gersh BJ, et al.** Preventing heart attack and death in patients with coronary disease. *Circulation.* 1995;92:2-4. [PMID: 7788911]
20. **Guidelines for the evaluation and management of heart failure.** Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Evaluation and Management of Heart Failure). *Circulation.* 1995;92:2764-84. [PMID: 7586389]
21. **Prystowsky EN, Benson DW Jr, Fuster V, Hart RG, Kay GN, Myerburg RJ, et al.** Management of patients with atrial fibrillation. A Statement for Healthcare Professionals. From the Subcommittee on Electrocardiography and Electrophysiology, American Heart Association. *Circulation.* 1996;93:1262-77. [PMID: 8653857]
22. **American Diabetes Association.** Diabetes Quality Improvement Project. Initial Measure Set (Final Version). Accessed at www.ncqa.org/dprp/dqip2.htm on 9 August 2004.
23. **Rossouw JE, Anderson GL, Prentice RL, LaCroix AZ, Kooperberg C, Stefanick ML, et al.** Risks and benefits of estrogen plus progestin in healthy postmenopausal women: principal results From the Women's Health Initiative randomized controlled trial. *JAMA.* 2002;288:321-33. [PMID: 12117397]
24. **Soumerai SB, Avorn J.** Principles of educational outreach ("academic detailing") to improve clinical decision making. *JAMA.* 1990;263:549-56. [PMID: 2104640]
25. **Woolf SH.** Changing physician practice behavior: the merits of a diagnostic approach. *J Fam Pract.* 2000;49:126-9. [PMID: 10718688]
26. **Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al.** Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA.* 1999;282:1458-65. [PMID: 10535437]
27. **Ornstein SM, Jenkins RG, Lee FW, Sack JL, LaKier EI, Roskin SD, et al.** The computer-based patient record as a CQI tool in a family medicine center. *Jt Comm J Qual Improv.* 1997;23:347-61. [PMID: 9257175]
28. **Donner A, Klar N.** Methods for comparing event rates in intervention studies when the unit of allocation is a cluster. *Am J Epidemiol.* 1994;140:279-89; discussion 300-1. [PMID: 8030631]
29. **Murray DM.** Design and analysis of group-randomized trials: a review of recent developments. *Ann Epidemiol.* 1997;7:S69-S77.
30. **Meinert CL.** *Clinical Trials: Design, Conduct, and Analysis.* New York: Oxford University Pr; 1986.
31. **Gail MH, Mark SD, Carroll RJ, Green SB, Pee D.** On design considerations and randomization-based inference for community intervention trials. *Stat Med.* 1996;15:1069-92. [PMID: 8804140]
32. **Bodenheimer T, Wagner EH, Grumbach K.** Improving primary care for patients with chronic illness. *JAMA.* 2002;288:1775-9. [PMID: 12365965]
33. **Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, et al.** The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA.* 2003;289:2560-72. [PMID: 12748199]
34. **Ogden LG, He J, Lydick E, Whelton PK.** Long-term absolute benefit of lowering blood pressure in hypertensive patients according to the JNC VI risk stratification. *Hypertension.* 2000;35:539-43. [PMID: 10679494]
35. **Physician Focused Quality Initiative.** Center for Medicare & Medicaid Services. Accessed at www.cms.hhs.gov/quality/pfqi.asp on 24 March 2004.

Appendix Table. Baseline and End-of-Study Performance on the 21 Quality Indicators*

Practice	Indicator†									
	Hypertension					Hyperlipidemia		Coronary Heart Disease		
	Baseline, % (n) End of Study, % (n)					Baseline, % (n) End of Study, % (n)		Baseline, % (n) End of Study, % (n)		
BP measurement in previous 12 mo	Diagnosis of hypertension for 3 BP measurements ≥140/90 mm Hg	BP measurement in previous 3 mo in patients with hypertension	Last BP measurement <140/90 mm Hg in all patients	Last BP measurement <140/90 mm Hg in patients with hypertension	Cholesterol level in previous 60 mo	HDL cholesterol level in previous 60 mo	LDL cholesterol level in previous 12 mo	Diagnosis of hyperlipidemia for LDL cholesterol level >3.37 mmol/L (>130 mg/dL)	Medication for LDL cholesterol level ≥3.37 mmol/L (≥130 mg/dL)	
Control practices										
A	51.5 (5776) 56.7 (6250)	82.3 (462) 85.0 (528)	49.6 (1294) 51.3 (1555)	69.9 (2973) 74.8 (3542)	49.1 (996) 60.6 (1249)	33.6 (5776) 36.8 (6250)	28.1 (5776) 36.1 (6250)	39.2 (189) 65.1 (215)	76.5 (17) 87.5 (32)	82.4 (17) 87.5 (32)
B	55.0 (3511) 52.5 (4022)	60.8 (255) 68.0 (269)	53.7 (460) 48.1 (616)	63.8 (1932) 68.9 (2112)	29.4 (384) 41.0 (503)	D 37.2 (4022)	D 35.6 (4022)	43.4 (83) 53.2 (124)	S 87.0 (23)	S 69.6 (23)
C	64.3 (1310) 63.3 (1320)	62.8 (269) 65.0 (263)	62.5 (373) 66.6 (359)	51.2 (842) 51.1 (835)	35.8 (316) 33.2 (298)	53.1 (1310) 66.2 (1320)	51.9 (1310) 66.0 (1320)	32.1 (84) 66.7 (75)	S 54.5 (11)	S 63.6 (11)
D	68.3 (8761) 63.9 (9552)	74.7 (821) 76.3 (788)	55.5 (1611) 55.3 (1817)	75.2 (5982) 75.8 (6099)	48.8 (1417) 52.7 (1552)	59.3 (8761) 54.7 (9552)	48.1 (8761) 52.4 (9552)	62.0 (300) 69.7 (310)	63.0 (46) 56.3 (48)	87.0 (46) 83.3 (48)
E	65.1 (3311) 58.5 (3547)	67.5 (418) 70.6 (371)	63.4 (555) 61.9 (661)	69.0 (2155) 71.1 (2074)	34.9 (467) 45.4 (570)	40.4 (3311) 44.9 (3547)	36.0 (3311) 42.7 (3547)	59.1 (171) 66.1 (171)	92.1 (38) 93.9 (33)	52.6 (38) 69.7 (33)
F	55.9 (2274) 47.2 (2378)	65.6 (93) 56.1 (41)	33.0 (267) 22.8 (337)	77.7 (1272) 81.2 (1123)	47.3 (205) 58.2 (182)	D 37.0 (2378)	D 28.1 (2378)	17.9 (56) 63.1 (65)	S 73.3 (15)	S 66.7 (15)
G	65.6 (2814) 44.2 (2650)	53.4 (406) 38.6 (311)	52.5 (680) 38.7 (243)	60.3 (1847) 57.1 (1171)	46.4 (565) 43.5 (331)	32.1 (2814) 48.6 (2650)	31.2 (2814) 48.2 (2650)	36.6 (145) 39.4 (94)	71.4 (14) S	78.6 (14) S
H	59.8 (1712) 53.6 (2355)	70.0 (90) 72.5 (51)	46.3 (175) 38.7 (243)	75.2 (1024) 86.3 (1263)	40.7 (150) 60.4 (182)	D 35.7 (2355)	D 35.4 (2355)	18.2 (11) S	S S	S S
I	68.2 (2664) 54.2 (4443)	65.3 (268) 64.9 (268)	52.5 (486) 43.5 (750)	71.4 (1817) 71.4 (2409)	45.3 (426) 51.6 (595)	D 33.7 (4443)	D 33.4 (4443)	36.9 (84) 37.3 (51)	S S	S S
J	70.2 (988) 65.2 (1516)	90.3 (155) 83.2 (256)	67.5 (314) 59.7 (501)	66.1 (694) 65.5 (988)	50.5 (303) 46.7 (433)	46.4 (988) D	33.5 (988) D	51.1 (45) D	S D, S	S D, S
Intervention practices										
K	50.0 (10 332) 57.8 (9648)	70.1 (642) 75.2 (777)	42.8 (1824) 46.9 (2033)	64.9 (5165) 69.1 (5573)	39.8 (1333) 48.6 (1709)	48.2 (10 332) 52.8 (9648)	47.1 (10 332) 52.7 (9648)	47.6 (357) 53.9 (397)	63.4 (41) 66.0 (50)	36.6 (41) 50.0 (50)
L	61.7 (3446) 68.2 (3197)	89.3 (280) 92.9 (198)	47.8 (1032) 51.3 (1281)	64.0 (2127) 80.8 (2181)	45.5 (881) 73.7 (1103)	38.5 (3446) 64.1 (3197)	37.1 (3446) 63.1 (3197)	57.9 (126) 67.4 (141)	21.4 (14) 19.0 (21)	71.4 (14) 90.5 (21)
M	55.4 (1933) 52.9 (2113)	49.8 (211) 94.5 (183)	46.2 (357) 63.0 (652)	66.3 (1071) 79.1 (1118)	49.6 (284) 67.5 (579)	71.1 (1933) 74.1 (2113)	62.5 (1933) 70.3 (2113)	67.7 (96) 80.8 (130)	62.5 (24) 97.5 (40)	87.5 (24) 92.5 (40)
N	62.6 (1297) 74.0 (2873)	45.9 (172) 85.6 (361)	68.8 (154) 65.4 (609)	60.8 (812) 68.0 (2125)	27.8 (133) 42.8 (577)	51.6 (1297) 49.3 (2873)	47.0 (1297) 47.6 (2873)	84.6 (39) 77.6 (49)	61.5 (13) 84.6 (13)	53.8 (13) 69.2 (13)
O	65.2 (3653) 64.7 (3314)	88.6 (492) 95.2 (291)	50.6 (1497) 52.8 (1600)	58.5 (2383) 76.7 (2144)	42.8 (1207) 71.0 (1291)	58.0 (3653) 72.6 (3314)	55.3 (3653) 69.8 (3314)	60.6 (330) 63.3 (300)	90.9 (55) 96.9 (32)	69.1 (55) 68.8 (32)
P	64.9 (6135) 56.0 (7002)	55.3 (347) 70.9 (244)	54.9 (563) 38.9 (854)	72.0 (3980) 81.2 (3918)	29.9 (485) 55.2 (692)	D 54.7 (7002)	D 55.1 (7002)	40.0 (75) 37.0 (81)	S S	S S
Q	49.8 (5597) 52.5 (5984)	75.2 (625) 82.1 (663)	51.2 (1201) 55.2 (1510)	57.6 (2788) 65.2 (3142)	32.6 (998) 46.3 (1231)	D 52.5 (5984)	D 51.0 (5984)	49.3 (292) 64.2 (346)	64.1 (39) 72.7 (55)	79.5 (39) 70.9 (55)
R	59.4 (507) 52.0 (773)	75.7 (37) 85.3 (34)	33.7 (89) 38.0 (129)	75.1 (301) 80.8 (402)	44.1 (68) 53.3 (75)	D 57.8 (773)	D 51.9 (773)	S 50.0 (10)	S S	S S
S	58.3 (3542) 57.5 (3683)	67.6 (210) 89.4 (404)	47.2 (504) 68.1 (849)	73.0 (2065) 70.3 (2118)	42.0 (429) 50.5 (755)	D 47.7 (3683)	D 48.2 (3683)	43.9 (98) 67.7 (133)	90.0 (10) 100.0 (24)	80.0 (10) 79.2 (24)
T	76.3 (2515) 57.6 (3843)	86.8 (53) 88.7 (53)	41.6 (442) 31.7 (665)	87.4 (1918) 90.3 (2214)	64.3 (389) 67.4 (460)	D 30.5 (3843)	D 30.5 (3843)	S 29.6 (27)	D, S S	D, S S
Baseline range	49.8%–76.3%	45.9%–90.3%	33.0%–68.8%	51.2%–87.4%	27.8%–64.3%	32.1%–71.1%	28.1%–62.5%	17.9%–84.6%	21.4%–92.1%	36.6%–87.5%
Baseline intraclass correlation coefficient	0.025	0.064	0.018	0.026	0.023	0.050	0.040	0.050	0.106	0.103
End-of-study range	44.2%–74.0%	38.6%–95.2%	22.8%–68.1%	51.1%–90.3%	33.2%–73.7%	30.5%–74.1%	28.1%–70.3%	29.6%–80.8%	19.0%–100.0%	50.0%–92.5%
End-of-study intraclass correlation coefficient	0.016	0.083	0.037	0.030	0.044	0.043	0.064	0.041	0.054	0.055

* ACE = angiotensin-converting enzyme; ARB = angiotensin-receptor blocker; BP = blood pressure; D = data not available on the given indicator at the particular time point; HbA_{1c} = hemoglobin A_{1c}; HDL = high-density lipoprotein; LDL = low-density lipoprotein; MI = myocardial infarction; S = data not reported because the indicator's denominator would be based on a sample size of <10 patients.

† In each set of values, the first 2 numbers are the baseline percentage and baseline number. The third and fourth numbers are the end-of-study percentage and end-of-study number.

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Appendix Table—Continued

Indicator†										
Baseline, % (n) End of Study, % (n)										
Coronary Heart Disease			Heart Failure	Atrial Fibrillation	Diabetes Mellitus					
Prescription for β -blocker in patients with history of MI	Last LDL cholesterol level <2.59 mmol/L (<100 mg/dL)	Last BP measurement <140/90 mm Hg	Prescription for ACE or ARB	Prescription for oral anticoagulant	HbA _{1c} measurement in previous 12 mo	LDL cholesterol level in previous 24 mo	BP measurement in previous 3 mo	Last HbA _{1c} level <7%	Last LDL cholesterol level <2.59 mmol/L (<100 mg/dL)	Last BP measurement <130/85 mm Hg
28.2 (39)	45.9 (74)	70.1 (134)	44.6 (184)	38.7 (75)	63.4 (355)	62.5 (355)	55.5 (355)	48.9 (225)	34.2 (158)	39.9 (271)
40.0 (35)	53.6 (140)	76.7 (189)	64.4 (163)	53.7 (67)	68.0 (412)	72.1 (412)	56.3 (412)	66.4 (280)	54.7 (247)	49.4 (330)
50.0 (30)	47.2 (36)	47.6 (63)	40.0 (45)	27.3 (33)	61.2 (196)	55.1 (196)	55.1 (196)	31.7 (120)	25.0 (96)	25.4 (169)
37.5 (24)	40.9 (66)	58.2 (91)	43.7 (71)	45.2 (42)	58.1 (265)	66.8 (265)	50.6 (265)	46.8 (154)	27.5 (142)	30.0 (213)
S	59.3 (27)	45.5 (66)	45.2 (31)	40.0 (20)	38.6 (83)	72.3 (83)	68.7 (83)	50.0 (32)	44.2 (43)	22.4 (76)
S	62.0 (50)	46.8 (62)	10.7 (28)	34.5 (29)	68.0 (75)	73.3 (75)	60.0 (75)	51.0 (51)	46.0 (50)	15.3 (59)
64.3 (14)	53.2 (186)	60.9 (258)	59.9 (167)	41.0 (78)	66.1 (557)	75.0 (557)	56.0 (557)	17.1 (368)	38.7 (336)	34.4 (485)
18.2 (11)	61.6 (216)	62.2 (267)	59.5 (158)	41.4 (87)	66.2 (693)	80.2 (693)	59.7 (693)	36.6 (459)	50.7 (440)	41.8 (569)
25.0 (12)	38.6 (101)	55.2 (143)	33.8 (80)	50.9 (57)	59.8 (169)	66.9 (169)	66.9 (169)	44.6 (101)	34.3 (105)	30.7 (137)
S	46.0 (113)	55.9 (136)	37.5 (80)	36.6 (71)	67.5 (197)	79.2 (197)	68.0 (197)	41.4 (133)	41.1 (141)	32.7 (165)
9.1 (11)	50.0 (10)	51.2 (41)	38.1 (21)	16.7 (18)	42.7 (82)	29.3 (82)	40.2 (82)	34.3 (35)	14.3 (14)	39.7 (63)
66.7 (12)	56.1 (41)	74.4 (43)	38.1 (21)	52.9 (17)	62.3 (114)	68.4 (114)	24.6 (114)	56.3 (71)	46.2 (65)	40.0 (60)
S	47.2 (53)	59.0 (117)	55.3 (38)	35.5 (31)	50.2 (225)	44.9 (225)	53.8 (225)	47.8 (113)	43.2 (74)	27.2 (184)
S	45.9 (37)	56.9 (51)	72.2 (18)	30.0 (20)	49.1 (220)	66.8 (220)	43.2 (220)	47.2 (108)	41.9 (93)	21.7 (138)
S	S	S	S	S	61.5 (39)	61.5 (39)	59.0 (39)	50.0 (24)	15.8 (19)	35.5 (31)
S	S	S	S	S	68.1 (47)	74.5 (47)	53.2 (47)	46.9 (32)	48.1 (27)	44.4 (36)
S	41.9 (31)	55.4 (65)	47.9 (48)	S	66.5 (182)	68.1 (182)	65.9 (182)	43.8 (121)	42.2 (102)	37.7 (162)
S	52.6 (19)	64.3 (42)	50.0 (42)	S	57.2 (311)	65.6 (311)	45.7 (311)	53.4 (178)	32.4 (136)	42.8 (257)
S	43.5 (23)	59.5 (42)	43.8 (16)	77.8 (18)	93.5 (77)	59.6 (77)	75.3 (77)	36.1 (72)	28.6 (42)	33.8 (74)
S	D	65.9 (41)	48.1 (27)	65.4 (26)	D	D	59.4 (138)	D	D, S	31.6 (117)
21.3 (61)	42.9 (170)	53.5 (256)	26.8 (291)	42.1 (114)	57.8 (606)	65.5 (606)	42.4 (606)	55.7 (350)	31.2 (301)	29.0 (404)
25.0 (60)	51.9 (214)	67.2 (320)	38.7 (253)	37.3 (134)	73.1 (605)	80.7 (605)	52.1 (605)	64.7 (442)	43.1 (418)	33.7 (496)
57.1 (35)	50.7 (73)	57.4 (108)	53.6 (28)	42.1 (19)	63.1 (306)	64.4 (306)	53.9 (306)	58.5 (193)	40.1 (167)	26.3 (259)
53.8 (13)	65.3 (95)	78.2 (124)	56.5 (46)	44.8 (29)	63.8 (345)	85.5 (345)	56.5 (345)	64.5 (220)	55.0 (249)	48.7 (300)
42.9 (14)	50.8 (65)	62.7 (83)	47.8 (23)	31.8 (22)	0.2 (628)	63.5 (628)	43.8 (628)	S	41.9 (346)	49.2 (455)
62.5 (16)	41.9 (105)	77.7 (112)	60.0 (35)	21.3 (89)	5.6 (646)	78.2 (646)	51.9 (646)	47.2 (36)	31.3 (432)	57.3 (473)
54.5 (11)	36.4 (33)	52.8 (36)	54.5 (11)	S	79.7 (59)	83.1 (59)	76.3 (59)	44.7 (47)	40.4 (47)	25.0 (52)
40.0 (10)	47.4 (38)	63.0 (46)	50.0 (14)	62.5 (16)	80.6 (170)	85.3 (170)	64.1 (170)	45.3 (137)	41.3 (126)	26.3 (160)
S	34.5 (200)	51.0 (259)	48.0 (150)	44.3 (122)	45.8 (332)	64.8 (332)	55.7 (332)	55.9 (152)	34.7 (193)	28.6 (255)
S	52.1 (190)	79.3 (242)	50.3 (147)	42.7 (117)	72.9 (321)	79.8 (321)	59.2 (321)	48.7 (234)	50.5 (218)	49.0 (259)
33.3 (15)	43.3 (30)	50.0 (68)	29.4 (17)	45.8 (24)	D	59.5 (148)	60.8 (148)	D	17.7 (62)	31.1 (132)
47.6 (21)	56.7 (30)	64.9 (57)	40.6 (32)	28.1 (32)	60.1 (263)	70.0 (263)	38.8 (263)	51.9 (158)	35.4 (130)	37.3 (212)
48.3 (29)	45.8 (144)	53.8 (225)	41.0 (178)	33.8 (198)	63.0 (405)	60.5 (405)	49.4 (405)	41.2 (255)	32.2 (180)	25.2 (309)
51.3 (39)	52.3 (222)	59.3 (280)	46.0 (215)	38.5 (213)	63.3 (455)	75.2 (455)	54.3 (455)	49.7 (288)	42.7 (253)	36.1 (355)
S	S	S	S	S	38.5 (13)	D	46.2 (13)	S	D, S	20.0 (10)
S	S	S	S	S	57.1 (28)	64.3 (28)	39.3 (28)	62.5 (16)	53.8 (13)	52.6 (19)
S	58.1 (43)	67.9 (81)	48.1 (77)	63.3 (60)	62.4 (221)	50.7 (221)	45.2 (221)	44.2 (138)	31.0 (84)	38.6 (184)
59.4 (32)	51.1 (90)	63.9 (108)	62.9 (105)	52.4 (84)	66.3 (267)	79.8 (267)	66.7 (267)	57.1 (177)	39.2 (189)	39.4 (216)
S	D, S	S	36.4 (33)	S	D	D	38.2 (186)	D, S	D	26.9 (160)
S	S	86.7 (15)	35.4 (48)	S	28.0 (254)	48.0 (254)	24.8 (254)	29.6 (71)	37.3 (75)	25.0 (152)
9.1%–64.3%	34.5%–59.3%	26.8%–59.9%	16.7%–77.8%	16.7%–77.8%	0.2%–93.5%	29.3%–83.1%	40.2%–76.3%	17.1%–58.5%	14.3%–44.2%	20.0%–49.2%
0.069	0.008	0.008	0.035	0.029	0.176	0.030	0.028	0.067	0.011	0.023
18.2%–66.7%	40.9%–65.3%	46.8%–86.7%	10.7%–72.2%	21.3%–65.4%	5.6%–80.6%	48.0%–85.5%	24.6%–68.0%	29.6%–66.4%	27.5%–55.0%	15.3%–57.3%
0.047	0.008	0.029	0.041	0.026	0.158	0.034	0.037	0.039	0.024	0.037

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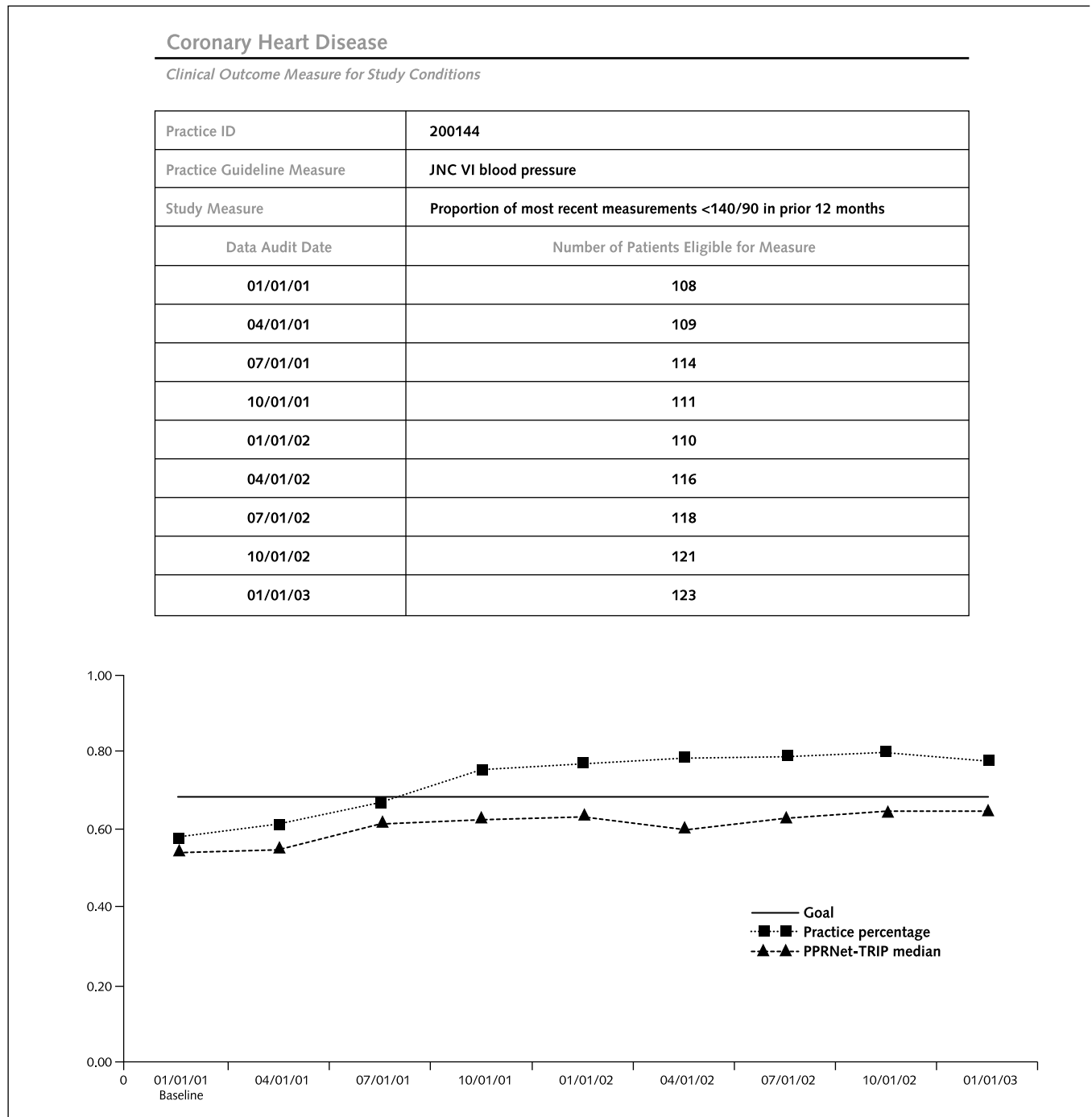
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Appendix Figure. Sample practice report for blood pressure in coronary heart disease.



JNC VI = Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.

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