Improving Care After Myocardial Infarction Using a 2-Year Internet-Delivered Intervention

The Department of Veterans Affairs Myocardial Infarction–Plus Cluster-Randomized Trial

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Background: Cardiovascular risk reduction in ambulatory patients who survive myocardial infarction (MI) is effective but underused. We sought to evaluate a provider-directed, Internet-delivered intervention to improve cardiovascular management for post-MI outpatients.

Methods: The Department of Veterans Affairs (VA) MI-Plus study was a cluster-randomized trial involving 168 community-based primary care clinics and 847 providers in 26 states, the Virgin Islands, and Puerto Rico, from January 1, 2002, through December 31, 2008, with the clinic as the randomization unit. We collected administrative data for 15 847 post-MI patients and medical record data for 10 452 of these. A multicomponent, Internet-delivered intervention included quarterly educational modules, practice guidelines, monthly literature summaries, and automated e-mail reminders delivered to providers for 27 months. Main outcome measures included percentage of patients who achieved each of 7 clinical indicators, a composite score of the 7 clinical indicators, and mean low-density lipoprotein cholesterol and hemoglobin A_{1c} levels.

Results: Clinics had a median of 3 providers (interquartile range, 2-6), with a median of 50.0% of providers (33.3%-66.7%) participating in the study. Patients in intervention clinics had greater improvements (from 70.0% to 85.5%) in the percentages prescribed β-blockers than patients in control clinics (71.9% to 84.0%; adjusted improvement gain for intervention vs control, 2.6%; 95% CI, 0.1%-4.1%). We found nonsignificant differences in improvements favoring patients in intervention clinics for 5 of 6 remaining clinical indicators and levels of low-density lipoprotein cholesterol and hemoglobin A_{1c}.

Conclusion: A longitudinal, Internet-delivered intervention improved only 1 of 7 clinical indicators of cardiovascular management in ambulatory post-MI patients.

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EACH YEAR, 1.3 MILLION AMERICANS experience a myocardial infarction (MI) or death from coronary heart disease (CHD).[1] In 2008, almost 8 million US adults were MI survivors.[1] Randomized trials have demonstrated that aspirin, β-blockers, angiotensin-converting enzyme inhibitors, and hydroxymethylglutaryl–coenzyme A reductase inhibitors (statins) can reduce morbidity and mortality for MI survivors.[2-6] Population-based evidence suggests that better medical treatment and secondary prevention of CHD has led to substantial declines in CHD mortality during the past 3 decades.[7-10] Despite these advances, providers often fail to adhere to evidence-based guidelines for the management and secondary prevention of CHD.[11-16]

Multicomponent interventions can increase adherence to clinical practice guidelines.[17,18] In patients with CHD, multicomponent interventions have been shown to improve in-hospital care[19-22] but have yielded mixed results in primary care settings.[23-25] Although guidelines usually focus on CHD in isolation, ambulatory patients who have survived MI (post-MI patients) frequently have multiple comorbidities that may interfere with adherence to CHD guidelines.[26] Furthermore, interventions to improve adherence are often limited by their short duration and lack of reinforcement, limiting sustainability over time.[27,28] Reliance on academic detailing and site visits may also make many interventions expensive and impractical.[23,24] Delivering an intervention for longer periods using the Internet (eg, online spaced education) may address some of these limitations.[29,30] Moreover, online spaced education may allow

See Invited Commentary at end of article

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intensive interventions to be widely disseminated with minimal marginal costs.

To test whether a longitudinal, multicomponent, Internet-delivered intervention, including educational cases, guidelines, monthly updates, and e-mail reminders, could improve guideline adherence and reduce CHD risk factors among post-MI patients with multiple comorbidities treated in primary care settings, we undertook a national cluster-randomized trial of community-based outpatient clinics affiliated with the Department of Veterans Affairs (VA).

METHODS

TRIAL DESIGN

The VA MI-Plus study was a cluster-randomized trial of post-MI patients with randomization at the clinic level. We were funded through the VA Health Services Research and Development office and by a parallel National Institutes of Health study.[26] The institutional review board at each medical center approved the study.

PARTICIPANTS

Our intervention targeted VA community-based primary care outpatient clinics.[31] We targeted all adults 18 years or older discharged from a participating facility with a primary or secondary diagnosis of acute or previous MI (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes 410.xx or 412.xx) and subsequently treated at a facility-affiliated clinic from January 1, 2002, through December 31, 2008. The index visit was the most recent clinic visit during the relevant study period, that is, January 1, 2002, through November 30, 2004, for the preintervention evaluation and February 1, 2007, through December 31, 2008, for the postintervention evaluation.

STUDY INDICATORS

A panel of 12 experts generated 7 clinical indicators of post-MI monitoring, treatment, and target goals using nominal group technique (eTable 1; http://www.archinternmed.com).[32,33] Monitoring indicators included measurement of low-density lipoprotein cholesterol (LDL-C) levels (all patients) and hemoglobin A_{1c} (HbA_{1c}) levels (all patients with diabetes mellitus) within 18 months of the index visit. Treatment indicators included prescriptions at the index visit for β-blockers, statins, and angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers. Target goals included last LDL-C level of less than 100 mg/dL and last HbA_{1c} level of less than 8% in patients with diabetes mellitus. (To convert LDL-C to millimoles per liter, multiply by 0.0259; to convert HbA_{1c} to a proportion of total hemoglobin, multiply by 0.01.) Although these clinical indicators are process measures, each is a strong independent predictor of clinical outcomes in post-MI patients.[2-6,34]

For the primary analysis, we extracted demographic information (age, race, and sex), diagnoses, medications, and laboratory data from more than 3 million records using the VA Decision Support System files (National Patient Care Data, Austin Information Technology Center, Austin, Texas). Comorbidities were defined using inpatient or outpatient *ICD-9-CM* codes during the 12 to 18 months before the index visit (eTable 2). Because a growing percentage of post-MI patients have contraindications to CHD therapies but often receive them,[12,35] and some contraindications may also be indications (eg, the use of β-blockers in post-MI patients with heart failure), we adjusted for patient comorbidity rather than excluding patients from the denominator for the primary analysis (described in the "Statistical Analysis" subsection).

We performed a secondary analysis to determine receipt of aspirin and to confirm our findings in post-MI patients who were ideal candidates (ie, having no contraindications) for available indicators (for definitions, see eTable 3). We used patient-level data obtained from the VA Office of Quality and Performance (eAppendix).

INTERVENTIONS

The intervention included a multicomponent Web site and pushed e-mail cues with educational content.[31] Eight case-based, interactive educational modules represented the core of the intervention. Each module reviewed the evidence and guidelines for 1 or more of the 7 clinical indicators developed by our expert panel, presented a clinical scenario followed by a series of questions, and provided tailored feedback to health care providers based on their responses. The Web site also included relevant clinical guidelines, monthly summaries of pertinent peer-reviewed manuscripts, downloadable practice tools, and patient educational materials. The Web site used service-oriented architecture and design principles refined previously.[36,37] Iterative usability sessions refined the content. A site map of the VA MI-Plus intervention, which was available from November 1, 2004, through January 25, 2007, is found in eFigure 1. Proactive e-mails, demonstrated to increase participation in Web-delivered provider interventions,[38] notified providers of new updates and materials.

When modules were released, providers in control clinics were sent a link to an existing VA Web site that contained links to a wide range of clinical guidelines for various medical conditions (http://www.healthquality.va.gov/). All enrolled intervention and control health care providers could obtain continuing education credits for reviewing materials on the Web site (for screen shots of the VA MI-Plus Intervention Web site, see eFigures 2-6) and receive a subscription to *The Medical Letter*.

OUTCOMES

The primary outcome was the percentage of patients who achieved each of the 7 clinical indicators. As a secondary outcome, we created a patient-level composite quality indicator score summing and then normalizing to a total of 100 those clinical indicators for which the patient was eligible. All patients were eligible for 3 contributors to the composite score (β-blocker use, angiotensin-converting enzyme inhibitor/angiotensin II receptor blocker use, and LDL-C level measurement), whereas diabetes mellitus and hyperlipidemia each added 2 additional condition-specific indicators. We also calculated mean levels of LDL-C and HbA_{1c}. All outcomes were based on the most recent test or clinic visit. User tracing of server logs assessed intervention uptake. Provider participation was measured by randomization group.

PROVIDER RECRUITMENT AND CLINIC RANDOMIZATION

Recruitment has been described elsewhere.[31] Briefly, among 66 eligible medical centers, we recruited 48 (72.7%) affiliated with 219 clinics, including 957 providers in 26 states, the Virgin Islands, and Puerto Rico; of these, 168 clinics (76.7%) were randomized (ie, had ≥1 of its providers enroll); of the 847 providers in these 168 clinics, 401 (47.3%) participated (**Figure 1**). Providers were recruited by e-mail, postal mail, fax, and telephone. A clinic was enrolled and randomized when the first eligible provider at that clinic logged on to the study Web site.

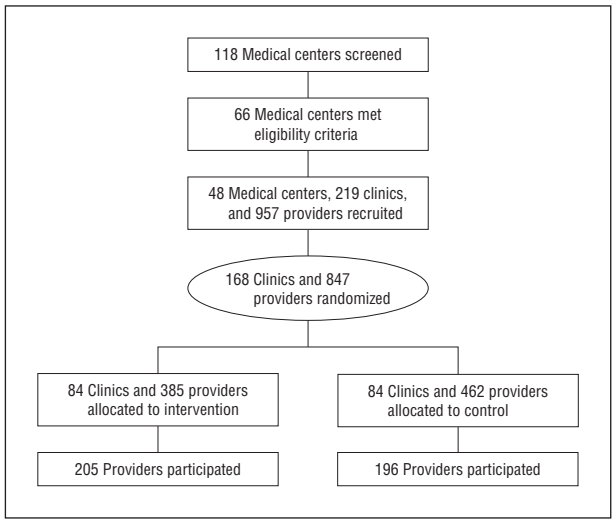

Figure 1. A CONSORT (Consolidated Standards of Reporting Trials) diagram of the selection process. Eligible medical centers required (1) an affiliated institutional review board, (2) 4 or more eligible clinics, and (3) no ongoing potentially overlapping quality improvement project. The 4-clinic requirement was relaxed toward the end of recruitment. Eligible clinics were noncontract (owned and operated by the Department of Veterans Affairs [VA]), delivered primary care, used the VA's electronic health record system, and provided Internet access to all providers.

All providers at a clinic were randomized to the same arm, but only those who logged on were enrolled. Using further e-mail reminders, we recruited providers throughout the 27 months of the intervention. Although we recruited continuously, all clinics had at least 12 months of exposure to the intervention or control Web site. After Web site posting, components remained available for the duration of the study. All providers completed an online consent to participate.

SAMPLE SIZE

The planned sample size of 200 clinics provided at least 80% power with 2-sided $\alpha = .05$ to detect a difference of improvement of 5% in each clinical indicator attributable to the intervention. Our post hoc analysis suggests that we had 80% power to detect a difference of 5%, assuming 168 clinics and an average of at least 33 patients per clinic per period.

STATISTICAL ANALYSIS

We used an intention-to-treat approach for our main analysis, basing our outcome measures on the entire eligible patient population in each of the 168 clinics regardless of the patient's provider enrolling on our Web site. Analyses were at the patient level but accounted for clustering of patients within clinics (unit of randomization). Baseline clinic characteristics were compared between the intervention and control groups using χ^2 tests, unpaired, 2-tailed *t* tests, or Wilcoxon rank sum tests as appropriate.

Performance improvement was calculated as the change (before vs after the intervention) in the proportion of patients receiving each clinical indicator or as the mean change in the LDL-C or HbA_{1c} level. The differences in performance improvement for each indicator were analyzed at the patient level by randomization group. Generalized linear models examined the associations between indicator performance, LDL-C and HbA_{1c} levels, and the main independent variable, randomized group, accounting for patient clustering within clinic and time of observation (before vs after the intervention), with and without adjustment for patient age, race, sex, and comorbidity using a summary count of the 12 comorbidities considered. The *P* value for the randomization group × time interaction assessed the statistical significance of the intervention effect. Analyses were performed before and after stratification by clinic size (number of providers) and by urban or rural location.

For the secondary analysis, using manually abstracted VA performance data, we examined receipt of aspirin and performance by ideal candidates using the same approach as for the primary analysis except we adjusted only for patient clustering within clinics because other patient-level covariates were unavailable. We conducted another secondary analysis to assess whether there was a dose-response effect manifested as a correlation between degree of participation in the intervention and improved performance (eAppendix and eTable 5).

RESULTS

The median number of providers per clinic (interquartile range) was 3 (2-6); most of the clinics were urban (**Table 1**). Clinic characteristics did not differ by intervention group. Patients (n = 15 847) were mostly male with a mean (SD) age of 66 (10) years, 68.5% white, and 8.7% black (**Table 2**). The most common comorbidities were hypertension and hyperlipidemia.

PROVIDER PARTICIPATION AND ACTIVITY

The median percentage of providers from all 168 clinics who logged on to the intervention or control Web sites was 50.0%, higher for intervention than for control clinics (58.6% vs 50.0%; $P = .03$). Provider Web site activity was greater at intervention compared with control clinics (median number of Web site visits per provider, 3.7 vs 0.8; median number of Web site pages accessed per provider, 57.7 vs 6.2; $P < .001$ for both) (Table 1). Among the intervention group, the median number of completed case modules (maximum, 8) was 1.8 (interquartile range, 1-3) modules per provider and 3.3 (interquartile range, 2-5) modules per participating provider. Among providers who enrolled, the median time between the first log-on to the end of the study (active enrollment) was similar in intervention and control groups (17.0 vs 15.8 months; $P = .2$). However, the median time of active participation (time from the first to last log-on) and the proportion of providers with at least 12 months of active participation were higher in intervention vs control clinics ($P < .001$ for both).

Clinic size was inversely correlated with all measures of provider activity, including proportion of providers logged on ($r = -0.55$), mean Web site visits per provider ($r = -0.30$), and mean number of Web site pages accessed per provider ($r = -0.24$) (all, $P < .001$). Correlations were similar across randomization groups.

CHANGES IN CLINICAL INDICATOR PERFORMANCE

Over time, all quality measures trended toward improved performance, and improvement was slightly greater in intervention vs control clinics for all 9 measures (**Table 3**). After adjustment for patient demographics, comorbidity score, and clustering, intervention clinic patients had greater improvements than control

Table 1. Characteristics and Participation Measures of Study Clinics by Randomization Group: the VA MI-Plus Study, 2002-2008[a]

Characteristic	Overall (N=168)	Intervention Group (n=84)	Control Group (n=84)	*P* Value[b]
Parent facility designated as a health services research program	39 (23.2)	19 (22.6)	20 (23.8)	.85
Urban location[c]	139 (84.2)	70 (84.3)	69 (84.1)	.97
Geographic region				
New England/Mid-Atlantic	48 (28.6)	28 (33.3)	20 (23.8)	
Midwest	54 (32.1)	25 (29.8)	29 (34.5)	
South	49 (29.2)	23 (27.4)	26 (31.0)	.71
West	14 (8.3)	7 (8.3)	7 (8.3)	
Puerto Rico/Virgin Islands	3 (1.8)	1 (1.2)	2 (2.4)	
No. of health care providers				
1 or 2	53 (31.5)	29 (34.5)	24 (28.6)	
3 or 4	55 (32.7)	30 (35.7)	25 (29.8)	.27
≥5	60 (35.7)	25 (29.8)	35 (41.7)	
Median (IQR)	3 (2-6)	3 (2-5)	4 (2-7)	.18
Participation measure				
Providers per clinic who participated (logged on to the Web site), median % (IQR)	50.0 (33.3-75.0)	58.6 (39.2-100.0)	50.0 (33.3-66.7)	.03
No. of Web site visits per provider per clinic, median (IQR)	1.7 (0.6-3.7)	3.7 (2.0-6.8)	0.8 (0.5-1.5)	<.001
No. of Web site pages accessed per provider per clinic, median (IQR)	17.9 (4.5-62.4)	57.7 (29.2-99.5)	6.2 (2.2-11.3)	<.001
No. of months from first log-on to study closure, median (IQR)[d]	16.5 (12.5-19.1)	17.0 (13.3-19.3)	15.8 (11.0-18.9)	.25
No. of months from first to last log-on (active participation), median (IQR)[d]	2.7 (0.0-11.5)	7.6 (0.7-14.2)	0.0 (0.0-3.8)	<.001
Providers with active participation of ≥12 mo, No./total No. (%)[d]	94/401 (23.4)	74/205 (36.1)	20/196 (10.2)	<.001

Abbreviations: IQR, interquartile range; VA MI-Plus, Department of Veterans Affairs Myocardial Infarction–Plus.
[a] Unless otherwise indicated, data are expressed as number (percentage) of clinics. Percentages have been rounded and might not total 100.
[b] Calculated using χ^2 test for number (percentage) and Wilcoxon rank sum test for median (IQR).
[c] Urban/rural location designation was not available for the 3 clinics in Puerto Rico and the Virgin Islands.
[d] Indicates participation measured among providers who enrolled.

Table 2. Characteristics of Post-MI Patients in Study Clinics by Randomization Group and Intervention Periods: the VA MI-Plus Study, 2002-2008[a]

	Before Intervention		After Intervention	
Characteristic	Intervention Group (n=4024)	Control Group (n=3727)	Intervention Group (n=3080)	Control Group (n=2911)
Male sex	98.6	98.3	98.8	98.7
Age at index visit, y				
<55	16.9	15.0	10.6	9.0
55-64	33.7	35.7	37.9	37.9
65-74	25.4	26.1	25.1	26.7
≥75	24.0	23.2	26.5	26.4
Race				
White	68.2	69.4	66.0	70.6
Black	9.7	8.1	8.7	8.0
Other	1.7	2.3	1.5	1.6
Missing/unknown	20.3	20.3	23.8	19.9
Hypertension	86.6	85.0	87.0	84.4
Hyperlipidemia	77.5	75.7	84.0	83.6
Diabetes mellitus	44.0	42.2	46.4	46.0
Heart failure	29.0	27.4	30.5	28.8
Emphysema	30.2	26.4	29.5	27.7
Depression	23.7	25.1	22.1	20.4
Chronic kidney disease	9.3	9.8	17.7	17.5
Stroke	12.3	11.5	11.1	11.0
Cancer	12.4	11.6	12.4	13.3
Peripheral vascular disease	8.9	8.3	6.0	6.2
Dementia	6.0	5.7	7.7	7.3
Asthma	5.6	5.3	5.0	3.5
No. of conditions, median (IQR)	3 (2)	3 (2)	3 (2)	3 (2)

Abbreviations: IQR, interquartile range; MI, myocardial infarction; VA MI-Plus, Department of Veterans Affairs MI-Plus.
[a] Unless otherwise indicated, data are expressed as percentage of patients.

Table 3. Performance of Quality Indicators Before and After Intervention Among Unselected Patients Based on Administrative Data and Intention-to-Treat Analysis: the VA MI-Plus Study, 2002-2008[a]

Indicator	Intervention Group		Control Group		Difference in Improvement, %[b]		
	Before Intervention	After Intervention	Before Intervention	After Intervention	Unadjusted	Adjusted (95% CI)[c]	*P* Value
Monitoring[d]							
LDL-C level measurement in previous 18 mo	3429/4024 (85.2)	2711/3080 (88.0)	3241/3727 (87.0)	2594/2911 (89.1)	0.7	–0.1 (–8.9 to 4.7)	.96
HbA_{1c} level measurement in previous 18 mo for adults with diabetes mellitus	1603/2129 (75.3)	1357/1563 (86.8)	1515/1916 (79.1)	1291/1457 (88.6)	2.0	0.4 (–1.4 to 1.9)	.62
Treatment[e]							
Prescription for β-blocker	2818/4024 (70.0)	2633/3080 (85.5)	2678/3727 (71.9)	2446/2911 (84.0)	3.4	2.6 (0.1 to 4.1)	.04
Prescription for statin	2994/3424 (87.4)	2708/2825 (95.9)	2773/3157 (87.8)	2506/2630 (95.3)	1.0	0.7 (–1.3 to 2.1)	.42
Prescription for ACEI or ARB	2806/4024 (69.7)	2299/3080 (74.6)	2631/3727 (70.6)	2141/2911 (73.5)	1.9	1.8 (–1.4 to 4.8)	.25
Achievement of Target Levels[d]							
Last LDL-C level <100 mg/dL	1738/3322 (52.3)	1922/2663 (72.2)	1699/3077 (55.2)	1766/2509 (70.4)	4.7	4.0 (–0.3 to 7.9)	.06
Last HbA_{1c} level <8% in adults with diabetes mellitus	1141/1600 (71.3)	1048/1356 (77.3)	1107/1514 (73.1)	953/1291 (73.8)	5.3	4.6 (–1.5 to 9.8)	.13
Composite Clinical Indicator Score[f]							
All patients, %	69.2	79.7	71.1	79.0	2.6	2.3 (–0.6 to 5.1)	.12
Patients with diabetes mellitus and hyperlipidemia, %	75.0	83.8	77.5	83.4	2.9	2.6 (–0.4 to 5.7)	.09
Physiological Levels[e]							
Last LDL-C level, mean (SD) reduction, mg/dL	102.4 (36.1)	87.0 (33.8)	100.5 (36.2)	88.8 (33.2)	3.7	3.5 (–0.8 to 7.7)	.10
Last HbA_{1c} level, mean reduction (SD), %	7.4 (1.8)	7.2 (1.5)	7.4 (1.7)	7.3 (1.6)	0.1	0.2 (–0.1 to 0.5)	.12

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; HbA_{1c}, hemoglobin A_{1c}; LDL-C, low-density lipoprotein cholesterol; VA MI-Plus, Department of Veterans Affairs Myocardial Infarction–Plus.

SI conversion factor: To convert cholesterol to millimoles per liter, multiply by 0.0259.

[a] Unless otherwise indicated, data are expressed as number of patients with quality indicator/number of patients eligible for indicator (percentage).

[b] Measured as the change (postintervention minus preintervention values, except for the physiological differences, for which the signs are reversed because decrease signifies improvement) among intervention clinics minus the change among control clinics. A positive difference reflects greater improvement among intervention clinics.

[c] With use of generalized mixed-effects regression models, these differences and the associated 95% CIs and *P* values reflect adjustment for patient clustering within clinics, patient-level covariates (age, sex, race, and comorbidity score), and random clinic effects (to account for correlation of patient measures within individual clinics). Comorbidity score was calculated using a composite score based on the following 12 major health conditions: hypertension, hyperlipidemia, diabetes mellitus, heart failure, emphysema, depression, chronic kidney disease, stroke, cancer (excluding skin, prostate, and thyroid), peripheral vascular disease, dementia, and asthma.

[d] Includes eligible patients for whom a measurement was obtained within 18 months of the index visit.

[e] Measured at the time of the index visit.

[f] The sum of the 7 clinical indicators for which the patient was eligible. All members of the cohort were eligible for 3 contributors to the composite score (β-blocker prescription, ACEI/ARB prescription, and LDL-C level measurement), whereas diabetes mellitus and hyperlipidemia each added 2 additional condition-specific indicators.

clinic patients for the prescription for β-blockers (adjusted improvement gain, 2.6%; 95% CI, 0.1%-4.1%). Small statistically nonsignificant differences in improvements favoring patients in intervention clinics were observed after adjustment in 7 of the 8 remaining measures (**Figure 2**). Results were similar in small or large clinics and in rural or urban clinics (data not shown). The composite quality indicator score tended to improve more for all patients or for patients with diabetes mellitus and hyperlipidemia (those at highest cardiovascular risk) in intervention vs control clinics, but these gains were not statistically significant (*P* = .12 and *P* = .09, respectively, for the group × time interaction terms).

SECONDARY ANALYSIS

Our analysis using medical record–abstracted data (n = 10 452) showed consistent results, again favoring the intervention for the LDL-C level, with borderline significance (*P* = .07) (eTable 4). Our analysis assessing a dose-response effect of provider participation revealed trends all as expected, but only statistically significant for some indicators, particularly when defined by the number of Web pages accessed per provider. For example, findings of a mean LDL-C level of less than 100 mg/dL increased significantly more from before the intervention to after the intervention as the level of provider participation increased, whether the latter was defined as the number of Web site visits per provider (*P* = .02) or as the number of pages accessed per provider (*P* = .01) (eTable 5).

COMMENT

Our longitudinal Internet-delivered intervention improved performance on only 1 of 7 quality indicators for care of post-MI patients, namely, prescription of β-blockers. These findings were observed in small and large and in rural and urban clinics and persisted after adjustment for patient demographics and comorbidity.

Few studies have assessed multicomponent interventions to improve CHD management in the primary care setting, and results have been mixed.[25] Among 20 primary care practices, an intervention with academic detailing, quality improvement facilitation, and audit and feedback demonstrated nonsignificant improvements in

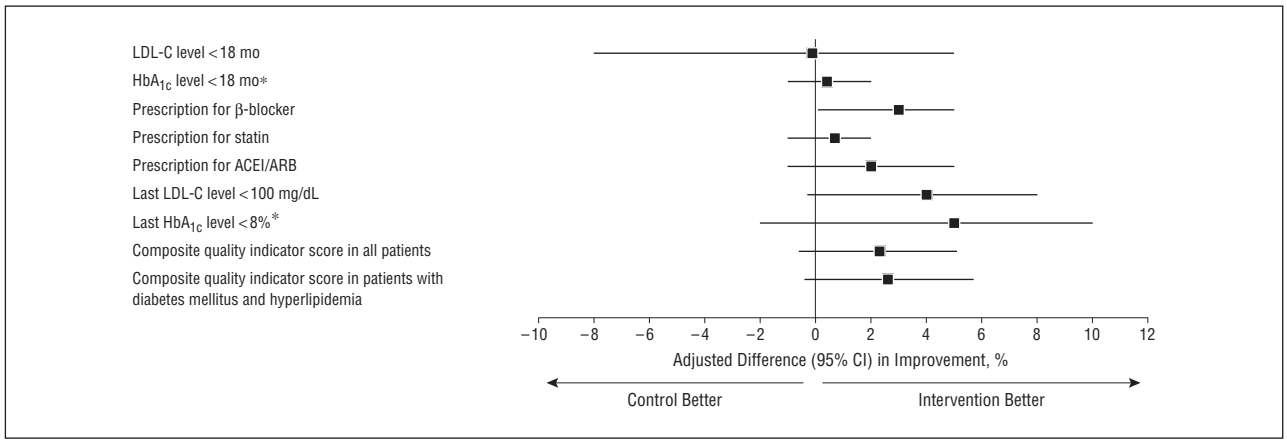

Figure 2. Adjusted differences in improvement in the clinical indicators, intervention minus control group. (Change measured as postintervention minus preintervention values, except for the physiological differences, for which the signs are reversed because a decrease signifies improvement among intervention clinics minus the change among control clinics.) With the use of generalized mixed-effects regression models, these differences and the associated 95% CIs and *P* values reflect adjustment for patient clustering within clinics, patient-level covariates (age, sex, race, and comorbidity score), and random clinic effects (to account for correlation of patient measures within individual clinics). The comorbidity score was calculated using a composite score based on the following 12 major health conditions: hypertension, hyperlipidemia, diabetes mellitus, heart failure, emphysema, depression, chronic kidney disease, stroke, cancer (excluding skin, prostate, and thyroid), peripheral vascular disease, dementia, and asthma. Levels of low-density lipoprotein cholesterol (LDL-C) and hemoglobin A_{1c} (HbA_{1c}) are provided for eligible patients who had a measurement obtained within 18 months of the index visit. The laboratory level or prescription was measured at the time of the index visit. ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker. *Includes adults with diabetes mellitus. To convert LDL-C levels to millimoles per liter, multiply by 0.0259.

blood pressure in patients with CHD but no improvements in lipid levels or β-blocker prescriptions.[23] An 18-month intervention with tailored care plans and academic detailing did not improve blood pressure or lipid levels but did reduce the number of hospitalizations in patients with CHD treated in 48 primary care practices.[24] Taken together with our results, these studies show the challenges of improving processes of care or clinical outcomes with intensive interventions in primary care.[39]

Our study has several strengths. Our large-scale intervention was disseminated to 168 community-based outpatient clinics across a wide geographic distribution. Our "light-touch" longitudinal intervention combined low-intensity and high-dissemination ability[40,41] and had low staffing and resource requirements. We used online spaced education with automated e-mail reminders to generate knowledge transfer, increase learning efficiency, and change provider behavior. Also, our system included downloadable patient support tools. We used e-mail marketing and continuing medical education credits to enhance engagement. The pushed cues and reminders allowed us to improve on our experience with provider participation and to achieve sustained intervention activity by some intervention providers.[37,42] Although our intervention was multicomponent, once designed it was sustained with minimal effort. It is scalable to other settings at a cost that is modest compared with other quality improvement interventions. Although the improvement in the number of β-blocker prescriptions attributable to the intervention was modest, published estimates[3,9] indicate that an additional 3% of CHD deaths may be prevented or postponed if the β-blocker prescription improvements are maintained for at least 6 months.

Still, our intervention improved only 1 of the studied process measures. Several factors may account for this. Consistent with previous research,[43] the high baseline performance—higher than in other reports[9,23,24]—may have limited efforts to further improve performance. Also, as is common in implementation studies, some intervention clinics had low-intervention fidelity (eg, the intervention delivered was never received for providers in the intervention group who did not enroll). Our intervention might have had a much larger effect had baseline performance been lower or had it successfully engaged more providers. Indeed, in a post hoc, as-treated analysis, the intensity of provider participation in our intervention was positively associated with clinical indicator performance (eTable 5). During our study period, there were intense efforts by VA and non-VA health systems to improve performance on our indicators. Our findings of large improvements in performance in the control and intervention groups (Table 3) suggest that these secular changes may have minimized our ability to detect the effect of our intervention. Moreover, interventions targeted solely at providers may be less effective than those involving teams or systems reengineering.[44,45]

Several limitations merit discussion. The VA findings may not be generalizable to other clinical settings or to women. However, the VA is the largest integrated health care delivery system in the United States, with 153 medical centers and more than 900 outpatient clinics providing care to about 5.5 million veterans in 2008.[46] Moreover, the VA offers unique uniformity of data and geographic diversity for intervention studies. Although our providers may be a select group owing to participation in a quality improvement study, their performance on the indicators studied was similar to that of all VA clinic providers. For example, performance on the indicator for control of lipid levels was 59.4% and 63.6% in 2005 (baseline) for the intervention and control groups, respectively, vs 55% in 2004 for all VA clinic providers. Similarly, these performances rose to 70.7% and 68.3% in 2007 through 2008 in our study compared with 68% in 2007 for all VA clinics. We did not evaluate differences in patient-centered or clinical outcomes, such as cardiovascular events,

because our sample size did not provide sufficient power to detect a clinically meaningful difference. Still, our study indicators are commonly used to assess provider adherence to CHD guidelines and to determine pay for performance in VA and non-VA health systems.

Our study has potential implications for implementation research. Disease management programs may improve performance in patients with CHD and/or heart failure, but they are resource intensive.[47] Electronic health records and clinical decision support may help providers manage chronic disease, but their benefits on ambulatory care quality are uncertain, and most ambulatory practices do not currently have electronic health records.[48] In addition, most electronic health records do not integrate educational systems and patient support tools. The current ubiquity of Internet access positions the Internet as a promising tool for implementation research and quality improvement. Given major initiatives to increase the meaningful use of health information technology and to improve health information technology systems with performance bonuses for tools that ensure patient-centered appropriate care,[49] multicomponent, Internet-delivered interventions may be feasible and cost-effective strategies to improve ambulatory care quality. Some previous Internet-delivered provider educational interventions have improved single performance measures for which baseline performance was low.[36,50] However, consistent with previous research,[37,42] our results suggest that light-touch educational interventions are less likely to be effective quality improvement strategies when baseline performance is high, when societal efforts targeting the same goals are under way, or when targeting a complex set of process measures.

In conclusion, we demonstrated that a longitudinal provider-directed, multicomponent, Internet-delivered intervention improved only 1 of 7 clinical indicators of cardiovascular management performance for post-MI outpatients. Light-touch educational interventions may improve quality less effectively when baseline performance is high or when targeting a complex set of process measures.

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REFERENCES

1. Roger VL, Go AS, Lloyd-Jones DM, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2011 update: a report from the American Heart Association [published correction appears in *Circulation*. 2011;123(6):e240]. *Circulation*. 2011;123(4):e18-e209. doi:10.1161/CIR.0b013e3182009701.
2. Antithrombotic Trialists' Collaboration. Collaborative meta-analysis of randomised trials of antiplatelet therapy for prevention of death, myocardial infarction, and stroke in high risk patients. *BMJ*. 2002;324(7329):71-86.
3. Freemantle N, Cleland J, Young P, Mason J, Harrison J. β Blockade after myocardial infarction: systematic review and meta regression analysis. *BMJ*. 1999;318(7200):1730-1737.
4. Flather MD, Yusuf S, Køber L, et al; ACE-Inhibitor Myocardial Infarction Collaborative Group. Long-term ACE-inhibitor therapy in patients with heart failure or left-ventricular dysfunction: a systematic overview of data from individual patients. *Lancet*. 2000;355(9215):1575-1581.
5. Baigent C, Keech A, Kearney PM, et al; Cholesterol Treatment Trialists' (CTT) Collaborators. Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90,056 participants in 14 randomised trials of statins. *Lancet*. 2005;366(9493):1267-1278.
6. Wilt TJ, Bloomfield HE, MacDonald R, et al. Effectiveness of statin therapy in adults with coronary heart disease. *Arch Intern Med*. 2004;164(13):1427-1436.
7. Hunink MG, Goldman L, Tosteson AN, et al. The recent decline in mortality from coronary heart disease, 1980-1990: the effect of secular trends in risk factors and treatment. *JAMA*. 1997;277(7):535-542.
8. Setoguchi S, Glynn RJ, Avorn J, Mittleman MA, Levin R, Winkelmayer WC. Improvements in long-term mortality after myocardial infarction and increased use of cardiovascular drugs after discharge: a 10-year trend analysis. *J Am Coll Cardiol*. 2008;51(13):1247-1254.
9. Ford ES, Ajani UA, Croft JB, et al. Explaining the decrease in U.S. deaths from coronary disease, 1980-2000. *N Engl J Med*. 2007;356(23):2388-2398.
10. Wijeysundera HC, Machado M, Farahati F, et al. Association of temporal trends in risk factors and treatment uptake with coronary heart disease mortality, 1994-2005. *JAMA*. 2010;303(18):1841-1847.
11. Asch SM, Sloss EM, Hogan C, Brook RH, Kravitz RL. Measuring underuse of necessary care among elderly Medicare beneficiaries using inpatient and outpatient claims. *JAMA*. 2000;284(18):2325-2333.
12. Funkhouser E, Houston TK, Levine DA, Richman J, Allison JJ, Kiefe CI. Physician and patient influences on provider performance: β-blockers in postmyocardial infarction management in the MI-Plus study. *Circ Cardiovasc Qual Outcomes*. 2011;4(1):99-106.
13. Luft HS. Variations in patterns of care and outcomes after acute myocardial infarction for Medicare beneficiaries in fee-for-service and HMO settings. *Health Serv Res*. 2003;38(4):1065-1079.
14. Seddon ME, Ayanian JZ, Landrum MB, et al. Quality of ambulatory care after myocardial infarction among Medicare patients by type of insurance and region. *Am J Med*. 2001;111(1):24-32.

15. Lee HY, Cooke CE, Robertson TA. Use of secondary prevention drug therapy in patients with acute coronary syndrome after hospital discharge. *J Manag Care Pharm*. 2008;14(3):271-280.
16. McGlynn EA, Asch SM, Adams J, et al. The quality of health care delivered to adults in the United States. *N Engl J Med*. 2003;348(26):2635-2645.
17. Weingarten SR, Henning JM, Badamgarav E, et al. Interventions used in disease management programmes for patients with chronic illness—which ones work? meta-analysis of published reports. *BMJ*. 2002;325(7370):925. doi:10.1136/bmj.325.7370.925.
18. Bertoni AG, Bonds DE, Chen H, et al. Impact of a multifaceted intervention on cholesterol management in primary care practices: guideline adherence for heart health randomized trial. *Arch Intern Med*. 2009;169(7):678-686.
19. Bailey TC, Noirot LA, Blickensderfer A, et al. An intervention to improve secondary prevention of coronary heart disease. *Arch Intern Med*. 2007;167(6):586-590.
20. Lai CL, Fan CM, Liao PC, et al. Impact of an audit program and other factors on door-to-balloon times in acute ST-elevation myocardial infarction patients destined for primary coronary intervention. *Acad Emerg Med*. 2009;16(4):333-342.
21. Kinsman LD, Buykx P, Humphreys JS, Snow PC, Willis J. A cluster randomised trial to assess the impact of clinical pathways on AMI management in rural Australian emergency departments. *BMC Health Serv Res*. May 25, 2009;9:83. doi:10.1186/1472-6963-9-83.
22. Birkhead JS, Walker L, Pearson M, Weston C, Cunningham AD, Rickards AF; National Audit of Myocardial Infarction Project Steering Group. Improving care for patients with acute coronary syndromes: initial results from the National Audit of Myocardial Infarction Project (MINAP). *Heart*. 2004;90(9):1004-1009.
23. Ornstein S, Jenkins RG, Nietert PJ, et al. A multimethod quality improvement intervention to improve preventive cardiovascular care: a cluster randomized trial. *Ann Intern Med*. 2004;141(7):523-532.
24. Murphy AW, Cupples ME, Smith SM, Byrne M, Byrne MC, Newell J; SPHERE Study Team. Effect of tailored practice and patient care plans on secondary prevention of heart disease in general practice: cluster randomised controlled trial. *BMJ*. 2009;339:b4220. doi:10.1136/bmj.b4220.
25. Scott IA, Denaro CP, Bennett CJ, et al. Achieving better in-hospital and after-hospital care of patients with acute cardiac disease. *Med J Aust*. 2004;180(10)(suppl):S83-S88.
26. Sales AE, Tipton EF, Levine DA, et al. Are co-morbidities associated with guideline adherence? the MI-Plus study of Medicare patients. *J Gen Intern Med*. 2009;24(11):1205-1210.
27. Shortell SM, Bennett CL, Byck GR. Assessing the impact of continuous quality improvement on clinical practice: what it will take to accelerate progress. *Milbank Q*. 1998;76(4):593-624, 510.
28. Shortell SM, O'Brien JL, Carman JM, et al. Assessing the impact of continuous quality improvement/total quality management: concept versus implementation. *Health Serv Res*. 1995;30(2):377-401.
29. Kerfoot BP, Fu Y, Baker H, Connelly D, Ritchey ML, Genega EM. Online spaced education generates transfer and improves long-term retention of diagnostic skills: a randomized controlled trial. *J Am Coll Surg*. 2010;211(3):331-337.e1. doi:10.1016/j.jamcollsurg.2010.04.023.
30. Kerfoot BP, Kearney MC, Connelly D, Ritchey ML. Interactive spaced education to assess and improve knowledge of clinical practice guidelines: a randomized controlled trial. *Ann Surg*. 2009;249(5):744-749.
31. Funkhouser EM, Levine DA, Gerald JK, et al. Recruitment activities for a nationwide, population-based group-randomized trial: the VA MI-Plus study [published online September 9, 2011]. *Implement Sci*. 2011;6:105. doi:10.1186/1748-5908-6-105.
32. McGlynn EA. Choosing and evaluating clinical performance measures. *Jt Comm J Qual Improv*. 1998;24(9):470-479.
33. Peña A, Virk SS, Shewchuk RM, Allison JJ, Williams OD, Kiefe CI. Validity versus feasibility for quality of care indicators: expert panel results from the MI-Plus study. *Int J Qual Health Care*. 2010;22(3):201-209.
34. Selvin E, Marinopoulos S, Berkenblit G, et al. Meta-analysis: glycosylated hemoglobin and cardiovascular disease in diabetes mellitus. *Ann Intern Med*. 2004;141(6):421-431.
35. Bernheim SM, Wang Y, Bradley EH, et al. Who is missing from the measures? trends in the proportion and treatment of patients potentially excluded from publicly reported quality measures. *Am Heart J*. 2010;160(5):943-950.e1-5. doi:10.1016/j.ahj.2010.06.046.
36. Allison JJ, Kiefe CI, Wall T, et al. Multicomponent Internet continuing medical education to promote chlamydia screening. *Am J Prev Med*. 2005;28(3):285-290.
37. Houston TK, Funkhouser E, Allison JJ, Levine DA, Williams OD, Kiefe CI. Multiple measures of provider participation in Internet delivered interventions. *Stud Health Technol Inform*. 2007;129(pt 2):1401-1405.
38. Houston TK, Coley HL, Sadasivam RS, et al; DPBRN Collaborative Group. Impact of content-specific email reminders on provider participation in an online intervention: a dental PBRN study. *Stud Health Technol Inform*. 2010;160(pt 2):801-805.
39. Landon BE, Hicks LS, O'Malley AJ, et al. Improving the management of chronic disease at community health centers. *N Engl J Med*. 2007;356(9):921-934.
40. Glasgow RE, Klesges LM, Dzewaltowski DA, Estabrooks PA, Vogt TM. Evaluating the impact of health promotion programs: using the RE-AIM framework to form summary measures for decision making involving complex issues. *Health Educ Res*. 2006;21(5):688-694.
41. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health*. 1999;89(9):1322-1327.
42. Colón-Emeric CS, Lyles KW, House P, et al. Randomized trial to improve fracture prevention in nursing home residents. *Am J Med*. 2007;120(10):886-892.
43. Hysong SJ. Meta-analysis: audit and feedback features impact effectiveness on care quality. *Med Care*. 2009;47(3):356-363.
44. Grumbach K, Bodenheimer T. Can health care teams improve primary care practice? *JAMA*. 2004;291(10):1246-1251.
45. Dietrich AJ, Oxman TE, Williams JW Jr, et al. Re-engineering systems for the treatment of depression in primary care: cluster randomised controlled trial. *BMJ*. 2004;329(7466):602. doi:10.1136/bmj.38219.481250.55.
46. US Department of Veterans Affairs. 2008 VA fact sheet. http://www.va.gov/health/MedicalCenters.asp. Accessed April 5, 2011.
47. Coberley C, Morrow G, McGinnis M, et al. Increased adherence to cardiac standards of care during participation in cardiac disease management programs. *Dis Manag*. 2008;11(2):111-118.
48. Romano MJ, Stafford RS. Electronic health records and clinical decision support systems: impact on national ambulatory care quality. *Arch Intern Med*. 2011;171(10):897-903.
49. Blumenthal D. Launching HITECH. *N Engl J Med*. 2010;362(5):382-385.
50. Houston TK, Richman JS, Ray MN, et al; DPBRN Collaborative Group. Internet delivered support for tobacco control in dental practice: randomized controlled trial. *J Med Internet Res*. 2008;10(5):e38. doi:10.2196/jmir.1095.

INVITED COMMENTARY

Being Successful at Prevention

Making It Easy to Do the Right Thing

Superior doctors prevent disease." While this may seem like a timely catchphrase in an era of accountable care organizations and medical homes, this adage is anything but new. In fact, it was a central theme of *The Yellow Emperor's Classic of Medicine*,[1] penned more than 2 millennia ago, and it most assuredly has been asserted in some form or another by every generation of health care instructors since then. The prevention of cardiovascular (CV) disease is a particularly critical target for implementing optimal preventive strategies. Not only is CV disease the leading cause of death, but it also is the most costly disease in the United States. Currently, it accounts for 17%