Physician and Patient Influences on Provider Performance

β-Blockers in Postmyocardial Infarction Management in the MI-Plus Study

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Background—Efforts to improve the quality of care for patients with cardiovascular disease frequently target the decrease of physician-level performance variability. We assessed how variability in providing β-blockers to ambulatory postmyocardial infarction (MI) patients was influenced by physician and patient level characteristics.

Methods and Results—β-Blocker prescription and patient characteristics were abstracted from charts of post-MI patients treated by 133 primary care physicians between 2003 and 2007 and linked to physician and practice characteristics. Associations of β-blocker prescription with physician- and patient-level characteristics were examined using mixed-effects models, with physician-level effects as random. Mean physician-specific predicted probabilities and the intraclass correlations, which assessed the proportion of variance explainable at the physician level, were estimated. Of 1901 patients without major contraindication, 69.1% (range across physicians, 20% to 100%) were prescribed β-blockers. Prescription varied with comorbidity from 78.3% in patients with chronic kidney disease to 54.7% for patients with stroke. Although physician characteristics such as older physician age, group practice, and rural location were each positively associated with β-blocker prescription, physician factors accounted for only 5% to 8% of the variance in β-blocker prescription; the preponderance of the variance, 92% to 95%, was at the patient level. The mean physician-specific probability of β-blocker prescription (95% confidence interval) in the fully adjusted model was 63% (61% to 65%).

Conclusions—β-Blocker prescription rates were surprisingly low. The contribution of physician factors to overall variability in β-blocker prescription, however, was limited. Increasing evidence-based use of β-blockers may not be accomplished by focusing mostly on differential performance across physicians. (Circ Cardiovasc Qual Outcomes. 2011;4:99-106.)

Key Words: myocardial infarction ▪ β-blockers ▪ provider performance

Evidence-based performance measures derived from medical record review have been used to identify variations in quality of care, followed by targeted provider feedback to encourage improvement.1–3 Recently, performance measures have become the basis for incentives in pay-for-performance initiatives. Public reporting of provider performance is rapidly becoming a reality, with the intent of motivating providers to improve quality and to allow health care consumers to make better informed choices. Although not always made explicit, an assumption that commonly underlies quality improvement interventions is that performance variability across providers must be reduced.

Medical record–based measurement of guideline-concordant, high-quality care, however, is dependent on more than provider performance. Rates of guideline-concordant care may be influenced by the organization and regional environment in which care is provided. Although attempts have been made to compare providers with local standards, organizational or environmental effects that may influence care are not accounted for in simple performance measures. Patient complexity also influences guideline-concordant care delivery; patient case mix or varying complexity is also not accounted for in many current performance measures. An assumption implicitly accepted in much quality improvement projects derived from analysis of patterns of care, and therefore required no special funding on the part of this contractor.

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research is that, to improve quality, interventions must be targeted to the epicenter of maximum variation. If guideline concordance is mostly related to provider characteristics (a physician “signature”), providing personalized feedback and differential pay based on performance is an intuitively compelling avenue for reducing variation. If variations are more related to the environment in which a provider practices or the provider’s patients, then provider-level performance pay may be an inappropriately blunt tool to improve delivery of guideline concordant care.

In a large, community-based sample of providers, we assessed how variations in prescribing β-blockers to ambulatory postmyocardial infarction (MI) patients were influenced by patient characteristics as opposed to characteristics measured at the provider level, be they personal or practice provider characteristics. We chose β-blockers as an example of an outcome of performance measures because of its significant mortality benefit, its known variation, and because prescription of a β-blocker is clearly in the hands of the individual provider. Many β-blockers are inexpensive compared with other therapies and therefore may be less influenced by environmental factors. Prescription of β-blockers, however, might be influenced by patient characteristics such as markers of cardiovascular disease severity and comorbidities that may be relative contraindications. Our primary goal was to explore sources of variance in this common and important therapy for post-MI patients. A secondary goal was to describe physician- and patient-level characteristics associated with receipt of β-blocker prescription.

WHAT IS KNOWN

- Although rates of β-blocker prescription immediately after hospitalization for acute myocardial infarction are high, less is known about longer-term β-blocker use in this population.
- Current accountability efforts (eg, pay-for-performance) focus on the clinician as the source of variability in quality of processes of care such as β-blockers after acute myocardial infarction.
- Formal assessment of the extent to which variability is attributable to the clinicians is not well characterized.

WHAT THE STUDY ADDS

- In this study cohort, long-term β-blocker use in ambulatory postmyocardial infarction patients was low (mean, 69%) and variable (ranging from 20% to 100%).
- Variability attributable to physician was minimal (5% to 8%), with most (92% to 95%) attributable to the patient.

Methods

Study Design, Setting, and Sample
We assessed use of β-blockers in 2455 ambulatory patients with a history of MI (post-MI patients) treated by 139 primary care physicians in community practices between 2003 and 2007. We used data from the MI-Plus study, a randomized trial of an Internet-delivered continuing professional development intervention, described elsewhere.4 MI-Plus recruitment targeted community-based primary care physicians in Alabama caring for post-MI patients. These physicians were identified by linking a database purchased from a commercial vendor (SK&A Information Services) by the Division of Continuing Medical Education, University of Alabama School of Medicine, to Medicare claims data. The Quality Improvement Organization for Alabama matched MI cases to physicians by linking inpatient and outpatient claims files (1999 to 2004). MI cases were identified using ICD-9 codes 410.xx (acute MI) and 412.xx (prior MI). We received only aggregated information with no patient identifiers. To be eligible for random assignment, physicians had to confirm at enrollment that they cared for Medicare post-MI patients. Per study protocol, only 1 physician per practice was enrolled. Institutional review board approval for the study was granted from the University of Alabama at Birmingham.

Quality Improvement Organization–trained medical record abstractors reviewed a median of 15 charts of post-MI patients followed by each physician. Of 3215 medical records, 2455 were eligible, available, and complete. Medical records were not eligible for abstraction if the patient had terminal illness, a history of any organ transplant, active cancer, or if there were no visits to the primary care physician since the index hospitalization. Chart abstractions were not considered complete if there were no data from the chart problem list or the physician’s visit diagnoses. We excluded 90 charts with the most recent visit date >3 years before abstraction date or with last visit date before 2003, 35 that were missing data on age, race, or insurance, 11 with patient race other than white or black, and 68 patients of 6 physicians we could not link to the American Medical Association database (below). Because our goal was to analyze a sample of patients who were truly eligible for post-MI β-blocker therapy, we also excluded charts with major contraindications to β-blockers as follows: allergy or intolerance to β-blockers (n=66), second- or third-degree heart block (n=5), and any documentation of wheezing (n=263) or severe (qualitative as determined by treating physician) chronic obstructive pulmonary disease (COPD) (n=73). A total of 347 patients had 1 or more of these conditions, leaving 1901 for final analysis. The visit dates for these charts ranged from January 2003 to August 2007.

Data Elements and Sources
We obtained the physician sex and birth date from the 2004 American Medical Association data available to the Continuing Medical Education division within the University. These data supplemented the SK&A database containing specialty, practice size (number of physicians) and practice location. Using the 5-digit office zip code, the practice location was designated as rural or urban based on the rural-urban commuting area code.5

Medical conditions or procedures for each patient were abstracted using the chart problem list or the physician’s visit diagnosis in the office visit narrative: chronic heart failure, coronary revascularization procedure, hypertension, hyperlipidemia, diabetes, chronic kidney disease, peripheral vascular disease, current cigarette smoking, COPD, asthma, diabetes mellitus, depression, stroke, atrioventricular heart block, allergy, or intolerance to β-blockers. These conditions were of interest because they indicated severity of cardiovascular disease, were in the same or related causal pathway, or might otherwise complicate post-MI treatment. Patient sex, race, and insurance coverage were obtained from the Centers for Medicare and Medicaid Services.

Main Outcome

Our outcome, or dependent variable, for all analyses was chart documentation of a current β-blocker prescription at the most recent visit. Abstractors reviewed office visit narratives, medication lists, and other locations in the chart, following a predetermined protocol. A subsample of charts (5%) was abstracted independently by 2 different abstractors for quality control. The inter-rater reliability ranged from 88% to 93% for key variables, including documentation of a current prescription for β-blockers. The proportion of patients for whom there was documentation of a current prescription for
β-blockers was estimated as a measure of provider’s “performance” in this sample of eligible post-MI patients.

**Statistical Analysis**

Differences in the proportion of patients prescribed β-blockers were compared between physician level characteristics (age, sex, specialty, size, and urbanicity) and patient level characteristics (comorbidity and demographics) using χ² statistics. Mean time since index hospitalization and most recent visit were compared between those who did and did not receive a β-blocker prescription using a t test.

We developed 2 models with prescription of β-blockers as the dependent variable, following an approach to sequential models generally described in Cohen and Cohen.6 Our goal was first to assess the association of physician level characteristics with performance (prescription of β-blockers) and then to evaluate whether the association of physician-level characteristics on performance was confounded or moderated by sequential introduction of patient-level variables. Models were developed using the STATA Generalized Linear Latent And Mixed Model (GLLAMM) command, taking the physician as a random effect, with patients clustered within physician. Each physician was assigned a unique intercept as a random effect. The distribution of these intercepts was assumed to be approximately normal with mean (µ) equal to zero.

We assessed physician-level effects with two types of estimations: (1) “physician-specific probabilities” of prescribing β-blockers for an average patient and (2) intraclass correlation coefficients (ICC). For each, we started with a null model, which included the physician-level intercepts and no other covariates to model the outcome (β-blocker prescription for a given patient) irrespective of patient-level characteristics. We added our available physician characteristics (model A) and then added to model A the available patient-level characteristics (model B). Estimation algorithms were run with adaptive quadrature. The predicted probability of prescribing a β-blocker for the average patient was calculated for each physician as exp(µ)/(1+exp(µ)), and 95% confidence intervals were calculated as exp(µ±1.96*se)/(1+exp(µ±1.96*se)). As such, the 95% confidence intervals for the mean physician-specific probability of β-blocker prescription reflect between-physician variability. ICCs were calculated for each model assuming an underlying latent distribution for the outcome. The patient-level variance was set to the standardized logistic variance of π²/3=3.29. Letting σᵦ shows the unexplained random variance at the physician level, the proportion of the total unexplained variance occurring at this level (ICC) was estimated as σᵦ²/(σᵦ²+3.29).7–10 For each of the 3 models, the ICC represents the proportion of the model variance that is explained at the physician level. Analyses were performed with SASv9.1.3 and STATA v9.

**Results**

**Physician-Level Characteristics and β-Blocker Prescriptions**

The mean age (±standard deviation) of the physicians was 49.6±8.6 years (range, 31 to 76); most were male, and half were internists (Table 1). About one-third of physicians practiced in rural areas and two-thirds were in group practices. The mean and median number of post-MI patients per physician was 13.7 and 15, respectively, with an interquartile range of 10 to 17. Overall, 69.1% (1314/1901) of the post-MI patients were prescribed β-blockers; the median percent at the physician level was 70.0%, with a range of 20% to 100% (interquartile range, 57% to 78%). There was no significant correlation of percent of patients prescribed β-blockers with number of post-MI patients (Spearman r=0.17, P=0.07). In unadjusted analyses at the patient level, physicians’ being an

### Table 1. Physician and Practice Characteristics and Proportion of 1901 Post-MI Patients Prescribed β-Blockers by These Characteristics: The MI-Plus Study, 2003 to 2007

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No. of Physicians</th>
<th>No. of Patients</th>
<th>No. of Patients on β-Blockers</th>
<th>Percentage of Patients on β-Blockers</th>
<th>P*</th>
</tr>
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<tbody>
<tr>
<td>Physician specialty</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Internal medicine</td>
<td>67</td>
<td>1029</td>
<td>733</td>
<td>71.2</td>
<td>0.09</td>
</tr>
<tr>
<td>Family practice</td>
<td>63</td>
<td>833</td>
<td>555</td>
<td>66.6</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>39</td>
<td>26</td>
<td>66.7</td>
<td></td>
</tr>
<tr>
<td>Physician sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Male</td>
<td>118</td>
<td>1718</td>
<td>1201</td>
<td>69.9</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>183</td>
<td>113</td>
<td>61.9</td>
<td></td>
</tr>
<tr>
<td>Physician age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>&lt;45 y</td>
<td>38</td>
<td>514</td>
<td>325</td>
<td>63.2</td>
<td></td>
</tr>
<tr>
<td>45–54 y</td>
<td>56</td>
<td>821</td>
<td>577</td>
<td>70.3</td>
<td></td>
</tr>
<tr>
<td>≥55 y</td>
<td>39</td>
<td>566</td>
<td>412</td>
<td>72.8</td>
<td></td>
</tr>
<tr>
<td>Practice size (No. of physicians in group)</td>
<td>0.004</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 physician</td>
<td>44</td>
<td>595</td>
<td>381</td>
<td>64.0</td>
<td></td>
</tr>
<tr>
<td>2–4 physicians</td>
<td>51</td>
<td>721</td>
<td>520</td>
<td>72.1</td>
<td></td>
</tr>
<tr>
<td>≥5 physicians</td>
<td>38</td>
<td>585</td>
<td>413</td>
<td>70.6</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
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<tr>
<td>Rural</td>
<td>43</td>
<td>569</td>
<td>425</td>
<td>74.7</td>
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</tr>
<tr>
<td>Urban</td>
<td>90</td>
<td>1332</td>
<td>889</td>
<td>66.7</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>1901</td>
<td>1314</td>
<td>1201</td>
<td>69.1</td>
<td></td>
</tr>
</tbody>
</table>

*P value based on c².
†Difference between internists and family practitioners.
internist, male, >45 years of age, in a group practice and practicing in a rural area were all associated with higher proportions of post-MI patients with β-blocker prescriptions (higher performance).

**Patient Characteristics and β-Blocker Prescriptions**

β-Blocker prescriptions did not vary with patient race, sex, insurance, or age (Table 2). β-Blocker prescription varied considerably with comorbidity ranging from 78.3% (235/300) in patients with chronic kidney disease to 54.7% (111/203) for patients with stroke (Figure). Patients with hypertension or diabetes had similar β-blocker prescription rates as the overall patient sample (69%). More than 60% of patients had at least 1 relative contraindication (ie, chronic heart failure, peripheral vascular disease, chronic renal failure, COPD, hypotension, or bradycardia). Of note, these patients were prescribed β-blockers at a slightly higher rate, not lower, than patients with no relative contraindications, 68.6% and 65.5% (P = 0.08), respectively. Mean and median time since index hospitalization was 2.6 and 2.4 years, respectively, with an interquartile range of 1.2 to 3.8 years. There was no difference in mean or median time since index MI hospitalization between patients who had a β-blocker prescription and those who did not. However, patients whose primary care visits occurred within 1 year of the index MI hospitalization were more likely to have a β-blocker prescription than patients whose visits occurred >1 year after the index MI hospitalization (76.6% versus 67.8%, P = 0.03).

**Predictors of β-Blocker Prescription in Multivariable Models**

When physician and practice characteristics were introduced into a multivariable, cluster-adjusted model (model A), patients of physicians who were >45 years old, in group practice or with practice locations in rural areas were more likely to receive β-blockers (Table 3). These associations were robust to further adjustment for patient comorbidity and demographics (model B). In the cluster-adjusted models, β-blocker use varied considerably by comorbidity, with the odds of being prescribed β-blockers increased for heart failure, coronary revascularization, and chronic kidney disease, whereas the odds decreased for COPD and stroke.

**Physician-Level Effects in Multivariable Models**

The ICC of the null model was 0.08, indicating that 92% of the variance in β-blocker prescription present in these data were at the patient and not at the physician level. Introduction of physician-level characteristics reduced the already low proportion to 0.05 and the addition of patient-level characteristics changed the ICC minimally (to 0.06) (Table 4). Mean physician-predicted probabilities ranged from 69.3% in the null model to 69.0% when adjusted for physician-level characteristics and to 62.9% when also adjusted for patient-level characteristics. The narrow confidence intervals for the predicted probabilities, consistent with the low ICCs, further indicate that little variance in β-blocker prescription was at the physician level.

**Discussion**

In our study of β-blocker prescription for ~2000 ambulatory post-MI patients, we found underuse of this recommended class of medications despite multiple national and local initiatives to address this underuse. Importantly, although we found marked variability in the β-blocker performance measure across study physicians, our 2-stage model suggests that this variability resides mostly at the patient level rather than at the physician level.

In May 2007, the National Committee for Quality Assurance (NCQA) announced its plans to discontinue the quality measure of β-blocker use within seven days of hospital discharge for MI, citing high performance attainment (>90% use) and little variation in performance across care plans. This high performance, however, is dependent on a limited time frame and restricting the denominator to ideal patients, namely, excluding patients with any absolute or relative contraindication to use of β-blockers. Given that some relative contraindications, such as heart failure, have become indications for β-blocker use, exclusion of patients with these contraindications in the assessment of β-blocker use may be ill advised. Because β-blocker use decreases with time since discharge after MI hospitalization, the NCQA still recommends use of “persistence of β-blocker use” at 6 months after discharge for acute MI as a quality indicator. Our findings of suboptimal β-blocker prescription to eligible ambulatory post-MI patients cared for by physicians practicing in the community indicate that continued efforts to measure and improve use of this medication in appropriate post-MI patients are needed.

We do not think comorbidity explains the low β-blocker prescription rate we observed: Restricting our patient pool to those with no contraindications, namely, ideal candidates, lowers—does not raise—the β-blocker prescription rate. Time since acute MI is a more likely explanation for the low

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**Table 2. Patient Characteristics and Proportion of 1901 Patients Prescribed β-Blockers by Each Characteristic: The MI-Plus Study, 2003 to 2007**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of Patients</th>
<th>Percentage of Patients</th>
<th>No. of Patients on β-Blockers</th>
<th>Percentage of Patients on β-Blockers</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 y</td>
<td>243</td>
<td>12.8</td>
<td>168</td>
<td>69.1</td>
<td>0.3</td>
</tr>
<tr>
<td>65 to 74 y</td>
<td>649</td>
<td>34.1</td>
<td>462</td>
<td>71.2</td>
<td></td>
</tr>
<tr>
<td>≥75 y</td>
<td>1009</td>
<td>53.1</td>
<td>684</td>
<td>67.8</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>788</td>
<td>41.4</td>
<td>544</td>
<td>69.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Male</td>
<td>1113</td>
<td>58.6</td>
<td>770</td>
<td>69.2</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1621</td>
<td>85.3</td>
<td>1121</td>
<td>69.2</td>
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</tr>
<tr>
<td>Black</td>
<td>280</td>
<td>14.7</td>
<td>193</td>
<td>68.9</td>
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<tr>
<td>Insurance</td>
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<td></td>
<td></td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Medicare only</td>
<td>386</td>
<td>20.3</td>
<td>278</td>
<td>72.0</td>
<td></td>
</tr>
<tr>
<td>Medicare and Medicaid</td>
<td>412</td>
<td>21.7</td>
<td>272</td>
<td>66.0</td>
<td></td>
</tr>
<tr>
<td>Medicare and other</td>
<td>1103</td>
<td>58.0</td>
<td>764</td>
<td>69.3</td>
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</table>
performance we observed. Consistent with the initial historical focus on performance measures within the acute care setting, most performance measures, for example, NCQA, are either at discharge or within 6 months of discharge. The high prevalence of patients >1 year after MI in our sample and decreasing use of secondary preventive therapies with longer time since MI may explain our lower performance rates, emphasizing the increasingly recognized need for longer-term and ambulatory performance measures.

Understanding variance in measures used to assess provider performance is increasingly critical as these performance measures, such as the proportion of post-MI patients prescribed β-blockers, are now used to determine financial rewards in pay-for-performance programs. Although this is not an area that has been extensively studied, we are not the first ones to use variance component analysis or similar analytic approaches to partition variability in health care quality across different levels of measurement. A recent systematic review of the literature concludes that the proportion of variability at levels higher than the patient is often low; further, many authors suggest that this low variability suggests lack of potential for quality improvement.

Similar approaches have been used, specifically for process of care measures, for example, for diabetes. Greenfield et al reported physician-level ICCs of 12% for hemoglobin A1c when assessed as a dichotomous variable indicating whether it was measured, and Krein et al found an 8% ICC for a similarly assessed hemoglobin A1c as a process measure. Most recently, O’Connor found the physician-level proportion of variance in hemoglobin A1c levels to be only of the order of 1%, confirmed by a similar finding of 2% by Tuerk. Davis found less than 10% variability attributable to the physician in prescribing medications, ordering diagnostic tests, or ordering follow-up appointments among primary care physicians in New Zealand. Thus, the magnitude of the overall contribution of the physician level variance to total variance for β-blocker prescription in our study is consistent with the findings of others who have sought to advance the understudied area of the locus of variability in quality measurement.

Although there clearly was marked variability in performance at the physician level, our 2-level models place the source of this variability at the patient rather than at the physician level. Although our measured patient characteristics did not confound the physician-level findings, other unmeasured patient factors might, for example, education. Thus, basing incentives on this performance measure may not necessarily be appropriate. Because older physicians had higher performance, and that higher performance was not attenuated by physician practice or patient characteristics, this subgroup may be more highly rewarded in a pay-for-performance system based on prescription of β-blockers to post-MI patients. To the extent that the purpose of any incentive program should be to reward beneficial improvements in performance, rather than performance tied to fixed characteristics, these issues need to be addressed to maximize any incentive program’s effectiveness.
On the other hand, it has been argued that even quality improvement interventions that target physicians when they contribute little to overall measurement variability may be worth doing.26 For example, Hofer et al26 found that individual physicians rarely account for 4% of the variation, “yet it still might be useful to profile and control this relatively small amount of physician variation.” Similarly, Krein et al22 point out that even changes in physician practices affecting only a small amount of the variation could have a significant effect on clinical outcomes. Indeed, Selby et al5 recently showed in a longitudinal study that performance can improve in the face of low baseline physician-level variance. Taking the case to the extreme, if all physicians perform at the same low level, then a physician-level intervention to remedy this low performance may succeed. Also, when performance is overall quite low (as in our β-blocker case), small improvements in effect size overall may still translate into substantial clinical benefit. However, if performance is fairly uniform across physicians, differential pay-for-performance may not be an efficient instrument to enhance quality. One of the most important unanswered questions in this area of investigation continues to be the study of what actually works in changing physician practice patterns, and the partitioning of variance approach is only one tool in this very complex arena.

Importantly, we did not find a strong “physician signature,” in that the proportion of variance in β-blocker prescription that could be attributed to the physicians was modest. However, we did find that some measured physician characteristics (older age) in our study predicted differences in β-blocker prescriptions, as did rural and group practice settings. These characteristics were independent predictors that were robust to multiple adjustments that accounted for


<table>
<thead>
<tr>
<th>Model</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
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<tbody>
<tr>
<td></td>
<td>Physician level</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Internal medicine specialty</td>
<td>1.35</td>
<td>1.11</td>
<td>1.64</td>
<td>0.002</td>
<td>1.29</td>
<td>0.99</td>
<td>1.68</td>
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</tr>
<tr>
<td>Male</td>
<td>1.28</td>
<td>0.93</td>
<td>1.77</td>
<td>0.1</td>
<td>1.20</td>
<td>0.78</td>
<td>1.84</td>
<td>0.4</td>
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</tr>
<tr>
<td>Age ≥45 y</td>
<td>1.36</td>
<td>1.10</td>
<td>1.67</td>
<td>0.005</td>
<td>1.38</td>
<td>1.04</td>
<td>1.83</td>
<td>0.03</td>
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</tr>
<tr>
<td>Solo (1 physician in group)</td>
<td>0.72</td>
<td>0.59</td>
<td>0.99</td>
<td>0.002</td>
<td>0.56</td>
<td>0.49</td>
<td>0.86</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Rural location</td>
<td>1.33</td>
<td>1.12</td>
<td>1.72</td>
<td>0.003</td>
<td>1.72</td>
<td>1.28</td>
<td>2.31</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Patient level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic heart failure</td>
<td>1.65</td>
<td>1.27</td>
<td>2.10</td>
<td>&lt;0.001</td>
<td>1.70</td>
<td>1.30</td>
<td>2.22</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Coronary revascularization</td>
<td>2.33</td>
<td>1.90</td>
<td>2.85</td>
<td>&lt;0.001</td>
<td>2.52</td>
<td>1.99</td>
<td>3.18</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.15</td>
<td>0.92</td>
<td>1.42</td>
<td>0.2</td>
<td>1.28</td>
<td>1.00</td>
<td>1.64</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1.21</td>
<td>0.98</td>
<td>1.49</td>
<td>0.07</td>
<td>1.10</td>
<td>0.86</td>
<td>1.40</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.15</td>
<td>0.94</td>
<td>1.40</td>
<td>0.2</td>
<td>0.94</td>
<td>0.75</td>
<td>1.18</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>1.55</td>
<td>1.17</td>
<td>2.05</td>
<td>0.002</td>
<td>1.89</td>
<td>1.35</td>
<td>2.64</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>1.12</td>
<td>0.85</td>
<td>1.48</td>
<td>0.4</td>
<td>0.98</td>
<td>0.72</td>
<td>1.35</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Current cigarette smoking</td>
<td>0.90</td>
<td>0.63</td>
<td>1.28</td>
<td>0.6</td>
<td>1.24</td>
<td>0.80</td>
<td>1.92</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>0.79</td>
<td>0.62</td>
<td>1.00</td>
<td>0.05</td>
<td>0.69</td>
<td>0.53</td>
<td>0.91</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>0.90</td>
<td>0.68</td>
<td>1.19</td>
<td>0.5</td>
<td>0.94</td>
<td>0.68</td>
<td>1.29</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>0.52</td>
<td>0.39</td>
<td>0.71</td>
<td>&lt;0.001</td>
<td>0.45</td>
<td>0.32</td>
<td>0.62</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

OR indicates odds ratios; CI, confidence intervals.

The bivariate model was run with the STATA logistic procedure; models A and B, STATA GLAMM procedure, taking the physician as a random effect with patients clustered within physician. In model A, only physician-level characteristics were entered; in model B, patient-level comorbidities and demographics (age, race, sex, insurance, not shown) in addition to physician-level characteristics were entered.


<table>
<thead>
<tr>
<th>Model</th>
<th>ICC</th>
<th>95% Confidence Interval</th>
<th>Mean Physician-Predicted Probability (PP)</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null: No covariates</td>
<td>0.08</td>
<td>0.04</td>
<td>0.12</td>
<td>0.694</td>
</tr>
<tr>
<td>Model A: Physician-level covariates only</td>
<td>0.05</td>
<td>0.01</td>
<td>0.08</td>
<td>0.690</td>
</tr>
<tr>
<td>Model B: Physician- and patient-level covariates</td>
<td>0.06</td>
<td>0.02</td>
<td>0.10</td>
<td>0.630</td>
</tr>
</tbody>
</table>

All models were run with STATA GLAMM procedure, taking the physician as a random effect with patients clustered within physician.
patient characteristics, which were also predictive of β-blocker use. Evidence for an association of provider age and performance is mixed. Some studies have noted lower performance with increasing age, whereas we found higher performance among older providers. The differences in the association of age and performance may be related to the specific measures assessed, differences in study methods, or differences in patient populations as other have postulated, namely, older physicians have older and sicker patients.

We were surprised at the association of rural status and higher performance. Rurality has often been associated with poorer care in terms of availability and quality of primary care. Access issues and resulting missed appointments could drive down guideline-concordant care, and rural patients might also be older and more complex. Based on our data, comorbidities may result in unpredictable swings in performance (dependent on which comorbidities are most prevalent). However, we found that patient demographics and comorbidities did not attenuate the association between rural location and higher performance. The reasons for higher performance by rural physicians in our study are unclear and should be further explored. One might speculate that rural patients and doctors in our sample (the Southern United States) may have a longer continuous relationship with their patients compared with those in urban settings and that a longer continuous relationship leads to higher performance.

Patient characteristics also predicted receipt of β-blockers. Our study provides new evidence that stroke survivors are less likely to receive β-blockers. Although numbers were small, stroke survivors had the lowest proportion (53%) of post-MI β-blocker prescription. Clinicians may have prescribed β-blockers less frequently to patients with history of stroke because of clinical trial data and competing guidelines for secondary stroke prevention that suggest use of angiotensin-converting enzyme inhibitors and thiazide diuretics in this group. Clinicians also may have responded to data from clinical trials and subsequent meta-analyses that demonstrated increased risk of stroke among hypertensive patients treated with β-blockers compared with calcium channel blockers and angiotensin receptor blockers, concerns that have been substantiated in a recent more comprehensive meta-analysis. Also, our results contradict older studies that suggest that patients with chronic kidney disease are less likely to receive β-blockers.

The limitations of our study relate mostly to our cross-sectional study design and that causal relationships cannot be specified. To truly understand whether physicians should be the target of effective quality improvement interventions even when their practices explain little of the variability in quality of care, we need experimental or quasi-experimental designs that include a longitudinal component. Also, we were limited in our number of predictor variables. Other factors may be important to guideline-concordant care (eg, having an electronic medical record, standard protocols, management templates or prompts, and organizational culture issues). Likewise, the sample was selected from practices agreeing to participate in a quality improvement program. Participation was higher among physicians treating more post-MI patients, as determined by Centers for Medicare and Medicaid Services linkage, and among those practicing in rural areas. Although this raises issues of generalizability, participation in quality improvement efforts is often voluntary and presumably subject to similar biases. We also measured prescription of β-blockers but did not measure filling of the prescription or actual use of the medication by the patient. Finally, our number of patients per physician was modest and probably indicates low reliability of individual level physician performance, again casting doubt on the appropriateness of incentives at the provider level based on such a measure. Nonetheless, this sample size is not uncommon when performance is evaluated at the physician level.

**Conclusion**

We conclude that the interpretation of simple performance measures, such as post-MI prescription of β-blockers, is complex. Our data suggest that patient clinical characteristics may be used consistently and perhaps appropriately by physicians to “deviate” from recommendations to prescribe β-blockers after MI, absent major contraindications. Given that most post-MI patients have multiple comorbidities or relative contraindications, physicians must use clinical judgment that balances guideline adherence (based on the benefit to groups or populations) and patient centeredness (based on the risk and benefit to the individual patient). Quality improvement targets should not penalize physicians for applying clinical guidelines and individualizing treatment decisions appropriately. We do not know how much control physicians exert over systematic variations in prescribing, nor do we understand the mechanisms of these variations. Understanding performance measures, creating new, more statistically adjusted performance measures that go beyond one diagnosis or condition, and experimenting with novel ways to motivate performance are all ripe for future research. Whether the disappointingly low use of β-blockers among ambulatory post-MI patients is a result of appropriate clinical judgment or a target for energetic quality improvement efforts merits further investigation.

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**Disclosures**

None.

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