

# Hospital Quality for Acute Myocardial Infarction

## Correlation Among Process Measures and Relationship With Short-term Mortality

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AS PART OF THE NATIONAL effort to improve hospital quality, the Centers for Medicare & Medicaid Services (CMS) and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) monitor and publicly report hospital performance on acute myocardial infarction (AMI) “core” process measures approved by the Hospital Quality Alliance.<sup>1</sup> Although the CMS/JCAHO process measures are considered indicators of quality of AMI care,<sup>2</sup> little is known about how these measures track with each other. Five of the 7 CMS/JCAHO process measures assess medication prescription practices. Because these processes are likely to be amenable to similar quality improvement interventions, one might expect them to be strongly correlated at the hospital level. In contrast, timely reperfusion therapy, which involves coordination

For editorial comment see p 95.

**Context** The Centers for Medicare & Medicaid Services (CMS) and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) measure and report quality process measures for acute myocardial infarction (AMI), but little is known about how these measures are correlated with each other and the degree to which inferences about a hospital’s outcomes can be made from its performance on publicly reported processes.

**Objective** To determine correlations among AMI core process measures and the degree to which they explain the variation in hospital-specific, risk-standardized, 30-day mortality rates.

**Design, Setting, and Participants** We assessed hospital performance in the CMS/JCAHO AMI core process measures using 2002-2003 data from 962 hospitals participating in the National Registry of Myocardial Infarction (NRFMI) and correlated these measures with each other and with hospital-level, risk-standardized, 30-day mortality rates derived from Medicare claims data.

**Main Outcome Measures** Hospital performance on AMI core measures; hospital-specific, risk-standardized, 30-day mortality rates for AMI patients aged 66 years or older.

**Results** We found moderately strong correlations (correlation coefficients  $\geq 0.40$ ;  $P$  values  $< .001$ ) for all pairwise comparisons between  $\beta$ -blocker use at admission and discharge, aspirin use at admission and discharge, and angiotensin-converting enzyme inhibitor use, and weaker, but statistically significant, correlations between these medication measures and smoking cessation counseling and time to reperfusion therapy measures (correlation coefficients  $< 0.40$ ;  $P$  values  $< .001$ ). Some process measures were significantly correlated with risk-standardized, 30-day mortality rates ( $P$  values  $< .001$ ) but together explained only 6.0% of hospital-level variation in risk-standardized, 30-day mortality rates for patients with AMI.

**Conclusions** The publicly reported AMI process measures capture a small proportion of the variation in hospitals’ risk-standardized short-term mortality rates. Multiple measures that reflect a variety of processes and also outcomes, such as risk-standardized mortality rates, are needed to more fully characterize hospital performance.

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among various hospital services and personnel,<sup>3</sup> may require other types of interventions and thus be less strongly correlated with the other process measures. Understanding how process measures are themselves correlated can suggest how sensitive hospital performance rankings may be to the process measures that are included.

Furthermore, whether inferences about a hospital's overall short-term risk-standardized mortality rate can be made from its performance on process measures is not known. Previous studies<sup>4,5</sup> have emphasized the association between medication prescription rates and in-hospital mortality, but have been limited to ascertainment of in-hospital events, which can be substantially biased by length of stay.<sup>6</sup> Thus, the degree to which process measure performance conveys meaningful information about short-term mortality rates remains unclear. Accordingly, we used data from the National Registry of Myocardial Infarction (NORMI) and CMS to determine the correlations among AMI process measures and the association between hospital performance on process measures and hospital-specific, risk-standardized, 30-day mortality rates. We calculated these mortality rates from CMS Medicare claims data using a risk-adjustment model<sup>7</sup> endorsed by the National Quality Forum, which was previously validated against a model based on medical record data.

## METHODS

### Study Design and Sample

We performed a cross-sectional analysis using hospitals that reported AMI discharges to the NORMI from January 2002 through March 2003 and CMS claims data on 30-day mortality for the same hospitals and time period. This was the most recent time period for which we could obtain NORMI data and CMS data with hospital identifiers included. As of April 2003, the NORMI deidentified hospitals in compliance with the Health Insurance Portability and Accountability Act. The NORMI

includes patients who meet any of the following criteria for an AMI: total creatine kinase or creatine kinase MB values that were 2 or more times the upper limit of the normal range; electrocardiographic evidence of AMI; enzymatic, scintigraphic, or autopsy evidence of AMI; or a diagnosis of AMI according to the *International Classification of Diseases, Ninth Revision, Clinical Modification* (code 410.X1). Each process measure was calculated for each NORMI hospital that reported at least 10 eligible patients for the selected measure during the study period. Hospitals that did not report at least 10 eligible patients for any of the process measures during the study period were excluded. Consistent with our validated risk-standardized mortality model,<sup>7</sup> we excluded hospitals with fewer than 12 patients with AMI in the CMS claims database for the study period.

### Data and Measures

We examined hospital performance for the process measures known as the CMS/JCAHO "core measures" for AMI. These measures include  $\beta$ -blocker prescription at admission and discharge, aspirin prescription at admission and discharge, angiotensin-converting enzyme (ACE) inhibitor prescription at discharge, smoking cessation counseling for smokers during the admission, and time to reperfusion therapy. For these processes, calculated to be consistent with the CMS/JCAHO specifications,<sup>8</sup> we classified patients as to whether they were eligible for and whether they received the selected process using patient-level data from the NORMI to calculate hospital performance indicated by each process measure. Similarly, for admissions medication prescriptions and timely reperfusion measures, we excluded patients who were transferred in, who were either transferred out or discharged, or who died on the day of arrival; for the discharge medication prescriptions and smoking cessation counseling measures,

we excluded patients who were transferred out or died before discharge. Furthermore, for the smoking cessation counseling measure, we excluded nonsmokers, and for the time to reperfusion therapy measure, we excluded patients with ST-segment elevation myocardial infarction who did not receive fibrinolytic therapy or primary percutaneous coronary intervention within 6 hours of admission. Fulfillment of the time to reperfusion therapy process was defined as receiving fibrinolytic therapy within 30 minutes of hospital arrival or receiving percutaneous coronary intervention within 120 minutes of hospital arrival.

### Statistical Analysis

We estimated performance (ie, fulfillment rate) for each hospital using a separate hierarchical generalized linear model (HGLM) for each process measure. The HGLM technique<sup>9,10</sup> allowed us to estimate rates for hospitals that accounted for clustering of patients within hospitals and that reflected the precision due to the number of patients included at each hospital. In secondary analyses, we also calculated crude process rates for each hospital. These crude rates were calculated as the number of times the selected process (eg,  $\beta$ -blocker at admission, timely reperfusion) was accomplished for eligible patients at a selected hospital divided by the total number of eligible patients for that measure who were treated at that hospital. Crude rates were nearly identical to the HGLM estimated rates.

We calculated the risk-standardized, 30-day, all-cause mortality rate for each hospital using patient-level data from CMS Medicare claims data for patients aged 66 years or older with AMI discharged in the study period. We used CMS data because NORMI data do not extend beyond discharge. We included patients who were at least 66 years old to have a full year of prior claims history to establish comorbidities. For each hospital, 30-day, all-cause mortality rates for

patients with AMI were risk standardized with a model<sup>7</sup> that was developed using an HGLM. The model adjusts

**Table 1.** Hospital Characteristics (N = 962)

Characteristic	No. (%)
Region	
New England	52 (5)
Middle Atlantic	91 (9)
South Atlantic	143 (15)
East North Central	181 (19)
East South Central	63 (7)
West North Central	76 (8)
West South Central	82 (9)
Mountain	64 (7)
Pacific	208 (22)
Unknown	2 (0)
Location	
Rural	250 (26)
Urban	676 (70)
Unknown	36 (4)
Ownership	
Public	108 (11)
Nonprofit	744 (77)
For profit	74 (8)
Unknown	36 (4)
Hospital type	
Teaching	231 (24)
Nonteaching	695 (72)
Unknown	36 (4)
Cardiac facilities	
Open-heart surgery facilities	302 (31)
Catheterization laboratory	224 (23)
Other	291 (30)
Licensed beds	
<200	472 (49)
200-599	409 (43)
≥600	45 (5)
Unknown	36 (4)
AMI annualized volume, median (range)*	12-495 (73)

\*Acute myocardial infarction (AMI) volume was calculated from the 962 hospitals that had Centers for Medicare & Medicaid Services claims data.

for clinical features of patients that are linked to differences in hospital-specific 30-day mortality rates, allowing one to identify the independent effects of process measures on mortality rates, adjusted for differences in case mix. This model,<sup>7</sup> endorsed by the National Quality Forum, has good agreement with a model based on medical chart review data. Agreement between the hospital risk-standardized mortality rates estimated by our claims database model and the medical chart database model was high (correlation coefficient=0.90;  $P<.001$ ), and the mean difference in estimated hospital-specific, risk-standardized, 30-day mortality rates between the claims database model for each hospital and the medical chart database model was 0.00 (range, -0.03 to 0.03).<sup>7</sup> The  $\kappa$  statistic for the claims model was 0.77.

For comparison with a recent study,<sup>5</sup> we also calculated the risk-standardized in-hospital mortality rate using NDMI data. This in-hospital mortality rate was estimated using an HGLM in which in-hospital mortality was adjusted for age, sex, body mass index, diabetes, chronic renal insufficiency, coronary artery disease, chronic obstructive pulmonary disease, use of prehospital electrocardiogram, heart

rate, blood pressure, presence of ST-segment elevation myocardial infarction, heart failure type, and hours since symptom onset. We calculated the risk-standardized in-hospital mortality rate both with all patients included and then excluding patients who were transferred out.

Using the hospital performance estimates for each of the 7 process measures, we calculated the set of pairwise correlations. Because different numbers of patients were eligible for the process measures at different hospitals, all analyses in which the hospital was the unit of analysis were weighted by the total number of patients from that hospital who were included in the calculation of process measures. For each correlation,  $\rho$ , we tested the hypothesis that  $\rho=0$ , adjusting the  $P$  values for multiple comparisons.<sup>11</sup> We also calculated the Cronbach  $\alpha$  coefficient<sup>12</sup> for the 7 process measures and assessed the item-scale correlation<sup>13</sup> for each measure. The item-scale correlation<sup>13</sup> reflects how well each measure correlates with the average of the remaining 6 measures.

We created a composite process measure using the measures that were most internally consistent based on the Cronbach  $\alpha$  coefficients and item-scale correlations. The composite measure reflected the percentage of recommended processes fulfilled for each eligible patient. We used an HGLM with binomial response to estimate the average percentage of recommended processes that were fulfilled for patients in each hospital, accounting appropriately for patients clustered within hospitals.

For the primary analysis, we used correlation analysis to determine the association of hospital risk-standardized 30-day mortality rates with hospital performance estimates on the process measures. We report both the relevant correlation coefficients and the percentage of the hospital-specific variation in risk-standardized mortality rates explained, ie, the square of the correlation coefficient.

**Table 2.** Hospital Performance in 2002-2003 on Process Measures and Risk-Standardized Mortality Rates\*

Measure	No. of Hospitals	Mean (SD)	25th Percentile	Median	75th Percentile
$\beta$ -Blocker at admission	938	78.0 (12.4)	70.6	80.7	87.4
$\beta$ -Blocker at discharge	883	75.8 (15.6)	68.8	80.1	87.1
Aspirin at admission	938	86.4 (7.8)	82.9	88.1	91.8
Aspirin at discharge	881	79.6 (15.3)	73.4	83.3	90.7
ACE inhibitor at discharge	560	70.7 (10.8)	64.8	71.6	78.7
Smoking cessation counseling	601	13.9 (14.2)	3.9	9.5	19.0
Timely reperfusion therapy†	709	54.5 (13.3)	45.5	53.9	63.9
Composite score‡	962	63.3 (16.2)	53.4	65.1	76.4
Risk-standardized mortality rate					
30-day	899	18.4 (2.5)	16.7	18.4	20.0
In-hospital	962	8.8 (1.4)	7.9	8.6	9.6

Abbreviation: ACE, angiotensin-converting enzyme.

\*Hospitals were included if they had at least 10 patients eligible for the given process measure. Data are expressed as percentages unless otherwise indicated.

†Percentage of all patients with ST-segment elevation myocardial infarction receiving reperfusion therapy within recommended time (30 minutes for fibrinolytic therapy and 120 minutes for percutaneous coronary intervention).

‡Composite score reflects hospital performance on  $\beta$ -blocker at admission and discharge, aspirin at admission and discharge, and ACE inhibitor at discharge.

cient, as indicators of the strength of the associations. To facilitate interpretation, we also examined the percentage of variation in risk-standardized 30-day mortality rates explained by hospital attributes, including teaching status, AMI volume, and geographical region.

We performed several secondary analyses to evaluate the robustness of our results. First, we restricted the NDMI patient sample to those who were aged 66 years or older, matching the age distribution of patients with CMS data. Second, we repeated all analyses using crude process measure rates, rather than rates estimated from the hierarchical models. Third, we used an alternative composite measure of process performance that incorporated all 7 process scores, rather than the 5 most strongly correlated. Fourth, we conducted the same analysis using NDMI and CMS data from 2001 to assess consistency in our findings over time. Fifth, we repeated the 30-day mortality analysis for hospitals with less than 5% transferred-out patients. Last, to replicate previous research,<sup>5</sup> we performed the analysis using risk-standardized in-hospital mortality instead of 30-day mortality, using all patients and then

again excluding patients who were transferred out.

Analyses were conducted using Stata version 9 (StataCorp, College Station, Tex), SAS version 8.0 (SAS Institute, Cary, NC), and HLM6 (Scientific Software International, Lincolnwood, Ill). All reported *P* values are 2-sided and considered significant at  $<.05$ .

## RESULTS

### Samples

The sample for the analysis of hospital performance on process measures included 208 238 patients treated in 962 NDMI hospitals, representing a broad range of teaching and nonteaching hospitals, geographic regions, rural/urban location, number of beds, and annual AMI volumes (TABLE 1). The sample for the analysis of risk-standardized, 30-day mortality rates included 83 330 patients aged 66 years or older treated in the 899 NDMI hospitals that could be matched to CMS data. Hospital rates for each of the process measures and the composite process measure as well as 30-day and in-hospital mortality are shown in TABLE 2.

### Correlation of Process Measures

We found moderately strong correlations (correlation coefficients  $>0.40$ ; *P* values  $<.001$ ) among all the medication prescription-related process measures. Even stronger correlations (correlation coefficients  $>0.60$ ; *P* values  $<.001$ ) were apparent between  $\beta$ -blocker prescription at admission and at discharge,  $\beta$ -blocker and aspirin prescription at admission,  $\beta$ -blocker and aspirin prescription at discharge,  $\beta$ -blocker and ACE inhibitor prescription at discharge, and aspirin and ACE inhibitor prescription at discharge (TABLE 3). The smoking cessation counseling and timely reperfusion therapy measures were less strongly correlated (most correlation coefficients  $\leq 0.30$ ) with each of the other 5 processes, although most correlation coefficients were statistically significant (*P* values  $<.001$ ).

Item-scale correlations (TABLE 4) also indicated that the estimated performance measures pertaining to  $\beta$ -blocker, aspirin, and ACE inhibitor prescription had good internal consistency, with the correlations between any single medication measure and the average score across the remain-

**Table 3.** Correlation Coefficients for Process Measures and Hospital Risk-Standardized Mortality Rate (30-Day and In-Hospital Mortality Rates)\*

	$\beta$ -Blocker at Admission	$\beta$ -Blocker at Discharge	Aspirin at Admission	Aspirin at Discharge	ACE Inhibitor at Discharge	Smoking Cessation Counseling	Timely Reperfusion	Composite
$\beta$ -Blocker at discharge	0.63†							
Aspirin at admission	0.73†	0.44†						
Aspirin at discharge	0.42†	0.84†	0.48†					
ACE inhibitor at discharge	0.51†	0.70†	0.40†	0.62†				
Smoking cessation counseling	0.19†	0.25†	0.21†	0.24†	0.21†			
Timely reperfusion therapy‡	0.17†	0.30†	0.21†	0.37†	0.30†	0.13		
Composite score of 5 measures§	0.56†	0.76†	0.58†	0.80†	0.57†	0.29†	0.38†	
Risk-standardized 30-day, all-cause mortality rate	-0.03	-0.16†	-0.06	-0.18†	-0.10	-0.03	-0.18†	-0.25†
Risk-standardized in-hospital, all-cause mortality rate	-0.04	0.07	-0.12	0.10	0.06	-0.01	-0.04	0.02

Abbreviation: ACE, angiotensin-converting enzyme.

\*Hospitals were included in the correlation analysis if they had at least 10 patients eligible for each of the 2 measures being correlated.

†*P* $<.001$  after correction for multiple comparison.<sup>11</sup>

‡Percentage of all patients with ST-segment elevation myocardial infarction receiving reperfusion therapy within recommended time (30 minutes for fibrinolytic therapy and 120 minutes for percutaneous coronary intervention).

§Composite score for each patient based on 1 to 5 indicators ( $\beta$ -blocker at admission and discharge, aspirin at admission and discharge, and ACE inhibitor at discharge) for which that patient was eligible.

||*P* $<.05$ .



**Table 4.** Item-Scale Correlations for Core Process Measures\*

Process Measure	No. of Hospitals	Item-Scale Correlation†
β-Blocker at admission	938	0.55
β-Blocker at discharge	883	0.67
Aspirin at admission	938	0.54
Aspirin at discharge	881	0.59
ACE inhibitor at discharge	560	0.63
Smoking cessation counseling	601	0.27
Timely reperfusion therapy‡	709	0.27

Abbreviation: ACE, angiotensin-converting enzyme.  
 \*Hospitals were included if they had at least 10 patients eligible for the given process measure and at least 10 patients eligible for at least 1 other process measure.  
 †Item-scale correlation<sup>13</sup> refers to the correlation between the specific item and the average score across the remaining items in the scale.  
 ‡Percentage of all patients with ST-segment elevation myocardial infarction receiving reperfusion therapy within recommended time (30 minutes for fibrinolytic therapy and 120 minutes for percutaneous coronary intervention).

**Table 5.** Percent Variance in 30-Day Risk-Standardized Mortality Rates Explained by Each Process Measure and Composite Measure\*

Process Measure	% Variance Explained
β-Blocker at admission	0.1
β-Blocker at discharge	2.6
Aspirin at admission	0.3
Aspirin at discharge	3.3
ACE inhibitor at discharge	0.9
Smoking cessation counseling	0.1
Timely reperfusion therapy‡	3.3
Composite score, timely reperfusion measure and smoking measure‡	6.0

Abbreviation: ACE, angiotensin-converting enzyme.  
 \*Hospitals were included if they had at least 10 patients eligible for the given process measures.  
 †Percentage of all patients with ST-segment elevation myocardial infarction receiving reperfusion therapy within recommended time (30 minutes for fibrinolytic therapy and 120 minutes for percutaneous coronary intervention).  
 ‡Composite score for each patient based on 1 to 5 indicators (β-blocker at admission and discharge, aspirin at admission and discharge, and ACE inhibitor at discharge) for which that patient is eligible.

ing process measures ranging from 0.54 (for aspirin at admission) to 0.67 (for β-blocker prescription at discharge). In contrast, the item-scale correlations between the estimated proportion receiving smoking cessation counseling or receiving timely reperfusion therapy and the remaining process measures were both only 0.27 (Table 4). The Cronbach α coefficients for the measures pertaining to β-blocker, aspirin, and ACE inhibitor use was 0.86, and the Cronbach α coefficient for all process measures was 0.81.

**Process Measures and Hospital-Level Risk-Standardized Mortality Rates**

The process measures each had a statistically significant but modest correlation with the risk-standardized, 30-day mortality rates (Table 3), individually explaining between 0.1% and 3.3% (TABLE 5) of hospital-level variation in risk-standardized, 30-day mortality rates. Hospitals across the 5 quintiles of the composite process measure had very similar risk-standardized, 30-day mortality rates (FIGURE). Furthermore, of the 180 hospitals in the top quintile of risk-standardized mortality rates, only 56 (31.1%) were in the top quintile of the composite process score. A model that included this composite measure and the smoking cessation counseling and timely reperfusion measures as independent variables explained only 6.0% of the hospital-level variation in risk-standardized, 30-day mortality rates.

To facilitate interpretation of this 6.0% of the variation explained, we compared it with the percentage of hospital-level variation in risk-standardized, 30-day mortality rates explained by hospital attributes and found that teaching status explained 6.5% of the variation, AMI volume explained 6.8% of the variation, and geographical location explained 4.5% of the variation in risk-standardized mortality rates.

**Sensitivity Analysis**

Our results did not differ substantially in secondary analyses using process measures for only patients who were 66 years or older or in analysis using crude rates, rather than rates estimated from hierarchical models. The results were also largely unchanged when we used a full composite process score using the mean performance on all of the CMS/JCAHO measures, rather than those most strongly correlated. In addition, our findings were consistent over time, showing similar results using earlier NRMI and CMS data from 2001. Furthermore, the results were similar in the analysis

including only hospitals with transferred-out rates of less than 5%. However, we found that excluding patients who were transferred out from the calculation of in-hospital mortality rates led to a substantially stronger association between process measures and in-hospital mortality rates. In a model with the composite process measure, smoking cessation counseling measure, and time to reperfusion measure as independent variables and in-hospital mortality as the outcome, performance on process measures explained 13.0% of the variation in in-hospital mortality rates when we excluded patients who were transferred out and only 0.6% of the variation in in-hospital mortality rates when we included all patients. We also found that hospitals with higher transfer rates had significantly lower AMI volume (correlation coefficient=0.43; P<.001) and had significantly worse performance (correlation coefficient=-0.78; P<.001) in the composite process measure.

**COMMENT**

We found that hospital performance on the CMS/JCAHO process measures for AMI explained only 6% of the hospital-level variation in short-term, risk-standardized mortality rates for patients with AMI. This finding suggests that a hospital's short-term mortality rates after AMI cannot be reliably inferred from performance on the publicly reported process measures. Our results highlight that the current process measures provide information that is complementary to, but not redundant with, a measure of 30-day mortality.

Our findings stand in contrast to a recent study by Peterson and colleagues,<sup>5</sup> which concluded that there is a strong correlation between process and outcome. However, the finding by Peterson and colleagues may be largely due to the exclusion of patients who are transferred out, a group that is known to be healthier on average than patients who are

not transferred.<sup>14</sup> This approach biases upward the mortality rate at smaller hospitals, which transfer out more patients and, in our data, have significantly lower performance in processes. Therefore, the exclusion of transferred-out patients overestimates the association between process and in-hospital mortality. When Peterson and colleagues restricted their analysis to hospitals with lower transfer rates, the magnitude of the association of process and outcome was markedly attenuated, with an absolute difference of only 0.7% between the top and bottom quintiles of process measures.

There are several plausible reasons for the modest correlation between processes and risk-standardized mortality, none of which, in our view, undermine the importance of continued measurement of these process measures. The CMS/JCAHO core measures were not designed to be a surrogate for overall short-term hospital mortality and are, in fact, weighted toward strategies that improve long-term outcomes. In addition, there is relatively little variation across hospitals in some processes, such as aspirin use at admission, limiting the ability to discriminate hospitals based on their performance on this measure. Last, hospital mortality rates, even risk-standardized, are likely influenced by many factors that are independent of the core measures, including processes that involve patient safety, staffing, response to emergencies, and clinical strategies that may contribute to a hospital's outcome performance.

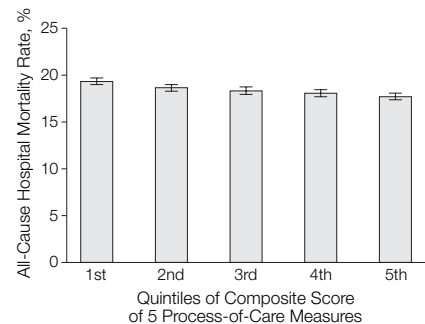
In light of the multiple determinants of hospital performance and patient survival that are currently not captured by the core measures, there is a need for new research to define these facets of care and construct new performance measures for key processes not addressed in the current core measures. As has been suggested by others,<sup>15-17</sup> ideal measures will demonstrate a strong link to outcomes, provide actionable information, target populations at high risk for poor quality care, allow for patient exceptions that do not

reflect differences in quality, include adequate risk adjustment, and be feasible to implement. Identifying processes of care that are particular to hospitals with exceptional performance in risk-standardized mortality rates and improving their implementation nationally offers great opportunity for further improving hospital performance, as measured by patient survival.

The analysis also revealed strong correlation among many of the national performance measures for AMI care, indicating that hospitals that perform well in one of these processes are likely to perform well in the other areas. However, other process measures were less strongly correlated with the admission and discharge medication-related measures. The finding indicates that different process measures reflect distinct components of quality in AMI care. Recent research<sup>18</sup> has shown that hospital rankings can vary substantially depending on subtle changes in weighting and aggregation rules of composite performance measures. Our work similarly demonstrates that hospital performance rankings are likely to differ substantially depending on which of the performance measures are being evaluated.

Our results should be interpreted in light of several considerations. The process measures are derived from hospitals that were participating in the NRMI. Although NRMI hospitals reflect a spectrum of hospital types and were diverse in process and outcome measures of performance, they generally have greater AMI volume and more advanced cardiac facilities than hospitals not participating in the NRMI. It is possible that we inadequately adjusted for the risk profile of patients; however, our risk-adjustment model<sup>7</sup> has good agreement with a medical record-based risk-adjustment model. Finally, our outcome was mortality, and other outcomes are also important to patients and should be evaluated in future studies.

**Figure.** Risk-Standardized 30-Day All-Cause Hospital Mortality Rate Based on Performance on Process Measures by Quintile



Ranges of composite score for each quintile are as follows: first, 12.3-16.3; second, 16.3-17.6; third, 17.6-19.0; fourth, 19.0-20.5; fifth, 20.5-27.4. Error bars indicate the 95% confidence interval around the mortality rate in each quintile.

In conclusion, although the core measures are important in pursuing improved AMI outcomes, they capture in aggregate only a small proportion of the hospital-level variation in short-term 30-day mortality rates. Until additional process measures are developed that explain more of the variation, reporting not only the current core measures but also short-term risk-standardized mortality rates is a reasonable approach to characterize hospitals' overall quality of care.

**Author Contributions:** Drs Bradley, Herrin, and Krumholz had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Study concept and design:** Bradley, Herrin, Elbel, McNamara, Magid, Spertus, Krumholz.

**Acquisition of data:** McNamara, Wang, Krumholz.

**Analysis and interpretation of data:** Bradley, Herrin, Elbel, McNamara, Magid, Nallamothu, Wang, Normand, Spertus, Krumholz.

**Drafting of the manuscript:** Bradley.

**Critical revision of the manuscript for important intellectual content:** Bradley, Herrin, Elbel, McNamara, Magid, Nallamothu, Wang, Normand, Spertus, Krumholz.

**Statistical analysis:** Bradley, Herrin, Normand.

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I had a poem in my head last night, flashing as only those unformed midnight poems can. It was all made up of unexpected burning words. I knew even in my half-sleep that it was nonsense, meaningless, but that forcing and hammering would clear its shape and form. Now not a word of it remains, not even a hint of its direction. What a pity one cannot sleepwrite on the ceiling with one's finger and lifted toe.

—Denton Welch (1915-1948)