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Management Practices and the Quality of Care in Cardiac Units

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Importance: To improve the quality of health care, many researchers have suggested that health care institutions adopt management approaches that have been successful in the manufacturing and technology sectors. However, relatively little information exists about how these practices are disseminated in hospitals and whether they are associated with better performance.

Objectives: To describe the variation in management practices among a large sample of hospital cardiac care units; assess association of these practices with processes of care, readmissions, and mortality for patients with acute myocardial infarction (AMI); and suggest specific directions for the testing and dissemination of health care management approaches.

Design: We adapted an approach used to measure management and organizational practices in manufacturing to collect management data on cardiac units. We scored performance in 18 practices using the following 4 dimensions: standardizing care, tracking of key performance indicators, setting targets, and incentivizing employees. We used multivariate analyses to assess the relationship of management practices with process-of-care measures, 30-day risk-adjusted mortality, and 30-day readmissions for acute myocardial infarction (AMI).

Setting: Cardiac units in US hospitals.

Participants: Five hundred ninety-seven cardiac units, representing 51.5% of hospitals with interventional cardiac catheterization laboratories and at least 25 annual AMI discharges.

Main Outcome Measures: Process-of-care measures, 30-day risk-adjusted mortality, and 30-day readmissions for AMI.

Results: We found a wide distribution in management practices, with fewer than 20% of hospitals scoring a 4 or a 5 (best practice) on more than 9 measures. In multivariate analyses, management practices were significantly correlated with mortality ($P=.01$) and 6 of 6 process measures ($P<.05$). No statistically significant association was found between management and 30-day readmissions.

Conclusions and Relevance: The use of management practices adopted from manufacturing sectors is associated with higher process-of-care measures and lower 30-day AMI mortality. Given the wide differences in management practices across hospitals, dissemination of these practices may be beneficial in achieving high-quality outcomes.

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Interest in quality improvement in health care during the past 10 years has been associated with a handful of important successes.[1-3] However, improvements in the quality of care have been slower than many would have hoped for,[4-8] and quality is still highly variable across organizations.[9] Although significant effort has been focused on the use of evidence-based medicine—clinical practices that lead to better care—an interest in organizational strategies and management practices that enable and incentivize high-quality health care is emerging.[10-15]

One of the most active areas of interest is in the use of management practices with origins in manufacturing, including, for example, "Lean" methodologies developed at Toyota[16] or the use of balanced scorecard approaches that originated in the technology sector.[17] These management approaches can be characterized as a set of formalized tools, the use of which is intended to improve quality through multiple pathways, such as eliminating inefficient and variable practices; engaging providers in a collaborative, team-based approach; and structuring mechanisms for setting targets and tracking progress. However, the evidence on the potential

See Invited Commentary

Table 1. Management Practice Dimensions

Practice	Basis of Score[a]
	Standardizing Care/Lean Operations
1. Admitting the patient	Is the admission process standardized (including predefined order sets) or does information and process vary by admitting team or physician?
2. Standardization and protocols within the unit	Does the approach to patient care vary substantially by provider, or does the unit rely on standardized processes (including checklists and bundles)?
3. Coordination on handoffs	Is the handoff an opportunity for miscommunication or lost information, or are handoff protocols known and used consistently by all staff?
4. Communication among staff	Do nurses and physicians practice bidirectional communication or is there, for example, relatively little opportunity for nurses to provide input on physician work?
5. Patient focus	Are multiple methods used to engage patient feedback and concerns? How do patients and family members receive or provide information when providers are absent?
6. Discharging the patient	Are patients adequately educated for posthospitalization, and is care coordinated with outpatient follow-up?
	Performance Measurement
7. Technology adoption	Are new technologies and drugs adopted based on evidence or does no formal process exist for the adoption of new technologies?
8. Monitoring errors/safety	Are strategies in place for monitoring patient safety and encouraging efforts to avoid errors? Are these efforts proactive or do changes happen primarily after an error occurs?
9. Continuous improvement	Are process improvements made only when problems arise, or are they actively sought for continuous improvement as part of a normal business process?
10. Performance review	Is performance reviewed infrequently and only on a success/failure scale, or is performance reviewed continually with an expectation of continuous improvement?
11. Performance dialogue	In review/performance conversations, to what extent are the purpose, data, agenda, and follow-up steps (like coaching) clear to all parties?
	Targets
12. Target balance	Are goals exclusively budget driven, or does a balance of targets include financial considerations, patient centeredness, and employee well-being?
13. Target interconnection	Are the unit's objectives tied to the overall performance of the hospital, and is it clear to employees how these targets connect?
14. Target stretch	Are the unit's targets appropriately difficult to achieve?
	Employee Incentives
15. Rewarding high performers	To what extent are people in the unit rewarded equally irrespective of performance level, or is performance clearly related to accountability and rewards? Are rewards tied to teamwork and coordination?
16. Removing poor performers	Are poor performers rarely removed, or are they retrained and/or moved into different roles or out of the company as soon as the weakness is identified?
17. Managing talent	To what extent are senior managers evaluated and held accountable for attracting, retaining, and developing talent throughout the organization?
18. Retaining talent	Does the unit do relatively little to retain top talent or does it demonstrate flexibility and effort in retaining top talent?

[a]Scores ranged from 1 to 5, where 1 indicates worst practice and 5, best practice.

effectiveness of these approaches in health care is relatively weak[13,18] and consists primarily of single-site studies.[19-21]

To address this gap in knowledge, we present a new framework and instrument for defining key management dimensions and for measuring them on a large scale in health care organizations. We describe the variation in management practices among a large sample of hospitals; assess its association with processes of care, readmissions, and mortality for patients with acute myocardial infarction (AMI); and suggest specific directions for the testing and dissemination of health care management approaches.

METHODS

SURVEY DESIGN

We took an approach originally developed by economists to measure management practices in manufacturing and adapted it to the cardiac inpatient setting.[22,23] This management framework has been used to measure organizational practices in more than 6000 firms across more than 15 countries and serves as the basis for the newly introduced Management and Organizational Practices Survey component of the US Census.[24] The management survey approach had been validated previously in selected health care settings, including 147 substance abuse treatment programs in the United States[25] and 100 hospitals in the United Kingdom.[26]

Our survey tool queried about 18 management practices grouped into the following 4 primary dimensions: standardizing care (the Lean methods; 6 practices), performance monitoring (5 practices), setting targets (3 practices), and incentivizing employees and managers (4 practices). **Table 1** provides a brief description of these 4 dimensions and 18 practices. The section on standardizing care focused on processes and systems that minimize variations. The monitoring section focused on strategies for collecting and tracking key performance indicators. Targets examined the clarity and ambition of unit targets (eg, "Was the unit engaged in a drive toward a 0% bloodstream infection rate?").

Following the design of previous work,[22,23] we scored unit performance on the 18 practices, with trained interviewers asking open-ended questions designed to elicit information on whether the unit is a poor, average, or high performer for that particular practice. The response was scored on a scale from 1

to 5, with a higher score indicating better performance. Surveys were conducted via telephone interview. **Table 2** provides the scoring grid and example responses for 4 of our 18 questions, along with the percentage of hospitals receiving scores of 1, 3, or 5. Additional details of the survey questions are provided in eAppendix 1 (http://www.jamainternalmed.com). Technical aspects of the survey implementation are provided in eAppendix 2 and the eTable.

We converted our management scores from the original 1- to 5-point scale to *z* scores (mean, 0; SD, 1) because scaling may vary across the 18 measured practices (eg, interviewers might consistently give higher scores on question 1 compared with question 2). We took an additional step to mitigate potential bias by regressing, without an intercept, the mean of the management *z* scores on a set of prespecified indicator variables for interviewer, interviewee job position (eg, nurse manager vs unit director), interviewee location (eg, intensive care unit vs telemetry), and the duration, day, and week of the interview.[22] The predicted values of this regression were then subtracted from the mean management score to create an adjusted mean management score. This adjusted management score was the primary measure of overall managerial practice.

HOSPITAL DATA COLLECTION AND SAMPLE

The survey was conducted during 2010. All research interviewers were trained on the interview guide and scoring grid for 1 week. We used the American Hospital Association Guide[27] to identify hospitals with interventional cardiac catheterization laboratories and to determine hospital contact information. We excluded federal (Veterans Administration) hospitals and hospitals with fewer than 25 annual Medicare discharges with a primary diagnosis of AMI. Interviewers made contact with a nurse manager in a cardiac unit, confirmed that the unit performed interventional cardiology, and confirmed consent to conduct the interview. Interviews were conducted using a standard interview guide and generally were scored by 2 members of the interview team, with one member asking questions and scoring responses and the second listening and scoring responses in parallel. At the conclusion of each interview, interviewers discussed discrepancies between scores and made changes where appropriate. Interobserver agreement was assessed using a subset of 58 interviews in which the 2 individuals scoring the interview were not permitted to change their score. The correlation coefficient in the mean management score for these interviews was 0.89 ($P < .001$).

We obtained hospital administrative data (ie, profit status, number of beds, teaching status, and presence of open heart surgery facilities) from the American Hospital Association Guide[27] and Medicare's Provider of Service file.

PROCESS-OF-CARE MEASURES

We obtained publicly available data from the Centers for Medicare & Medicaid Services on 6 AMI process measures included in the Hospital Compare evaluation for 2010.[28] These measures include aspirin use within 24 hours of arrival, angiotensin-converting enzyme inhibitor use for left ventricular dysfunction, provision of percutaneous coronary intervention within 90 minutes of arrival, aspirin prescribed at discharge, β-blocker prescribed at discharge, and provision of smoking cessation counseling.

MORTALITY AND READMISSIONS RISK ADJUSTMENT AND SAMPLE

Analyses of mortality and readmissions were based on the 2010 Medicare Provider Analysis and Review file and used risk adjustment variables described by Krumholz and colleagues.[29,30] We calculated hospital risk-adjusted mortality using the Dimick and Staiger method, a Bayesian "shrinkage" estimator that accounts for some of the random variation associated with mortality rates and has been shown to have the best predictive accuracy among potential estimators.[31] Readmissions were calculated as any readmission within 30 days of discharge from the index admission, excluding transfers or admissions into a skilled nursing facility or a long-term acute care hospital and admissions for rehabilitation (diagnosis related group code 462 or admission diagnosis code V57.xx).

STATISTICAL ANALYSIS

We present univariate unadjusted values for quality measures, displayed by hospitals at the top and bottom quartiles of the management score. To test for trends by quartile, we calculated the Pearson correlation coefficient.

In multivariate models assessing the association of management with risk-adjusted 30-day mortality, we estimated a weighted linear least squares model weighted by the number of AMI discharges. We controlled for a set of independent variables that have a previously demonstrated association with AMI mortality,[32-38] including AMI volume (25-75, 76-125, 126-250, and >250 discharges annually), region, ownership, number of licensed beds (<151, 151-374, and >374), location (rural vs urban), teaching status, open heart surgery capability, and hospital system membership. To assess the association with each process-of-care measure, we used a binomial regression weighted by the number of patients and including the same set of independent variables used in the mortality regression.[39]

To provide results that are interpretable across quality measures, we estimated the change in mortality or process measures associated with moving a typical hospital (defined as a hospital with the median values for all independent variables except the adjusted management score) from the 25th to the 75th percentile of the adjusted management score. We used bootstrapping to generate 95% confidence intervals.

Analyses of mortality and process-of-care measures were conducted at the hospital level. In sensitivity analyses, we ran patient-level models of 30-day AMI mortality using mixed-effects logistic models with a hospital-level random effect. In additional analyses, we included a composite measure of performance on AMI process-of-care measures (based on a sum of the *z* score of each process measure[40]) as an additional covariate in our hospital-level analyses of management on mortality.

To examine the relationship between management practice scores and 30-day readmission, we used competing-risks survival regressions, which control for the fact that patients who die are no longer at risk for readmission. Models were adjusted for the described individual and hospital factors, with standard errors adjusted for hospital-level clustering.[29] Mortality and readmission models also adjusted for patient comorbidities, age, sex, and emergency admission. In these analyses, we tested the proportionality assumption that the effect of management on readmission is constant over time. We used a significance level of .05 and 2-sided tests for all hypotheses.

The study protocol was approved by the institutional review board of Oregon Health & Science University. Additional details on modeling choices and survey approach are available in eAppendix 2.

RESULTS

From the administrative data, we identified 1358 nonfederal hospitals with interventional cardiac catheterization

Table 2. Management Practice Interview Scoring Guide and Example Responses for 4 of the 18 Practices

	Score		
	1	3	5
Practice 2: Standardization and Protocols Within the Unit			
Scoring grid	Little standardization and few protocols exist.	Protocols have been created but may exist only for certain patient groups or are not commonly used because they are too complicated or not monitored adequately.	Protocols exist for all patients, are known and used by all clinical staff, and are regularly followed up through some form of monitoring or oversight.
Examples	Unit has not standardized main clinical procedures but it intends to during the next year. Nurse managers assume that nurses and physicians are "on the same page" in terms of protocols. Medical records are reviewed monthly for completion.	Unit has protocols for key procedures (eg, peripherally inserted catheters). Clinicians receive training when hired and have annual competency checks. Managers rely primarily on direct observation to ensure that individuals are conducting procedures appropriately and consistently.	Main clinical processes are standardized and regularly monitored. Bundles exist for all key clinical procedures. Each bundle has an associated checklist that is audited regularly for compliance. Staff must pass competency examinations on all unit processes and procedures quarterly. Staff must attend regular practice update and skills review meetings.
Hospitals receiving this score, %	1.9	42.9	10.6
Practice 8: Monitoring Errors and Safety			
Scoring grid	Staff recognize the importance of avoiding errors but safety depends primarily on individual efforts.	Strategies are in place but not aggressively monitored; staff are aware of efforts to reduce/avoid adverse outcomes, but barriers exist to discussing them or making the necessary changes.	Strategies for avoiding/reducing errors are in place and monitored; near misses are viewed as evidence of systems that should be improved to reduce potential harm to patients.
Examples	Hospital leadership regularly communicates about the importance of patient safety; all employees are expected to work hard to avoid medical errors. A hospital-wide reporting system for errors exists but is not used most of the time. Audits are occasionally performed when problems are reported to determine fault.	A bar-coding system is in place to avoid medication errors. The computerized system allows for continuous monitoring but the hospital currently does not have the budget to increase the quality department's staff. Nurse supervisors perform observational audits on this strategy and others to ensure proper use. The quality department reviews errors monthly with the manager.	The unit has adopted a systems-oriented approach to medication error reduction that includes steps to reduce workplace fatigue and automated medication dispensing devices. A unit safety officer reviews reported errors immediately. On "Patient Safety Friday," multidisciplinary teams review errors and near misses. Unit uses Pareto medical records and failure mode and effects analysis for risk management.
Hospitals receiving this score, %	1.7	38.5	12.7
Practice 14: Target Stretch			
Scoring grid	Goals are too easy or impossible to achieve, at least in part because they are set with little clinician involvement (eg, simply based on historical performance).	In most areas, senior staff push for aggressive goals based on external benchmarks, but with little buy-in from clinical staff; a few "sacred cows" are not held to the same standard.	Goals are genuinely demanding for all parts of the organization and developed in consultation with senior staff (eg, to adjust external benchmarks appropriately).
Examples	Unit always meets their targets. The bar is set low to ensure success. Targets and the subsequent successes exist for marketing purposes; the hospital likes saying they are reaching all of their quality targets.	The unit meets its goals 75% of the time. Significant variance in success exists; some targets are met 100% of the time whereas others are never met. They struggle the most with reducing falls to their target level but managers have had no say in adjusting or reevaluating this goal, which is a source of frustration for the manager.	Each goal has the following 3 categories of success to encourage stretch: target, expected but difficult, and distinguished. The unit reached only 10% of distinguished level goals. Setting target levels is a collaborative process supported by leadership and clinical staff. Targets are compared internally and externally to national standards. All units are held to the same standard of excellence.
Hospitals receiving this score, %	8.0	37.2	4.0

(continued)

Table 2. Management Practice Interview Scoring Guide and Example Responses for 4 of the 18 Practices (continued)

	Score		
	1	3	5
Practice 15: Rewarding High Performers			
Scoring grid	Staff members are rewarded in the same way irrespective of their level of performance.	An evaluation system awards performance-related rewards, but people are rewarded only on an individual basis (teamwork is not rewarded), or rewards are relatively small and/or nonfinancial or available only to certain clinical groups.	An evaluation system awards performance-related rewards, including personal financial rewards and shared group/team rewards.
Examples	Employees receive an annual 3% cost of living raise irrespective of individual or group performance.	Employee performance is continuously evaluated based on their individual targets relating to the 5 hospital pillars. Staff are eligible for quarterly bonuses based on level of performance. Managers will also send thank-you cards to individuals and select an employee of the month to recognize high performers. Group performance is not recognized.	Performance evaluations include a self, peer, and manager evaluation of each individual. Eligibility for individual salary is based on the combination of these 3 scores; top performers receive a 3%, 5%, or 7% raise if they achieve a customary, above-average, or excellent rating, respectively. The management team chooses a yearly bonus-eligible goal. This year if the hospital meets its aggressive patient-satisfaction target, all employees receive a $1500 bonus.
Hospitals receiving this score, %	19.1	40.4	3.9

laboratories and with at least 25 annual AMI discharges. Of those hospitals, 199 indicated verbally that they did not conduct interventional catheterization.

We completed interviews and scored management practices in 597 hospitals, capturing detailed management data for 51.5% of 1159 units with interventional cardiology and at least 25 annual AMI discharges. Table 2 provides an indication of the spread of management processes for practices 2, 8, 14, and 15. Although only a small percentage (1.9% and 1.7%) of units were scored a 1 (indicating little or no adoption of modern management processes) for practices 2 (standardization of protocols) and 8 (monitoring errors), the percentages scoring a 5 (indicating high adoption and fidelity to best practices) were also relatively small (10.6% and 12.7%, respectively). A similar spread was observed for all 18 practices, with only 23.1% of hospitals scoring a 4 or a 5 on more than half.

The **Figure** displays the distribution of overall management scores across our 597 hospitals. We found a wide distribution in management practices, with 38.2% of hospitals scoring a mean of less than 3 across the 18 practices.

Table 3 compares surveyed and nonsurveyed hospitals. Surveyed hospitals were slightly more likely to be located in the western United States, be not-for-profit hospitals, offer cardiac surgery, and exhibit slightly lower mortality.

Table 4 displays unadjusted, unweighted quality measures for hospitals in the top, bottom, and middle 2 quartiles of the management practice score. In comparison with hospitals in the bottom quartile of management, hospitals in the top quartile had better performance on all process-of-care measures, except for the provision of smoking cessation counseling.

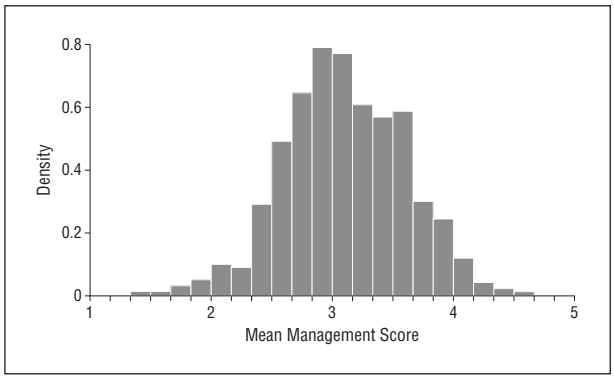

Figure. Distribution of overall management practice score. Mean scores were calculated for practices 1 through 18 (described in Table 1).

Table 5 displays results for regression models that adjust for all hospital-level covariates described previously. To provide results that are interpretable across process and mortality measures, we estimated the effect of increasing the adjusted management score from the 25th to the 75th percentiles. The overall management score was associated with statistically significant improvements in 30-day risk-adjusted mortality ($P = .01$) and the process-of-care measures ($P = .03$ for aspirin at discharge; $P = .02$ for smoking cessation; and $P < .01$ for all other process-of-care measures).

Table 5 also displays the hazard ratio for our competing risk regression of risk-adjusted 30-day readmission. The proportionality assumption was met for the hospital-level exposure of interest ($\chi^2 = 1.4$; $P = .24$). The overall management score was not associated with a reduction in readmissions.

Table 3. Hospital Characteristics and Survey Response[a]

Characteristic	Respondents (n = 597)	Nonrespondents (n = 562)	*P* Value[b]
Region			
New England	26 (4.4)	31 (5.5)	
Atlantic			
Middle	60 (10.1)	77 (13.7)	
South	106 (17.8)	106 (18.9)	
Central			
East/north	103 (17.3)	105 (18.7)	.03
East/south	35 (5.9)	43 (7.7)	
West/north	65 (10.9)	34 (6.0)	
West/south	88 (14.7)	75 (13.3)	
Mountain	45 (7.5)	29 (5.2)	
Pacific	69 (11.6)	62 (11.0)	
Location			
Rural	85 (14.2)	60 (10.7)	.07
Urban	512 (85.8)	502 (89.3)	
Ownership			
Public	72 (12.1)	53 (9.4)	
Nonprofit	459 (76.9)	419 (74.6)	.03
For profit	66 (11.1)	90 (16.0)	
Hospital type			
Teaching	114 (19.1)	101 (18.0)	.62
Nonteaching	483 (80.9)	461 (82.0)	
Cardiac facilities			
Catheterization only	110 (18.4)	130 (23.1)	.05
Open heart surgery	487 (81.6)	432 (76.9)	
No. of licensed beds			
≤150	77 (12.9)	82 (14.6)	
151-374	335 (56.1)	321 (57.1)	.51
≥375	185 (31.0)	159 (28.3)	
System membership			
System member	391 (65.5)	375 (66.7)	.66
Independent	206 (34.5)	187 (33.3)	
Annual AMI volume, No. of discharges[c]			
25-50	142 (23.8)	161 (28.6)	
51-99	257 (43.0)	240 (42.7)	.20
100-199	173 (29.0)	139 (24.7)	
≥200	25 (4.2)	22 (3.9)	
30-d AMI risk-adjusted mortality rate, mean, %[d]	14.8	15.0	.01
30-d AMI readmission rate, mean, %	16.5	16.8	.31

Abbreviation: AMI, acute myocardial infarction.
[a] Unless otherwise indicated, data are expressed as number (percentage) of hospitals. Percentages have been rounded and might not total 100.
[b] *P* values designate the statistical significance of the difference between a characteristic of the hospital for respondents vs nonrespondents.
[c] Based on Medicare fee-for-service visits.
[d] Based on the Dimick-Staiger estimator.[31]

In sensitivity analyses, patient-level models of 30-day AMI mortality using a mixed-effects logistic model demonstrated similar results (odds ratio, 0.93 [95% CI, 0.88-0.99]). In hospital-level models of mortality that included a composite measure of AMI process-of-care measures as an additional covariate, the overall management score was still significantly associated with mortality ($P = .02$).

COMMENT

In our survey of more than half the US hospitals with interventional cardiac services, we found a wide distribution in management practices. Higher management practice scores were correlated with lower mortality and better performance on AMI process-of-care measures. Models that included a composite measure of AMI process-of-care measures also demonstrated a strong association between management practices and mortality, suggesting that the benefits of management were not solely attributable to better performance on process-of-care measures. Although strongly associated with mortality and process-of-care measures, management practices were not associated with lower readmission rates, a finding that may be consistent with evidence suggesting that 30-day readmission rates are driven primarily not by hospital practice but by a hospital's patient population and the resources of the community in which it is located.[41,42]

The practices that we measured have been promoted by business schools, researchers, and industry leaders as mechanisms for reducing variations in practice, increasing motivation and accountability of employees, and identifying errors or subpar performance. In short, these practices can be seen as concrete examples of a system for

Table 4. Hospital Performance on AMI Quality Measures by Quartile

AMI Quality Measure	Quartile of Management Score, %			*P* Value[a]
	Bottom (n = 150)	Middle Two (n = 298)	Top (n = 149)	
30-d risk-adjusted mortality rate[b]	15.0	14.9	14.6	.02
30-d risk-adjusted readmissions	16.9	16.2	16.5	.45
Medicare core process measures for AMI				
Aspirin use within 24 h of arrival	98.9	99.0	99.3	.02
ACEI use for left ventricular dysfunction	95.5	96.0	97.4	.005
Provision of percutaneous coronary intervention within 90 min of arrival	87.5	90.7	91.8	.006
Aspirin prescribed at discharge	98.7	98.9	99.2	.03
β-Blocker prescribed at discharge	98.4	98.5	99.0	.01
Provision of smoking cessation counseling	99.6	99.7	99.7	.57

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction.
[a] Calculated as the test of trend across management practices quartiles.
[b] Based on Dimick-Staiger estimator.[31]

Table 5. Regression Results[a]

Dimensions	Change in Management Score From 25th to 75th Percentile (95% CI)[b]							30-d Risk-Adjusted Readmission, HR (95% CI)[d]
	30-d Risk-Adjusted Mortality[c]	Aspirin Use Within 24 h of Arrival	ACEI Use for LVD	PCI Within 90 min of Arrival	Aspirin Prescribed at Discharge	β-Blocker Prescribed at Discharge	Smoking Cessation Counseling	
Overall management score	−0.17 (−0.31 to −0.05)[e]	0.06 (0.02 to 0.18)[e]	1.6 (0.7 to 3.4)[e]	1.6 (0.32 to 2.9)[e]	0.08 (0.01 to 0.29)[e]	0.16 (0.04 to 0.47)[e]	0.9 (0.05 to 4.2)[e]	1.02 (0.97 to 1.07)

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; HR, hazard ratio; LVD, left ventricular dysfunction; PCI, percutaneous coronary intervention.
[a] Calculated using 2010 data. Estimates adjusted for acute myocardial infarction volume, region, ownership, licensed beds, rural vs urban, teaching status, open heart surgery capability, and hospital system membership. Mortality and readmission models also adjusted for patient comorbidities, age, sex, and emergency admission. Confidence intervals are calculated using the statistical bootstrap method with hospital clustering.
[b] Indicates adjusted estimates of improvement associated with changes.
[c] Based on the Dimick-Staiger estimator.
[d] Indicates cumulative incidence function.
[e] $P \leq .05$.

improving care. Our findings are consistent with the empirical research in manufacturing and reports of individual organizational successes that have been attributed to the adoption of Lean management and related approaches.[21,43-47]

Our findings parallel additional studies of management in health care settings. A survey of 537 hospitals identified 5 key strategies that were significantly associated with lower AMI mortality and noted that a small proportion of hospitals used all 5 strategies.[10] A study of management in 42 intensive care units found that attributes such as coordination, communication, and conflict management abilities were associated with better quality.[48] Qualitative studies of AMI care also provide support for many of the practices defined in Table 1.[12,49,50]

In our study, a movement from the 25th to the 75th percentile in management scores was associated with a 0.17% reduction in mortality, a potentially important although modest improvement. A number of studies have indicated that process-of-care measures are correlated with lower AMI mortality, although the magnitude of effect has also been small.[39,51-53] Our estimates may underestimate the true effect of management for several reasons. First, the noise inherent in our scoring method, coupled with the shrinkage approach of the Dimick-Staiger estimator, may introduce attenuation bias, leading to an underestimate of the true effect of better management.[54] Second, our study measures association, not causation. Experimental and survey evidence from manufacturing studies suggest that cross-sectional studies may underestimate substantially the improvements that can be realized through the adoption of modern management practices.[22,55] The small effect size may also reflect a plateau in the widespread improvements in the quality of AMI treatment that have occurred during the past 10 years.[2] The management practices that we tested—many of which are not specific to the care of AMI patients—may have significant potential in clinical areas that have not experienced similar improvements in quality.

Our study has additional limitations. Process-of-care measures depend on systems that are in place in several locations in the hospital, and good performance on these measures is not solely the domain of the cardiac unit, where we measured management. However, some of our questions reflect a systems perspective, and "good management" in the cardiac unit may in part be reflected by an overall hospital approach.

Our study used only 1 respondent at each site. In their work on manufacturing, Bloom and Van Reenen[22] ran a second interview with a different manager on a subset

of firms and found a strong correlation between the first and second interviews ($\rho = 0.734$; $P < .001$). Unfortunately, the pool of managers in cardiac units who could provide reliable answers to our questions was relatively small, restricting our ability to conduct a second interview with a different manager. However, because we used the same approach, training team, and materials as Bloom and Van Reenen,[22,23] it is likely, although uncertain, that our scores would have similar accuracy.

Finally, our study was based on data collected from approximately 50% of cardiac units, and the surveyed hospitals differed in some ways from the nonrespondents (eg, surveyed hospitals were slightly more likely to be located in rural areas). However, the surveyed hospitals also had smaller but statistically significantly lower mortality rates, providing some indication that management scores might be worse in the nonsurveyed group. In other words, if our survey of management does not reflect accurately the full distribution of practices across all hospitals, it should be relatively close, although perhaps biased toward better-managed hospitals. The study's strengths included the use of a method for measuring management that has been validated in large-scale studies of manufacturing, a large sample size, and an empirical test of management's association with widely accepted quality metrics.

Our results suggest future directions for hospital management practices and quality of care. We find wide variation in the dissemination of modern management practices, with better management associated with higher performance in process-of-care measures and lower risk-adjusted mortality. Many of these practices are relatively moderate in scope and do not require substantial capital investment. The identification of essential aspects of management can help administrators, clinicians, and policymakers understand the types of organizational changes that are feasible and currently in place in some hospitals and may speed the adoption of practices that are relatively new to health care but have the potential to improve patient care.

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Online-Only Material: The eAppendixes and eTable are available at http://www.jamainternalmed.com.

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