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Management Practices and the Quality of Care in Cardiac Units

K. John McConnell, PhD, Richard C. Lindrooth, PhD, Douglas R. Wholey, PhD, Thomas M. Maddox, MD, Nick Bloom, PhD

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Contact information for corresponding author:
K. John McConnell
3181 Sam Jackson Park Rd.
Mail Code CR-114
Portland, OR 97239
Tel: 503.494.1989
Fax: 503.494.4640
email: mcconnjo@ohsu.edu

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Abstract

Background
In efforts to improve the quality of care, many have suggested that health care adopt management approaches that have been successful in the manufacturing and technology sectors. However, there is relatively little information about how these practices are disseminated in hospitals, and whether they are associated with better performance.

Methods
We adapted an approach used to measure management and organizational practices in manufacturing to collect management data on cardiac units, scoring performance on 18 practices, covering "Lean" methods, tracking of key performance indicators, setting targets, and incentivizing employees. Multivariate analyses assessed the relationship of management practices with process of care measures, 30-day risk adjusted mortality, and 30-day readmissions for acute myocardial infarction (AMI).

Results
We measured management practices for 597 cardiac units, representing 51.5% of hospitals with interventional cardiac catheterization laboratories and at least 25 annual AMI discharges. We found a wide distribution in management practices, with fewer than 20% of hospitals scoring a “4” or “5” (best practice) on more than 9 measures. In multivariate analyses, management practices were significantly correlated with mortality ($P=0.01$) and 6 out of 6 process measures ($P<0.05$). No statistically significant association was found between management and 30-day readmissions.

Conclusions
The use of management practices adopted from manufacturing sectors was 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.

INTRODUCTION

Interest in quality improvement in healthcare over the last ten 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 – there is an emerging interest in organizational strategies and management practices that enable and incentivize high quality care.[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 whose use is intended to improve quality through multiple pathways: elimination of inefficient and variable practices; engaging providers in a collaborative, team-based approach; and structured mechanisms for setting targets and tracking progress. However, the evidence on the potential effectiveness of these approaches in healthcare 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 basis in healthcare 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 healthcare management approaches.

METHODS

Survey Design

We adapted, to the cardiac inpatient setting, an approach originally developed by economists to measure management practices in manufacturing.[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 Practice Survey (MOPS) component of the US Census.[24] The management survey approach had been previously validated 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 on 18 management practices grouped into 4 primary dimensions: standardizing care ("Lean", 6 practices), performance monitoring (5 practices), targets (3 practices), and employee incentives (4 practices). Table 1 provides a brief description of these 4 groupings 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 (e.g., was the unit engaged in a drive towards a zero percent bloodstream infection rate?). The incentives section examined employee and manager incentives.

Following previous work,[22,23] we scored unit performance on 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 a score of 1, 3, or 5. Additional details of the survey questions are provided in Appendix A. Technical aspects of the survey implementation are provided in Appendix B.

We converted our management scores from the original 1-5 scale to z-scores (mean 0 and standard deviation 1) because scaling may vary across the 18 measured practices (e.g., interviewers might consistently give higher scores on Question 1 compared to Question 2). We took an additional step to mitigate potential bias by regressing, without an intercept, the average of the management z-scores on a set of pre-specified indicator variables for interviewer, interviewee job position (e.g. nurse manager vs. unit director), interviewee location (e.g. ICU vs. telemetry), and duration, day, and week of the interview.[22] The predicted values of this regression were then subtracted from the average management score to create an adjusted average 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 one week. We used the American Hospital Association (AHA) Guide 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 scored by 2 members of the interview team, with one member asking questions and scoring responses, and the second

member listening and scoring responses in parallel. At the conclusion of each interview, interviewers discussed discrepancies between scoring and made changes where appropriate. Interobserver agreement was assessed using a subset of 58 interviews where the two individuals scoring the interview were not permitted to change their score. The correlation coefficient in the average management score for these interviews was 0.887 ($p<0.001$).

We obtained hospital administrative data (profit status, number of beds, teaching status, and presence of open heart surgery facilities) from the AHA Guide and from Medicare's Provider of Service file.

Process of Care Measures

We obtained publicly available data from the Centers for Medicare and Medicaid Services (CMS) on 6 AMI process measures included in the Hospital Compare evaluation for 2010. These measures include: aspirin use within 24 hours of arrival; angiotensin-converting enzyme (ACE) inhibitor use for left ventricular dysfunction; provision of percutaneous coronary intervention (PCI) 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 (MEDPAR) file and used risk adjustment variables described by Krumholz and colleagues.[27,28] We calculated hospital risk-adjusted mortality using the Dimick-Staiger methodology, a Bayesian “shrinkage” estimator which accounts for some of the random

variation associated with mortality rates and has been shown to have the best predictive accuracy among potential estimators.[29]

Readmissions were calculated as any readmission within thirty days of discharge from the index admission, excluding transfers or admissions into a skilled nursing facility or a long term acute care hospital, as well as admissions for rehabilitation (diagnosis related group 462 or admission diagnosis code V57.xx).

Statistical Analyses

We present univariate, unadjusted values for quality measures, displayed by hospitals at the top and bottom quartiles of management score. To test for trends by quartile, we calculated Pearson's 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 number of AMI discharges. We controlled for a set of independent variables that have been previously demonstrated association with AMI mortality,[30-36] including AMI volume (25 to 75, 76 to 125, 126 to 250, and more than 250 discharges annually), region, ownership, licensed beds (less than 151, 151 to 374, and more than 374), 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 number of patients, and including the same set of independent variables used in the mortality regression.[37]

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 percentile 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 a 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[38]) 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 controls for the fact that patients who die are no longer at risk for readmission. Models adjusted for individual and hospital factors described above, with standard errors adjusted for hospital-level clustering.[27] 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 Appendix B.

RESULTS

From the administrative data, we identified 1,358 non-federal hospitals with interventional

cardiac catheterization 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 1,159 units with interventional cardiology and at least 25 annual AMI discharges. Table 2 provides an indication of the spread of management practices for example questions 2, 8, 14, and 15. While only a small percentage (2%) of units were scored a "1" (little or no adoption of modern management practices) on question 2 (Standardization of Protocols) and question 8 (Monitoring Errors), the percentage scoring a "5" (high adoption and fidelity to best practices) was also relatively small (11% and 13%, respectively). A similar spread was observed for all 18 questions; only 17% of hospitals scoring a "4" or "5" on more than half of the practices.

Figure 1 displays the distribution of overall management scores across our 597 hospitals. We found a wide distribution in management practices, with 40% of hospitals scoring below a "3" on average across the 18 practices.

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

Table 4 displays unadjusted, unweighted quality measures for hospitals in the top, bottom and middle two quartiles of management practice score. In comparison to 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.

Table 5 displays results for regression models that adjust for all hospital-level covariates described above. To provide results that are interpretable across process and mortality measures, we estimate the effect of increasing the adjusted management score from the 25th percentile to the 75th percentile. The overall management score was associated with statistically significant improvements in 30-day risk adjusted mortality (P = 0.01) and process of care measures (P = 0.03 for aspirin at discharge, P = 0.016 for smoking cessation, P < 0.01 for all other process measures).

Table 5 also displays hazard ratios 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 = 0.24). Overall management was not associated with a reduction in readmissions.

In sensitivity analyses, patient-level models of 30-day AMI mortality using a mixed effects logistic model demonstrated similar results (OR 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 = 0.02).

COMMENT

In our survey of over half of the U.S. 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 from 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 30-day readmission rates may be primarily driven not by hospital practice but by a hospital's patient population and the resources of the community in which it is located.[39,40]

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 improving care. Our findings are consistent with the empirical research in manufacturing as well as reports of individual organizational successes that have been attributed to the adoption of Lean management and related approaches.[21,41-45]

Our findings parallel additional studies of management in health care settings. A survey of 537 hospitals identified five key strategies that were significantly associated with lower AMI mortality and noted that a small proportion of hospitals used all five strategies.[10] A study of management in 42 ICUs found that attributes such as coordination, communication, and conflict management abilities were associated with better quality.[46] Qualitative studies of AMI care also provide support for many of the practices that defined in Table 1.[12,47,48]

In our study, a movement from the 25th percentile 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 measures are correlated with lower AMI mortality, although the magnitude of effect has also been small [37,49-51] 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.[52] Second, our study measures association, not causation. Experimental and survey evidence from manufacturing studies suggest that cross-sectional studies may substantially underestimate the improvements that can actually be realized through the adoption of modern management practices.[22,53] The small effect size may also reflect a plateau in the widespread improvements in the quality of AMI treatment that has occurred over the last 10 years.[2] The management practices that we test - 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 one respondent at each site. In their work on manufacturing, Bloom and Van Reenen ran a second interview with a different manager on a subset of firms and found a strong correlation between the first and second interviews ($\rho = 0.734$, $P < 0.001$). Unfortunately, the pool of managers in cardiac units who could reliably answer our questions was relatively small, restricting our ability to conduct a second interview with a different manager. However, since we used the same approach, training team and materials as Bloom and Van Reenen, 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 (e.g., surveyed hospitals were more likely to be located in urban 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 non-surveyed group. In other words, if our survey of management does not accurately reflect the full distribution of practices across all hospitals, it should be relatively close, although perhaps biased towards better managed hospitals

The study's strengths were the use of a methodology 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. Importantly, 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 policy-makers 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 healthcare but have the potential to improve patient care.

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Table 1: Management Practice Dimensions

Area	Practice	Score from 1-5 based on:
Standardizing care/Lean operations	(1) Admitting the patient	Is the admission process standardized (including predefined order sets) or is does information and process vary on 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, e.g., relatively little opportunity for nurses to provide input on physician work?
	(5) Patient focus	Are there multiple methods 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 post-hospitalization, and is care coordinated with outpatient follow-up?
Performance measurement	(7) Technology adoption	Are new technologies and drugs adopted based on evidence or is there no formal process for the adoption of new technologies?
	(8) Monitoring errors/safety	Are there 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 out for continuous improvement as part of a normal business processes?
	(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 is the purpose, data, agenda, and follow-up steps (like coaching) clear to all parties?
Targets	(12) Target balance	Are goals exclusively budget driven, or is there a balance of targets that include financial considerations, patient-centeredness, and employee well-being?
	(13) Target inter-connection	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?

Table 2. Management Practice Interview Scoring Guide And Example Responses For 4 Of The 18 Practices

Practice 2: Standardization and protocols within the unit			
	Score 1	**Score 3**	**Score 5**
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 regularly followed up on through some form of monitoring or oversight.
Examples	Unit has not standardized main clinical procedures but it intends to over the next year. Nurse managers assume that nurses and physicians are "on the same page" in terms of protocols. Charts are reviewed monthly for completion.	Unit has protocols for key procedures (E.g. 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 exams on all unit processes and procedures quarterly. Staff must attend regular practice update and skills review meetings.
Percent of hospitals receiving this score	2%	42%	11%
Practice 8: Monitoring errors and safety			
	Score 1	**Score 3**	**Score 5**
Scoring grid	Staff recognize 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. There is a hospital-wide reporting system for errors but it 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.	Unit has adopted a systems-oriented approach to medication error reduction that includes steps to reduce work place fatigue and automated medication dispensing devices. Unit safety officer reviews reported errors immediately. On "Patient Safety Friday", multi-disciplinary teams review errors and near misses. Unit uses Pareto charts and Failure Mode and Effects Analysis for risk management.
Percent of hospitals receiving this score	2%	38%	13%

Table 2 (continued). Management Practice Interview Scoring Guide And Example Responses For 4 Of The 18 Practices

Practice 14: Target stretch			
	Score 1	**Score 3**	**Score 5**
Scoring grid	Goals are either too easy or impossible to achieve, at least in part because they are set with little clinician involvement (e.g. simply off historical performance).	In most areas, senior staff push for aggressive goals based on external benchmarks, but with little buy-in from clinical staff; there are a few sacred cows that are not held to the same standard.	Goals are genuinely demanding for all parts of the organization and developed in consultation with senior staff (e.g. 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. There is significant variance in success; some targets are met 100% of the time while others are never met. They struggle the most with reducing falls to their target level but managers have had no say in adjusting or re-evaluating this goal, which is a source of frustration for the manager.	Each goal has 3 categories of success to encourage stretch: Target;.Expected but Difficult; Distinguished. The unit reached only 10% of distinguished level goals. Setting targets 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.
Percent of hospitals receiving this score	8%	37%	4%
Practice 15: Rewarding high performers			
	Score 1	**Score 3**	**Score 5**
Scoring grid	Staff members are rewarded in the same way irrespective of their level of performance.	There is an evaluation system for the awarding of performance related rewards, but people are rewarded only on an individual basis (teamwork is not rewarded), or rewards are relatively small and/or non-financial; or available only to certain clinical groups.	There is an evaluation system for the awarding of 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 five hospital pillars. Staff are eligible for quarterly bonuses based on level of performance. Manager 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 three 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 $1,500 bonus.
Percent of hospitals receiving this score	19%	40%	4%

Table 3. Hospital Characteristics and Survey Response

Characteristic	Responded to Survey		Did not Respond		
	N (597)	%	N (562)	%	P-value
Region					**0.03**
New England	26	4	31	6	
Middle Atlantic	60	10	77	14	
South Atlantic	106	18	106	19	
East North Central	65	11	105	19	
East South Central	35	6	43	8	
West North Central	65	11	34	6	
West South Central	88	15	75	13	
Mountain	45	8	29	5	
Pacific	69	12	62	11	
Location					0.07
Rural	85	14	60	11	
Urban	512	86	502	89	
Ownership					**0.03**
Public	72	12	53	9	
Nonprofit	459	77	419	75	
For profit	66	11	90	16	
Hospital type					0.62
Teaching	114	18	101	19	
Nonteaching	483	82	461	81	
Cardiac facilities					**0.05**
Catheterization only	110	18	130	23	
Open heart surgery	487	82	432	77	
Licensed beds					0.51
<=150	77	13	82	15	
151-374	335	56	321	57	
>=375	185	31	159	28	
System membership					0.66
System member	391	65	375	67	
Independent	206	35	187	33	
Annual AMI volume*					0.20
25-50	142	24	161	29	
51-99	257	43	240	43	
100-199	173	29	139	25	
>=200	25	4	22	4	
30-day AMI risk adjusted mortality rate** (mean)	14.8%		15.0%		0.01
30-day AMI readmission rate (mean)	16.5%		16.8%		0.31

(P-values designate the statistical significance of the difference between a characteristic of the hospital for hospitals that responded to the survey and those that did not)
*AMI volume based on Medicare FFS visits
**Risk adjusted mortality rates are based on Dimick-Staiger estimator

Table 4. Hospital Performance on AMI Quality Measures, by Quartile

AMI Quality Measures		Measure for Hospitals in Bottom Quartile of Management Score (N = 150)	Measure for Hospitals in Middle two Quartiles of Management Score (N = 298)	Measure for Hospitals in Top Quartile of Management Score (N = 149)	P-value, test of trend across management practices quartiles.
30-day risk adjusted mortality rate*		15.0%	14.9%	14.6%	**0.02**
30-day risk adjusted readmissions		16.9%	16.2%	16.5%	0.45
Medicare Core Process Measures for AMI	Aspirin use within 24 hours of arrival	98.9%	99.0%	99.3%	**0.02**
	Angiotensin-converting enzyme (ACE) inhibitor use for left ventricular dysfunction	95.5%	96.0%	97.4%	**0.005**
	Provision of percutaneous coronary intervention (PCI) within 90 minutes of arrival	87.5%	90.7%	91.8%	**0.006**
	Aspirin prescribed at discharge	98.7%	98.9%	99.2%	**0.03**
	β-blocker prescribed at discharge	98.4%	98.5%	99.0%	**0.01**
	Provision of smoking cessation counseling	99.6%	99.7%	99.7%	0.57

*Risk adjusted mortality rates are based on Dimick-Staiger estimator

Table 5. Regression Results (adjusted for all covariates)

	Adjusted Estimates of Improvement Associated with Change in Management Score from 25th Percentile to 75th percentile (95% CI*)							Hazard Ratio (Cumulative Incidence Function) and 95% CI*
Management Dimensions	30-day Risk Adjusted Mortality**	Medicare Core Process Measures for AMI						30-day Risk Adjusted Readmission
		Aspirin use within 24 hours of arrival	Angiotensin-converting enzyme (ACE) inhibitor use for left ventricular dysfunction	Provision of percutaneous coronary intervention (PCI) within 90 minutes of arrival	Aspirin prescribed at discharge	β-blocker prescribed at discharge	Provision of smoking cessation counseling	
Overall Management Score	**-0.17% (-0.31%, -0.05%)‡**	**0.06% (0.02%, 0.18%) ‡**	**1.6% (0.7%, 3.4%) ‡**	**1.6% (0.32%, 2.9%) ‡**	**0.08% (0.01%, 0.29%)‡**	**0.16% (0.04%, 0.47%)‡**	**0.9% (0.05%, 4.2%)‡**	1.02 (0.97, 1.07)

Source: Authors calculations using 2010 data. Estimates adjusted for AMI 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, gender, and emergency admission.

* CI denotes confidence interval based on statistical bootstrap with hospital clustering.

** Risk adjusted mortality rates are based on Dimick-Staiger estimator

‡ P≤0.05

Figure 1. Distribution of Overall Management Practice Score