MODERN MANAGEMENT PRACTICES AND HOSPITAL ADMISSIONS

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ABSTRACT

We investigate whether the modern management practices and publicly reported performance measures are associated with choice of hospital for patients with acute myocardial infarction (AMI). We define and measure management practices at approximately half of US cardiac care units using a novel survey approach. A patient's choice of a hospital is modeled as a function of the hospital's performance on publicly reported quality measures and the quality of its management. The estimates, based on a grouped conditional logit specification, reveal that higher management scores and better performance on publicly reported quality measures are positively associated with hospital choice. Management practices appear to have a direct correlation with admissions for AMI—potentially through reputational effects—and indirect association, through better performance on publicly reported measures. Overall, a one standard deviation change in management practice scores is associated with an 8% increase in AMI admissions. Copyright © 2015 John Wiley & Sons, Ltd.

1. INTRODUCTION

Hospitals across the country have exhibited a strong interest in new management techniques, sometimes promoting their use of 'Lean' methods or similar management tools adopted from other sectors. The notion of management as a strategic advantage has become more prominent: one Lean learning collaborative, the Healthcare Value Network, has grown from 15 members in 2009 to 57 members in 2012, with over 300 additional organizations having expressed interest in joining the learning collaborative (personal communication, Jack Bowhan, Healthcare Value Network).

Presumably, hospitals invest in these practices to further their mission, through increased efficiency, higher revenue and profits, and/or improvements in the quality care. These goals are not mutually exclusive. Increased quality can, directly or indirectly, attract more patients and increase revenue, especially if quality is easy for patients to observe. However, the extent to which investments in management influence patient choice is not well understood.

The primary goal of this paper is to shed light on the relationship between modern management practices, hospital admissions, and performance on quality measures. Until recently, 'management' has typically been subsumed in a fixed effect in most economic models. In this study, we present credible measures of

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management, adapting a survey approach for manufacturing firms (Bloom and Van Reenen, 2007) to the hospital setting (McConnell *et al.,* 2013).

In addition to our measure of management, we incorporate information about publicly reported measures of quality and patient satisfaction, which may be influenced by better management and may also directly influence patient choice. The evidence that publicly reported quality measures affect patient choice is mixed (Fung *et al.,* 2008), with some studies supporting the relationship (Bundorf *et al.,* 2009; Jung *et al.,* 2011; Pope, 2009; Varkevisser *et al.,* 2012; Werner *et al.,* 2012; Romano *et al.,* 2011; Mukamel and Mushlin, 2001; Mukamel *et al.,* 2007), and others' finding that patients respond more to evidence of poor quality—avoiding those providers—as opposed to seeking out high quality providers (Cutler *et al.,* 2004; Dranove and Sfekas, 2008; Wang *et al.,* 2011). In contrast, several studies find very little response to publicly reported measures (Hibbard *et al.,* 2003; Epstein, 2010; Baker *et al.,* 2003; Hibbard *et al.,* 2005; Hannan *et al.,* 1994).

We focus on the application of management tools and approaches that can enhance patient welfare, which in turn should influence patients' choice of hospital. A close parallel to our measurement tool is the work led by Elizabeth Bradley and colleagues to identify organizational changes that can improve the quality of care. A series of complementary studies by her team provides support for many of the practices defined in our paper, with studies concluding that high performing hospitals could be distinguished by specific practices such as proactive problem solving, clear communication and coordination, the use of data for nonpunitive learning, and clear and ambitious goals for the unit as well as shared goals for improvement and the use of credible data feedback (Bradley *et al.,* 2001, 2012; Curry *et al.,* 2011).

Our paper also parallels the work by Chandra and colleagues (Chandra *et al.,* 2013), who use variations in hospital productivity as a starting place and note that more productive (i.e., higher quality) hospitals have increased market share. In our paper, we use observed measure of management and assess its correlation with hospital admissions. We estimate the direct relationship between management practices and hospital choice as well as the indirect relationship that takes into account the correlation between management practices and performance on quality measures. Overall, we find a strong, robust, positive relationship between management practices and hospital admissions.

2. BACKGROUND ON MANAGEMENT PRACTICES

Our focus on management is closely tied to the concept of 'evidence-based management' (Kovner and Rundall, 2006; Shortell *et al.,* 2007; Walshe and Rundall, 2001; Clancy and Kronin, 2004), which recognizes that health care delivery is as much as a *managerial* challenge as it is *clinical*. In contrast to evidence-based medicine, which focuses on clinical practices known to provide superior health outcomes, evidence-based management identifies organizational strategies and management practices that enable providers and organizations to give the highest quality and most efficient patient care.

'Management' is a large and amorphous concept; in order to provide structure to the way we think about how these tools might be implemented, we turn to a framework developed for manufacturing and used to measure management across a large number of firms (Bloom and Van Reenen, 2007; Bloom *et al.*, 2013; Bloom and Van Reenen, 2010; Bloom *et al.,* 2012). This approach identifies four dimensions of management for which a variety of tools and empirical evidence has surfaced: (i) Lean operations; (ii) performance monitoring; (iii) targets; and (iv) employee incentives.

Lean operations include policies and processes designed to standardize operations and improve efficiency. These tools include those within the Lean philosophy as developed by the Toyota Motor Corporation (Liker, 2003; Womack and Jones, 1996). Lean can be characterized as a set of tools whose use is intended to reduce waste (Kenney, 2010, 2008; Toussaint and Berry, 2013; Toussaint, 2010, 2009; Pham *et al.,* 2007). These tools include, for example, value stream mapping (the ultimate goal of which is to eliminate or reduce steps in the input–output process that do not directly add value), 5S (workspace organizational tools, 'sorting, set in order, systematic cleaning, standardizing, and sustaining'), poka-yoke (error-proofing), and jidoka (empowering workers to stop the process or production line when there is a quality problem).

Performance monitoring refers to how well organizations measure what goes on internally and use these data to drive and evaluate change (Chassin *et al.,* 2010; Simons, 1994; Chassin, 1998). The use of visual tools to display data and frequent 'huddles' to discuss performance and drive continuous improvement is closely related to Lean operations.

The formalization of *targets* has its roots in the 'balanced scorecard' approach, a management tool that has been adopted to allow organizations to manage their units from multiple perspectives (typically financial, customer, process, and learning) (Kaplan and Norton, 1992). Organizational targets are one methodology for insuring that employee efforts are aligned and organizational resources are allocated appropriately to achieve all aims.

Employee incentives, or talent management, refer to human resource management practices, including an emphasis on recruitment efforts, merit-based promotion, skill training, compensation, and retraining or firing poor performing employees. These are often referred to as high performing work practices (U.S. Department of Labor, 1993; McAlearney *et al.,* 2011; Bassi and McMurrer, 2007; Garman *et al.,* 2011; Robbins *et al.,* 2012).The rationale for these practices is that they may motivate employees, reduce turnover, and encourage underperformers to leave the firm (Pfeffer, 1999a; 1999b).

While these four components do not comprise an exhaustive list of management approaches, they are indicative of the types of tools that are frequently taught at business schools and encapsulate many of the concepts promoted by the Institute of Medicine in its recent call to bring a 'systems' approach to health care (Kaplan *et al.,* 2013).

These management dimensions do not appear to be equivalent in the ways in which they affect organizational performance. A comprehensive meta-analysis by Nair (2006), which used similar management constructs to those described earlier, found a positive relationship between employee incentives and financial and operational performance but not customer service or product quality. The construct most closely associated with performance monitoring was associated with financial and customer service measures of performance but not operational performance. Furthermore, management practices also appear to be synergistic and complementary, with components grouped together in a 'system' generally outperforming individual practices (Combs *et al.,* 2006).

3. MODELING HOSPITAL MANAGEMENT AND ADMISSIONS

3.1. Patients' choice of hospital

We model the utility of an admission to a given hospital as a function of hospital attributes that include a management score (M_h, a measurement of management quality that includes dimensions described earlier), performance on publicly reported quality measures (Q_h), other exogenous hospital characteristics (X_h), the distance between patient i's zip code and hospital h (D_{hi}), and an interaction between patient attributes (P_i) and D_{hi}. Thus, the utility of patient i's admission to hospital h is modeled as

$$U_{hi}(M_h, Q_h, X_h, D_{hi}, P_i) = \beta_M M_h + \beta_Q Q_h + \beta_X X_h + \delta_1 D_{hi} + \delta_2 D_{hi} \cdot P_i + \varepsilon_{hi} \tag{1}$$

where e_{hi} is the idiosyncratic component of patient i's evaluation of hospital h. The out-of-pocket price of an admission of patient i to hospital h is assumed to be constant across hospitals in patient i's choice set, a reasonable assumption for Medicare fee-for-service patients. Information about hospitals comes from a variety of sources, including publicly reported quality measures (e.g., the Hospital Compare website sponsored by the Centers for Medicare and Medicaid Services) and discussions with physicians, family, and/or friends. Patients are assumed to choose the hospital that provides them with the greatest expected utility based on their appraisal of quality and location.

The model allows for patients to be idiosyncratic in their decision-making. On the one hand, a patient with a scheduled open heart surgery will be more likely to gather information about a hospital prior to admission, perhaps weighting hospital location relatively low in his or her choice of hospital. It may be that he or she chooses a hospital primarily based on the reputation of surgeons with privileges at the hospital or he or she may select the hospital where his or her cardiologist or primary care physician has admitting privileges. Regardless of the underlying mechanism, the efficacy and quality of physicians working within a hospital is both a reflection and

a determinant of hospital performance on quality measures and its reputation. On the other hand, a patient who needs emergency care will often be admitted to the closest hospital, reflecting the importance of time to treatment and the importance of location in their hospital choice. For example, Tay (2003) notes that one-half of acute myocardial infarction (AMI) patients arrive at the hospital via ambulance, and thus, proximity of the hospital to the patient is likely to be the most important factor. Nonetheless, even after controlling for distance, Tay showed that the choice of hospital was also influenced by quality. This is consistent with studies of patient choice that conclude that demand for hospital is influenced positively by higher quality (Burns and Wholey, 1992; Cutler *et al.,* 2004; Pope, 2009; Luft *et al.,* 1990; Howard, 2006; Escarce *et al.,* 1999; Chernew *et al.,* 1998; Varkevisser *et al.,* 2012; Beckert *et al.,* 2012; Goldman *et al.,* 2010; Romley and Goldman, 2011).

3.2. The relationship between management and patients' choice of hospital

We hypothesize that management practices (defined in more detail in the succeeding text) determine hospital performance of observable and unobservable attributes that influence patient choice. First, management is hypothesized to influence performance on publicly reported quality measures (Q_h). To measure management's influence on admissions through performance on Q_h, we estimated the following model:

$$Q_h = f(M_h, X_h) \tag{2}$$

where X_h is exogenous hospital characteristics that also influence Q_h. Estimates of $\partial Q_h / \partial M_h$ from Equation 2 are used in conjunction with estimates of β_Q in Equation 1 to measure how management influences admissions through Q_h. We refer to this as the 'indirect' association of management with hospital admissions.

Second, management is hypothesized to influence the desirability of a hospital to patients in ways that are not observable in publicly available measures. Patients, and their referral agents, could place a higher value on well-managed hospitals through management's influence on the performance of the hospital's workforce or the effectiveness of its physicians. In addition, management may play an important role in influencing wait-times, patient throughput (i.e., patient flow within the hospital) and Emergency Department (ED) crowding that can divert ambulances. These unmeasured elements will likely both influence a patient's choice of a hospital and be influenced by management practices. Thus, conditional on Q_h, we also include M_h in Equation 1 to reflect its importance as a determinant of a patient's utility from admission to hospital h. We refer to this as the 'direct' association of management with hospital admissions.

We model and report associations because we do not have reliable instruments or longitudinal data that would allow for a credible causal model. Although the measurement tool (described in the succeeding text) provides a mechanism for opening the 'black box' of hospital management, it is a labor and resource intensive approach. A caveat of the data we have collected is that we lack instruments or longitudinal measures to provide true causal estimates of the effect of management on admissions and performance on quality measures.

However, understanding the sources of the endogeneity bias may help with interpretation of our results. Endogeneity in the management score may arise if hospitals that are more attractive to patients have the financial resources to invest in modern management. Alternatively, it may be that poor performing hospitals may be more likely to adopt better management practices in an effort to improve. Thus, the estimates of the conditional association between management scores and admissions may be larger than they would be in a purely causal model, but the estimates of the indirect mechanism through performance on publicly reported quality measures may be in either direction.

We do not present our results as conclusive evidence that management practices are the first link in the causal chain toward hospital performance, although management theory and similar empirical research are suggestive of a causal relationship. We are conservative in interpretation of our results and strive to point out the nature of the bias that exists in this cross-sectional analysis. This approach is consistent with the emerging management literature; much can be learned by understanding the association between management, publicly reported quality measures and hospital admissions. This first step stands as motivation and a rationale for future research into causal and generalizable effects of management.

4. DATA

4.1. Survey approach—measuring management

We measure management using an approach developed by Bloom and Van Reenen for manufacturing firms (Bloom and Van Reenen, 2007). These questions were adapted for the cardiac setting, resulting in a structured interview that queried on 18 management practices grouped into four primary management dimensions discussed in Lean (six practices), performance monitoring (five practices), targets (three practices), and employee incentives/talent management (four practices). Table I provides a brief description of these four groupings and 18 practices. The Lean section measured the unit's approach to standardizing care and minimizing variations. The monitoring section focused on the tracking of key performance indicators, including how the data are collected and disseminated to employees. The targets section examined the clarity and ambition of unit targets (e.g., was the unit actively engaged in a drive toward a zero percent bloodstream infection rate?) The incentives section examined methods for engaging and incentivizing employees. Units were scored between 1 and 5 for each question, with a higher score indicating better performance. A list of detailed examples of these practices and their individual distributions is available in McConnell *et al.* (2014). The survey was conducted during

Table I. Management practice dimensions

Area	Practice	Score from 1 to 5 based on:
Lean operations	(1) Admitting the patient	Is the admission process standardized (including predefined order sets) or 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, for example, 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?

2010. Details of the survey approach and the method for mitigating self-report bias have been described previously (McConnell *et al.*, 2013). The study protocol was reviewed and approved by the institutional review board of Oregon Health & Science University.

We converted our management scores from the original 1–5 scale to *z*-scores (mean 0 and standard deviation 1) because the scaling may vary across the 18 measured practices (e.g., interviewers might consistently give a higher score on Question 1 when compared with Question 2). In the analyses, the adjusted management score is used as the primary measure of overall managerial practice. We also discuss the relative influence of each of the component groupings when analyzed separately.

4.2. Patient-level data

We used the 2010 Medicare Provider Analysis and Review file, which contains all Medicare Part A claims. We selected all discharges of AMI based on ICD-9 codes starting with '410' excluding those with fifth digit '2' for 'subsequent care'. We excluded patients who had invalid zip codes ($n = 1319$), were under 65 (n=21,824), or lived more than 50 miles away from the admitting hospital ($n = 17,577$). Distance from patient to hospital was computed as the shortest distance from the centroid of each enrollee residence zip code to the centroid of each hospital zip code. Next, we excluded discharges from hospitals that had fewer than 24 discharges in 2010 ($n = 12,874$) and discharges from markets with only one hospital ($n = 682$). Our final sample is based on 126,566 admissions. We defined a patient's choice set based on the zip code of residence. A patient could potentially be admitted to any hospital within 50 miles of his or her residence that treated at least 24 Medicare AMI patients that year. In summary, our sample includes AMI admissions reimbursed under Fee for service (FFS) Medicare of persons 65 years and older who were admitted at a hospital, which treated at least 24 patients; was within 50 miles of the patient's principal residence; and had another competitor within 50 miles.[1]

We included measures from the US Census Bureau's Tiger files on the percent of a zip code's surface that was covered by water and the size of a zip code in square miles, variables which adjusted for variation in travel times related to distance. We created variables to indicate whether the patient was older than 80 years old and whether the patient had a previous coronary artery bypass graft (CABG) surgery or percutaneous transluminal coronary angioplasty. We aggregate the data into up to four groups per zip code where each group reflects each possible cell defined by these two variables. The groups are used in the grouped conditional logit analyses where the dependent variable is the number of admissions of each group to each hospital in the choice set. The choice set is comprised of all hospitals within 50 miles that admitted at least 24 FFS Medicare patients aged 65 years or older. The fixed radius definition of the hospital choice set leads to choice sets that vary based on the zip code of each group. (Models with alternate fixed radius definitions are presented in the Appendix of the Supporting information).The group-level sample size is the product of the number of groups (16,950) and the average number of hospitals in the choice set (~22.398). Grouping the data enable us to significantly reduce the sample size from 2,834,825 = (# discharges * average # hospitals in choice set) to 379,511 = (# groups * average # hospitals in choice set). The reduced sample size enables us to use multiple imputation (MI) and a national specification, although with reduced efficiency (Guimarães and Lindrooth, 2007).

4.3. Hospital characteristics

We merged information on hospital characteristics from the AHA Guide and from Medicare's 2009 Hospital Cost Reporting and Information System file into the claims database. These variables included ownership status, hospital occupancy rate (greater than 70%), number of beds (less than 150, between 151 and 375), teaching status (member of Council of Teaching Hospitals), system membership, and presence of cardiac catheterization

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[1]The estimates of specifications that varied the distance used to define the sample are reported in Appendix Table A1. These models were computational feasible even at a distance of 120 miles because we used mean imputation of missing management scores. The results reported in the current paper are based on multiple imputation using chained equations. It was not computationally feasible to estimate sample that included admissions beyond 50 miles using this approach.

lab and/or open heart surgery capability. Rural hospitals are defined as those who were not located with a metropolitan statistical area, as defined by the US Census Bureau.

We obtained data from the Centers for Medicare and Medicaid Services Hospital Compare website on hospitals' *AMI mortality rate*, *AMI readmission rate*, and performance of process of care measures. We calculated a composite measure, denoted *AMI processes*, using the hospital weighted average of the following scores: aspirin use within 24 h of arrival, angiotensin-converting enzyme inhibitor use for left ventricular dysfunction, provision of percutaneous coronary intervention within 90 min of arrival, and aspirin prescribed at discharge where the number of eligible admissions for each measure was used as a weight. The Hospital Compare data also included patient satisfaction measures, based on the Hospital Consumer Assessment of Healthcare Providers and Systems survey. We used the 'percent of patients who reported YES, they would definitely recommend the hospital', hereafter *% recommend hospital*, as a global measure of patient satisfaction. In the logit demand analyses, we used data on measures that were publicly posted in the last quarter of 2009, reflecting the information set that would have been available to individuals needing medical care in 2010.

We used the Medicare Provider Analysis and Review data to calculate predicted AMI admissions and a predicted Herfindahl–Hirschman Index (HHI). Admissions were predicted using coefficients estimated from a logit demand model that was analogous to the model described in the succeeding text. However, the sample and each respective choice set are based on a 120-mi radius. The specification was parsimonious, including only distance from the patient's residence to each hospital and distance interacted with using only patient-level data. The HHI was aggregated to the hospital level based on zip code market shares following Kessler and McClellan (2000).

4.4. Multiple imputation of missing data

We did not have management data for all hospitals of interest. When assessing missingness of data, we cannot assume that the data are missing completely at random. The management survey response rate for hospitals in this study was 46%, although we had management data on 64% of patients because high-volume hospitals were more likely to respond. To address missingness, we used the method of multiple imputation, assuming the data were missing at random (i.e., missingness is conditional on observed data, including hospital size, teaching status, and other variables associated with the response rate.) We note that it is not possible to completely rule out correlation of response with unmeasured characteristics (Little and Rubin, 2002).We estimated the models using both mean imputation and MI with chained equations using Stata 13.1 (Royston and White, 2011). We report estimates based on MI with chained equations because it does not require the data to be missing completely at random. In addition, the estimates were more conservative than those using mean imputation.

Multiple imputation was performed using an ordinal logit model of each management survey response and a linear specification of Hospital Compare or Hospital Consumer Assessment of Healthcare Providers and Systems measures. The imputations were performed at the patient level for the logit demand model and at the hospital level for the analysis of Equation (2). The variables were imputed as a function of all patient, hospital, and market variables that were included in the primary models. We based the number of imputations on the fraction of missing information[2] (FMI) such that the recommended number of imputations $\approx$FMI/0.01. In our analyses, the FMI never exceeded 0.46, so we used 50 imputations throughout the analysis.

The patient-level analysis includes data from 1671 hospitals with 126,566 admissions for AMI in 2010. The hospital-level analysis of the publicly reported performance measures as a function of the management score is limited to the 1095 hospitals that reported at least one surgical cardiac admission for AMI or reported offering cardiac surgical services; of these, we have actual survey responses for 581 hospitals. The remaining responses were imputed. Table II displays summary statistics at the patient level and hospital level, for key variables including the publicly reported performance measures, hospital-level variables, and zip code level data.

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[2]The fraction of missing information is calculated by dividing the average between imputation variance by the sum of the average within and between imputation variance. As the number of imputations increases the true parameter variance is weighted more heavily by the average within imputation variance relative to the between imputation variance. See White, Royston, and Wood for details.

Table II. Summary statistics

		Patient level[a]	Hospital level[b] (all)	Hospital level[c] (respondent)
	Management score	−0.01 (1.00)	0.02 (1.00)	0.00 (1.00)
Hospital compare publicly reported measures	% recommend hospital	67.01 (9.72)	69.24 (9.45)	69.86 (8.308)
	AMI processes	97.37 (2.67)	97.66 (2.30)	97.63 (2.452)
	AMI mortality rate	15.88 (1.86)	15.99 (1.92)	16.00 (1.860)
	AMI readmission rate	20.17 (1.50)	19.82 (1.51)	19.74 (1.483)
Hospital-level data	Presence of cardiac catheterization laboratory	0.670 (0.470)	0.794 (0.405)	0.785 (0.411)
	Presence of CABG surgery	0.840 (0.367)	0.899 (0.302)	0.974 (0.159)
	Hospital occupancy rate			
	Greater than 70%	0.451 (0.498)	0.410 (0.492)	0.399 (0.490)
	Teaching	0.177 (0.382)	0.183 (0.387)	0.179 (0.384)
	For profit	0.121 (0.326)	0.155 (0.362)	0.119 (0.324)
	Public	0.0767 (0.266)	0.0831 (0.276)	0.0981 (0.298)
	Beds ≤150	0.119 (0.323)	0.111 (0.314)	0.136 (0.343)
	Beds between 151 and 375	0.486 (0.500)	0.517 (0.500)	0.508 (0.500)
	Member of hospital system	0.644 (0.479)	0.685 (0.465)	0.656 (0.476)
	Rural hospital	0.108 (0.310)	0.101 (0.302)	0.129 (0.336)
Hospital-level data (Hospital-level analysis only)	Predicted admissions	N/A	64.00 (27.31)	64.04 (27.48)
	Predicted Herfindahl–Hirschman Index	N/A	0.270 (0.133)	0.278 (0.135)
Patient (zip code) level data	Distance (natural log)	1.118 (2.363)	N/A	
	Age greater than 80 years	0.474 (0.499)		
	Has previous CABG/PTCA	0.0201 (0.140)		
	Zip code area	0.169 (1.524)		
	Percent water in zip code	0.0401 (0.0782)		
	Total discharges/hospitals	126,566	1095	581

Variable means with standard deviation are in parentheses.
AMI, acute myocardial infarction; CABG, coronary artery bypass graft; PTCA, percutaneous transluminal coronary angioplasty.
[a]Missing values imputed at the patient-level using multiple imputation with chained equations. All hospitals with >12 AMI admits.
[b]Missing values imputed at the hospital-level using multiple imputation with chained equations.
[c]Hospitals that responded to the management survey, no imputation used.

5. STATISTICAL APPROACH

As described earlier in Equation 1, patient i's utility of an admission to hospital h is modeled as a function of hospital attributes including management (M_h), publicly reported quality measures (Q_h), other hospital characteristics and service offerings (X_h), the distance between group g's zip code and hospital h, D_{hg}, and interactions between patient attributes (P_g) and D_{hg}, where θ_i is a patient fixed effect and ε_{hi} is the idiosyncratic component of group g's evaluation of hospital h. Assuming that the conditions for a logit demand specification are met, the predicted probability s of a patient with characteristics (D_{hg}, P_g) of choosing hospital h with characteristics (M_h, Q_h, X_h) from a set of H hospitals is

$$s\big(M_h, Q_h, X_h, D_{hg}, P_g\big) = \frac{\exp\big\lfloor U_{hg}\big(M_h, Q_h, X_h, D_{hg}, P_h\big)\big\rfloor}{\sum_{h \in H_G} \exp\big[U_{hg}\big(M_h, Q_h, X_h, D_{hg}, P_g\big)\big]} \tag{3}$$

Equation 3 was estimated using a grouped conditional logit (Guimarães and Lindrooth, 2007). The grouped conditional logit equivalent to McFadden's conditional logit model of consumer choice (McFadden, 1974) except that patients are grouped based on common characteristics (i.e., location, age, and previous AMI) and group-level, as opposed to patient level, variation is used to estimate the parameters. The premise of group patients is that patients within each group will have identical valuations of each hospital in the choice set. This enables us to substantially reduce the sample size, making national estimates with MI computationally feasible. We report the results the hospital choice model for all markets, as well as the subset of hospitals that responded

to the survey for comparison. An urban choice set is defined as areas where *all* hospitals in the choice set are within a metropolitan statistical area.

Next, we separately calculated the change in admissions associated with a one standard deviation improvement in management score, % recommend hospital AMI processes, AMI mortality rate, and AMI readmission rate, denoted $\Delta^{S.D.Var}$, using the estimated coefficients:

$$\Delta Admissions_h^{Direct} = \Sigma_{g=1}^{G} \exp\left(X_h \hat{\beta}^{Equation\,3} + \Delta^{S.D.Var} * \hat{\beta}^{Var}\right) - \exp\left(X_h \hat{\beta}^{Equation\,3}\right) \qquad (4)$$

We report the hospital average of $\Delta Admissions_h$. The percentage change in admissions is just Equation 4 divided by $\Sigma_{g=1}^{G} \exp\left(X_h \hat{\beta}^{Equation\,3}\right) \Delta^{Column1} * \hat{\beta}^{Equation\,3}$.

We also modeled hospital-level performance on the publicly reported quality measures as a function management score and other hospital characteristics using an ordinary least squares specification of Equation 2:

$$Q_h = a + b_M M_h + b_X X_h + e_h \qquad (5)$$

where e_h is an independently and identically distributed error. Equation 5 is estimated separately for each publicly reported quality measure and is estimated using MI with 50 imputations with the sample of hospitals that perform cardiac surgeries. The coefficients b_M for each regression are used to calculate the indirect relationship of a one standard deviation change in management for hospital admissions as follows:

$$\Delta Admissions_h^{Indirect} = \Sigma_{g=1}^{G} \exp\left(X_h \hat{\beta}^{Equation\,3} + \Delta^{M} * \hat{\beta}_M * \hat{\beta}^{Var}\right) - \exp\left(X_h \hat{\beta}^{Equation\,3}\right) \qquad (6)$$

In addition to the management score and publicly reported performance measures, we included the following independent variables: patient distance to hospital, patient age >80 years, and previous procedure for AMI, including CABG surgery or percutaneous transluminal coronary angioplasty. Zip code variables included area (in square miles) and percent area covered by water (which may affect travel times). Hospital-level variables included presence of a cardiac catheterization laboratory; whether the hospital conducts CABG surgery; teaching status; ownership (for profit, not-for-profit, and public); licensed beds (less than 151, 151 to 374, and more than 374), rural versus urban; hospital system membership; and teaching status. We also included quadratic predicted AMI admissions and predicted HHI in the hospital-level regression of the publicly reported quality measures on management.

6. RESULTS

Table III displays the results of two specifications of the grouped logit model regression. We show results for all hospitals, in addition to stratifying by urban and non-urban markets. We show coefficient estimates for measures of interest, although the regression models include additional hospital-level and zip code level variables as described earlier. In regressions that include the management score but do not include performance measures, higher management score is positively associated with increased likelihood of that the patient chooses that hospital (a coefficient estimate of 0.0527, $p < 0.01$). The association is higher for urban choice sets and slightly smaller suburban/rural choice sets.

Our second specification includes the management score plus four performance measures: *% recommend hospital* and publicly reported *AMI processes*, *AMI mortality*, and *AMI readmission*. Higher management scores are positively associated with the patient choice of hospital, and the magnitude is lower in this specification (a coefficient estimate of 0.0338, $p < 0.01$). Higher patient satisfaction scores and process of care scores are significantly associated with patient choice, as are lower mortality rates and readmission rates ($p < 0.01$).

Table IV offers an alternative view of the association between different management constructs and patient admissions. We assess the association between individual management scores, the four major constructs (Lean [questions 1–6], performance monitoring [7–11], targets [12–14], and employee incentives [15–18]), and a measure of management that might be considered management dimensions that could be observable to the

Table III. Coefficient estimates from conditional logit model of hospital admissions

	Composite management score		
	All	Urban	Suburban/rural
Specification 1[a]:			
Composite management score only	0.0527*** (0.00683)	0.0615*** (0.00876)	0.0421*** (0.00996)
Specification 2[b]:			
Composite management score	0.0338*** (0.00696)	0.0457*** (0.00892)	0.0198* (0.0102)
% Recommend hospital	0.0105*** (0.000658)	0.00817*** (0.000830)	0.0143*** (0.00111)
AMI processes	0.0168*** (0.00228)	0.0142*** (0.00300)	0.018*** (0.00351)
AMI mortality rate	−0.0143*** (0.00289)	−0.0195*** (0.00374)	−0.0127*** (0.00465)
AMI readmission rate	−0.0390*** (0.00381)	−0.0451*** (0.00497)	−0.0245*** (0.00591)
Observations[c]	379,511	242,244	137,267

Standard errors are in parentheses. Full results are included in the Appendix of the Supporting information.
[a]Specification 1 includes all hospital-level variables listed in Table II and distance interacted with age greater than 80 years, has previous CABG/PTCA, zip code area, and percent water in zip code and rural, if applicable.
[b]Specification 2 includes all variables in specification 1 plus the Hospital Compare publicly reported measures listed in Table II and a dummy variable that indicates whether the hospital reported each measure.
[c]Sample size is the product of the number of groups (30,930) and the average number of hospitals in the choice set (~12.27). Sample includes 1671 unique hospitals, of which 1095 had at least one cardiac surgical admission. Missing values imputed using multiple imputation with chained equations (50 iterations). See text for details.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

patient, consisting of an composite measure of questions 4–6 and 16–18. Of these constructs, employee incentives show the greatest association with patient admissions. An estimate of the association with individual management questions and patient admissions is available in the Appendix of the Supporting information.

Table V uses the estimates from Table III to estimate the change in hospital admissions associated with a one standard deviation improvement in five metrics that are likely to influence patient choice: the management score; *% recommend hospital*, *AMI processes*, *AMI mortality*, and *AMI readmission*. Following Specification 2, a change in one standard deviation of the management score, holding other measures constant, results in a 3.43% increase in admissions. The largest change in admissions is associated with *% recommend hospital*. Note, however, that management is more strongly associated with *AMI processes*, and thus, management's indirect effect on admissions is likely to be stronger through the pathway of *AMI processes* (and its reputational effects). Full model results are available in the Appendix of the Supporting Information.

These direct and indirect associations are displayed in Table VI. These results are based on Equation 6, which demonstrates the relationship between management practices and publicly reported quality measures, decomposed into the direct and indirect relationship of a one standard deviation change in management on AMI admissions. Table V shows, for example, that management has a statistically significant correlation with *AMI process* and *% recommend hospital*. (The correlations between management and publicly reported measures of mortality and readmission are not statistically significant, in contrast to previous work that used a different risk-adjustment technique than that used in Hospital Compare.[3])

Overall, the results in Table VI suggest that a one standard deviation increase in the management score is associated with an 8.31% increase in AMI admissions. Part of this is the direct 3.43% increase in admissions from a one standard deviation increase in the management score reported in Table V, and the remaining

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[3]We do note a lack of a significant correlation between the Hospital Compare measures of mortality and readmissions. This finding is somewhat in contrast to the findings of McConnell and colleagues (McConnell et al., 2013.), which shows a strong correlation between management practices and 30-day risk-adjusted mortality. The difference may be attributable to two factors. First, mortality rates published by Hospital Compare are based on 3 years of data. While this may reduce the year-to-year fluctuations in mortality rates that would be useful for public reporting, it also means that the outcome measure includes years of data (2008 and 2009) that may not reflect the outcomes associated with management practices in the year that we measured these practices (2010). Second, the Hospital Compare models use a random effects estimator, which has been criticized by some observers as removing too much of the variation that could be explained by certain hospital characteristics (Silber *et al.*, 2010). In contrast, McConnell and colleagues calculated hospital risk-adjusted mortality using the Dimick–Staiger methodology, an alternative Bayesian 'shrinkage' estimator, which has been shown to have the best predictive accuracy among potential estimators (Ryan et al., 2012).

Table IV. Coefficient estimates from conditional logit model of hospital admissions, by management domain

	Management domains[a]				Observable management practices[b]
	Lean	Monitoring	Targets	Talent	
Specification 1:					
Composite score only	0.0275*** (0.00717)	0.0320*** (0.00686)	0.0488*** (0.00658)	0.0596*** (0.00692)	0.0527*** (0.00709)
Specification 2:					
Composite score	0.0171** (0.00725)	0.0181*** (0.00690)	0.0290*** (0.00671)	0.0428*** (0.00703)	0.0373*** (0.00723)
% recommend hospital	0.0108*** (0.000655)	0.0107*** (0.000657)	0.0105*** (0.000659)	0.0105*** (0.000656)	0.0106*** (0.000656)
AMI processes	0.0179*** (0.00228)	0.0179*** (0.00227)	0.0175*** (0.00227)	0.0173*** (0.00226)	0.0170*** (0.00227)
AMI mortality rate	−0.0138*** (0.00289)	−0.0136*** (0.00288)	−0.0138*** (0.00288)	−0.0144*** (0.00289)	−0.0147*** (0.00290)
AMI readmission rate	−0.0395*** (0.00381)	−0.0398*** (0.00381)	−0.0391*** (0.00381)	−0.0370*** (0.00383)	−0.0380*** (0.00382)
Observations	379,511				

Standard errors are in parentheses. See Table III notes for specification. Full results are included in the Appendix of the Supporting information.

AMI, acute myocardial infarction.

[a]Lean construct based on questions 1–6, monitoring on 7–11; targets on 12–14, and talent on 15–18.

[b]Observable management score includes the scores on Q4 communication, Q5 patient focus, Q6 discharge procedures, Q15 reward higher performers, Q16 remove poor performers, Q17 management of talent, and Q18 retain talent.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table V. Average change in hospital admissions associated with improvement in management and quality measure

	Change in management or quality measure[b]	Average change in hospital admissions[c] (standard deviation)	Average % change in hospital admissions[c]
Specification 1[a]:			
Management score only	1.00	5.17 (3.35)	5.41%
Specification 2[a]:			
Management score	1.00	3.28 (2.12)	3.43%
% recommend hospital	9.72	10.25 (6.94)	10.72%
AMI processes	2.67	4.38 (2.84)	4.58%
AMI mortality rate	−1.86	2.57 (1.67)	2.69%
AMI readmission rate	−1.50	5.76 (3.73)	6.02%

AMI, acute myocardial infarction.
[a]See Table III notes.
[b]One standard deviation change in each respective measure.
[c]Calculated using Equation 4.

Table VI. Direct and indirect average change in admissions associated with a one unit increase in management score

	Management coefficient (standard error)	Change in hospital admissions[b] (standard deviation)	% Change in hospital admissions[b]	Management coefficient (standard error)	Change in hospital admissions[b] (standard deviation)	% Change in hospital admissions[b]
Sample:	All hospitals with heart surgery ($N = 1095$)[a]			Respondent hospitals only ($N = 581$)		
Indirect						
% recommend hospital	0.855** (0.377)	0.91 (0.59)	0.95	1.814*** (0.645)	1.78 (1.19)	1.92
AMI processes	2.210*** (0.692)	3.59 (2.32)	3.76	5.202** (2.277)	8.47 (5.64)	9.12
ami mortality rate	−0.00546 (0.0715)	0.004 (0.003)	0.01	−0.0970 (0.149)	0.13 (0.09)	0.14
AMI readmission rate	−0.0302 (0.0630)	0.16 (0.10)	0.17	−0.0891 (0.120)	0.32 (0.22)	0.34
Direct association (Table III)	N/A	3.28 (2.13)	3.43	N/A	3.19 (2.12)	3.43
Indirect + direct association[1]	N/A	7.94 (5.14)	8.31	N/A	13.89 (9.25)	14.96

AMI, acute myocardial infarction.
[a]Management survey questions imputed using multiple imputation with chained equations (50 iterations).
[b]Calculated using Equation 6.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

difference reflects management's association with publicly reported measures (especially *AMI processes*) and their influence on hospital admissions.

7. DISCUSSION

This study provides new evidence of the relationships between management practices, publicly reported quality measures, and hospital admissions. We collected detailed information on management practices that have not been routinely measured in hospitals or healthcare organizations. We merged these unique management data with hospital-level public reports related to quality to estimate a patient-level hospital choice model reflecting virtually all admissions for AMI reimbursed under FFS Medicare. Our study has several important findings.

First, conditional on publicly reported measures, management scores are correlated with patient choice. However, relative to publicly reported measures, the overall magnitude of the association between management and patient choice is somewhat modest. On the one hand, the modest estimate makes sense given that management practices themselves are not directly observed to patients, and thus, we only measure the relationship between hospital choice and unmeasured attributes that are observed by the patient and correlated with management.

On the other hand, our estimates do not reflect the true causal effect of management on admissions, with the potential for downward bias. Finally, the noise inherent in our measure of management may introduce attenuation bias that leads to an underestimate of the 'true' effect of better management (Wooldridge, 2002).

Second, patient choice is sensitive to publicly reported measures. We tested the association between patient choice and four types of publicly reported measures: a composite measure of process of care measures, a global measure of patient satisfaction, mortality, and readmissions. Each measure is strongly and positively correlated with patient choice. This finding is consistent with the similar studies examining the effect of publicly reported quality information on patient choice (Bundorf *et al.*, 2009; Jung *et al.*, 2011; Pope 2009; Varkevisser *et al.*, 2012; Werner *et al.,* 2012).

Third, some management components are more strongly associated with hospital admissions than others. As shown in Table IV, talent management has the strongest association with admissions, followed by targets and performance monitoring, with Lean operations having the smallest association. This stands in contrast to our research on the associations of management practices and AMI mortality. In that analysis, Lean was the most strongly associated with lower mortality, while talent management was not significant (Appendix; McConnell *et al.*, 2013). This is consistent with the literature on management in manufacturing that has demonstrated that different management components affect different aspects of performance (Nair, 2006). With respect to the findings in this paper, we might hypothesize that talent management has the greatest impact on how the clinical staff interacts with patients and that good, balanced targets might include elements of customer satisfaction. Lean operations and performance monitoring might be more carefully focused on quality elements that are not observable to the patient.

Finally, management practices are associated with publicly reported process of care measures and patient satisfaction measures. Thus, management practices are directly correlated with admissions directly through reputational effects and indirectly through improved performance on publicly reported measures. Overall, a one standard deviation increase in the management score is associated with an 8.3% increase in hospital admissions.

Our study, which builds on new methods and interest in management, presents a number of opportunities for future research. We believe there are significant benefits to a concise and measureable definition of 'management', even if the measures we have used are not comprehensive. Furthermore, research in this area may be substantially advanced with data on management from a large number of hospitals, which is collected longitudinally or through experiments or methodologies that allow for the identification of a causal estimate.

There are several limitations that should be noted in our study. Perhaps most importantly, our study does not establish a causal link between management and patient choice. In terms of the direction of the bias on the management score, we believe the bias is likely to be downward, based on the empirical experience in studies on manufacturing. Data comparing experimental studies of management in manufacturing (Bloom *et al.,* 2013) and studies where valid instruments are available (Bloom *et al.,* 2010) suggest that the direction of the bias is downward and that, relative to the cross-sectional association, the true effect may be two to five times larger. Intuitively, our management coefficient could be biased downwards if units that were underperforming were more likely to attempt to improve their performance through the use of modern management practices. This may be particularly pertinent to cardiac care, where performance has been publicly reported since 2004. On the other hand, there may be an upward bias on the coefficient for management, if, for example, units with higher quality were subsequently provided with financial resources that were directed to improving managerial practices.

Another limitation pertains to the focus on patients with heart attack. Many of these patients require immediate care and may have little time to weigh the benefits of one hospital over another. Publicly reported measures and management practices may have an even stronger association with patient choice in service lines that provide a greater share of non-urgent or elective care.

In summary, the use of modern management practices may enable a hospital to improve the clinical delivery system and the patient experience and thus place it in a position to use public reporting to its strategic advantage. Our results also suggest a tangible benefit to patients, through their revealed preference for hospitals that have

adopted modern management practices, and to hospitals that have thereby increased market share, supporting the argument that diffusion of modern management practices is in both hospitals' and patients' best interest.

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