

**Leveraging Electronic Health Records to Improve Hospital Performance:  
The Role of Management**

**Julia Adler-Milstein, PhD**

**Assistant Professor**

**School of Information & School of Public Health**

**University of Michigan**

**Kirstin Woody Scott, MPhil**

**PhD Candidate in Health Policy**

**Harvard University**

**Ashish K. Jha, MD MPH**

**Professor**

**School of Public Health**

**Harvard University**

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## **ABSTRACT**

The U.S. is in the midst of an ambitious effort to achieve nationwide adoption of electronic health records (EHRs) to drive improvements in the quality and efficiency of care. However, recent studies fail to find a consistent relationship between EHR adoption and improved hospital performance, suggesting that EHRs are insufficient, unto themselves, to drive improvements in care delivery. In this study, we examine whether the quality of hospital management modifies the relationship between EHR adoption and cost and quality outcomes for acute myocardial infarction (AMI). In our random sample of US hospitals, we find that when hospitals are poorly managed, EHRs are associated with worse efficiency. Further, when hospitals are well managed, having an EHR is associated with greater efficiency. Our findings suggest that EHR implementation needs to be coupled with effective management to drive value from these systems.

An ambitious policy effort is underway to promote adoption of electronic health records (EHRs) in every hospital across the nation. Under the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act, hospitals that implement EHRs and demonstrate that they meet federally-defined meaningful use criteria are eligible for incentive payments.(1, 2)

The motivation for HITECH was widespread agreement that the use of EHRs would result in substantial performance improvement. Easier access to patient medical records could enable physicians to make better clinical decisions and more effectively coordinate care; computerized provider order entry could avoid unsafe medications and the associated cost of adverse events; and laboratory and radiology result viewing could decrease the likelihood of duplicative testing. However, evidence to date has failed to find a consistent relationship between EHR adoption and improved hospital performance (3-6), suggesting that the average effect may be close to zero. Given that much of the evidence that supports the beneficial impact of EHRs comes from a small number of institutions (7-9), we need a better understanding of the conditions under which EHRs lead to improved performance.

In industries such as retail and banking, the degree to which an organization is well-managed has been shown to be an important facilitator of IT-enabled performance improvement. In healthcare, the degree to which management matters in driving gains from IT is unknown. The intuition that management should matter is simple: IT is a tool that influences performance based largely on how it is used, and without a concerted and thoughtful approach to managing how IT is used to improve performance, it will not achieve the potential quality and efficiency gains. In fact, implementing IT systems in poorly managed organizations may be disruptive in ways that cause productivity losses. These hypotheses have growing empirical support. For example,

Bloom, Sadun, and Van Reenan find that the strength of human capital management practices appears to be drive productivity gains from IT.(10) On the other end of the spectrum, in poorly managed organizations, Hitt, Wu and Xiaoge find that IT can result in productivity losses by adding technological complexity that the organization may not be equipped to address.(11)

Evaluating whether the same phenomena applies in hospital settings has been difficult because, until recently, we have lacked nationally representative data on the quality of hospital management. We have therefore been unable to assess whether high-quality management is the missing link that explains when hospital EHR adoption results in performance improvement. In this paper, we leverage a unique data set on hospital management practices collected through interviews with managers in a nationally representative random sample of acute-care hospitals in order to explore whether management quality modifies the relationship between EHR adoption and cost and quality outcomes. We focus on outcomes related to acute myocardial infarction (AMI) because management survey respondents were predominantly from cardiology units.

## **Methods**

### *Data, Measures, and Sample*

Our study leverages four sources of data. To determine whether a hospital had an electronic health record, we use the American Hospital Association (AHA) IT supplement that was administered to all AHA member hospitals in 2009 and captures IT functionalities in place at the end of 2008.(12) We determined which hospitals had at least a basic EHR, defined by Jha et al. (2009) as a system that includes ten specific functionalities, such as computerized provider order entry for medications, test result viewing, problem lists, and medication lists.(13) We leverage

the broader AHA Annual Survey to capture data on key hospital characteristics – size (<100 beds, 100-399 beds, 400 or more beds), teaching status (major teaching, minor teaching, non-teaching), ownership (private, for-profit; private, not-for-profit; public), urban location, percent of discharges from patients with Medicare, and whether the hospital was part of a larger system.

Management practices were measured using a team of trained analysts who conducted phone interviews with unit or departmental managers in cardiology or orthopedics units in a random sample of 325 AHA-member acute care hospitals. Interviews took place between March and October 2009, and they covered management practices in four broad areas. (Appendix Table 1A)

The first area, *operations management*, captures the extent to which primary clinical procedures are standardized and how well the clinical staff is trained in these protocols. The second area, *performance monitoring*, focuses on how well the organization's performance monitoring system informs day-to-day operations of the hospital. The third area, *target setting*, captures how tightly targets are linked to the hospital's wider objectives and how well targets cascade down and are clear to employees. The last area is *talent management* and it captures various dimensions of human capital management, including the types of systems that are in place to recruit hospital staff, whether the hospital evaluates employees and rewards based on performance, and whether there is an active promotion system that strives to maintain and incentivize employees.

The tool applied definitions and scores from one (“worst practice”) to five (“best practice”) along 20 dimensions across the four areas listed above, with an average of the 20 scores serving as the overall management practice measure. In other words, a score of 5 suggests that the unit has excellent management practices. Appendix Table 1B reports sample questions and a link to the

complete instrument. Bloom and Van Reenen (2007) present extensive tests of the reliability of these management measures and their robustness to many different forms of psychological bias.(14) To obtain accurate and unbiased responses, the analysts conducting the interviews with hospital managers were “double blind”. This means that both (1) managers are unaware of the scoring methodology and the criteria they are being scored against, and (2) interviewers are unaware of the hospitals’ performance or other distinguishing features of the organization in which they are conducting interviews.

To capture both the cost and quality performance of hospitals in our sample, we examined three measures: length-of-stay (LOS), 30-day risk adjusted mortality, and payment per discharge. All measures were generated from 2009 Medicare data for fee-for-service beneficiaries 65 years of age or older who were hospitalized for acute myocardial infarction (AMI). We chose to focus on AMI outcomes because we were concerned that there might be substantial unit-to-unit variation in both management and outcomes within hospitals. Since the majority of respondents represented cardiology units, we felt that AMI-focused outcomes would be the most reliable indicators of the impact of management on EHR effectiveness.

Our analytic sample is the 203 U.S. acute-care hospitals that were included in the random sample of AHA hospitals used to collect management data and that responded to AHA IT supplement in 2009. Since not all hospitals also had Medicare outcomes data available, our models include between 127 and 191 hospitals, depending on the outcome used.

### *Analytic Approach*

To assess whether management modifies the relationship between EHR adoption and hospital performance, we estimated an ordinary least squares regression in which we predicted (a) average length-of-stay for AMI discharges, (b) 30-day risk adjusted AMI mortality rate, or (c) average payment for AMI discharges. Our focal predictors are the hospital's management score (range of 1-5) and whether or not the hospital had adopted at least a basic EHR. We include a set of control variables that may confound the relationship between management, EHR adoption, and outcomes: size, teaching status, ownership, urban versus rural location, percent Medicare discharges, and whether the hospital is affiliated with a larger system. We use weights to adjust for potential nonresponse bias due to known differences between respondents and non-respondents to the AHA IT supplement, as is common practice. To assess whether management moderates the impact of EHR adoption on various outcomes, we include a term that interacts management with EHR adoption. We also calculate predictive margins across the range of management scores in increments of 0.5 (approximately equal to the standard deviation of 0.56 in our sample) in order to compare predicted outcomes for hospitals with and without EHRs.

We also conducted a set of robustness tests to assess whether our results change under different specifications. First, we include in our models a set of variables that capture potential confounders driven by differences in interviewee characteristics. Specific variables include the duration of the interview (in minutes), the reliability of the interviewee (assessed by scoring both their knowledge of management practices and their willingness to reveal information), whether the interviewee was a nurse or a physician, the seniority of the interviewee, and the number of years that the interviewee had been in their current position. Our second set of robustness tests examines each individual component of management independently: operations management,

performance monitoring, target setting, and people management. This enables us to assess whether any observed effects are primarily driven by one particular dimension of management.

## **Results**

Eleven percent of the 203 hospitals in our sample had adopted at least a basic electronic health record as of the end of 2008. (Table 1) The average management score of 2.98 (SD=0.56; range 1.4-4.3) was effectively at the mid-point of the 1-5 scale. For our outcomes of interest, mean length-of-stay for patients hospitalized for AMI was 5.33 days (SD=1.55; range 1.08-9.95). Thirty-day risk-adjusted mortality rate was 19% (SD=17%, range 0%-100%). Average payment per discharge was \$9,071 (SD=\$5,533, range \$787-\$28,133). When we examined key characteristics stratified by EHR adoption status, we found few differences. (Table 2) Hospitals with an EHR were slightly better managed (mean score of 3.18 compared to 2.96 in hospitals without an EHR;  $p=0.082$ ). Compared to those without an EHR, hospitals with an EHR were more likely to be a major teaching hospital and a private, not-for-profit hospital (14% versus 4% for major teaching,  $p$ -value across categories of teaching 0.058; 77% versus 62% private, not-for-profit,  $p$ -value across categories of ownership 0.072). Finally, hospitals with EHRs had a somewhat lower proportion of Medicare admissions (45% compared to 51% among hospitals without EHRs,  $p=0.069$ ).

In our baseline models, we failed to find evidence that basic EHR adoption is independently associated with improved performance for any of our three outcomes. Hospitals with EHRs had slightly lower length-of-stay (coefficient=-0.223;  $p=0.63$ ; Model 1, Table 3) and slightly higher 30-day mortality for AMI patients compared to those without EHRs (coefficient=0.03;  $p=0.53$ ;



Model 3, Table 3). Hospitals with EHRs also had slightly higher payment per AMI discharge (coefficient=\$164.84; p=0.88; Model 5, Table 3).

When we examined whether management modifies the relationship between EHR adoption and our outcomes of interest, all three outcomes were in the predicted direction, two of which were statistically significant: length-of-stay (coefficient on interaction between EHR and management= -1.22 ; p=0.09) and payment (coefficient on interaction between EHR and management= -4,074.24 ; p=0.002). (Models 2 and 6; Table 3) Although the effect was in the predicted direction, we did not find evidence of effect modification for mortality (coefficient on interaction between EHR and management= -0.52 ; p=0.37). (Model 4; Table 3) The modified effects are depicted in Figures 1-3, which display the predictive margins across the range of management scores for hospitals with, and without, EHRs. For length-of-stay, as management improves, hospitals with EHRs have shorter average LOS for their AMI patients, while the opposite is true for hospitals without EHRs.(Figure 1) Similarly, as management improves, AMI payment per discharge decreases for hospitals with EHRs, but increases for those without EHRs.(Figure 3) In both hospitals with and without EHRs, as management improves, mortality decreases.(Figure 2)

To help interpret the magnitude of the modified effects, we compared the predictive margins for length-of-stay and payment for hospitals with and without EHRs at two levels of management – relatively poor management (a score of 2) and relatively strong management (score of 4). For length-of-stay, in a hospital that is not well managed, hospitals with EHRs have an LOS of 6.4 days compared to 5.0 days in hospitals without an EHR (21% higher). In contrast, in well-

managed hospitals, those with EHRs have an LOS of 4.5 days compared to 5.5 days in hospitals without EHRs (24% lower). Similarly, for payment, in a hospital that is not well managed, hospitals with EHRs have a payment per discharge of \$13,116 compared to \$7,611 in hospitals without an EHR (42% higher). In well-managed hospitals, those with EHRs have a payment of \$7,657 compared to \$10,301 in hospitals without EHRs (35% lower).

Our robustness tests revealed findings consistent with our primary analyses after we included variables to adjust for differences in interviewee characteristics.(Appendix Table 2) We found directionally consistent results when replacing our composite measure of management with each of the four individual dimensions separately, although the interaction effect for length-of-stay was no longer statistically significant. (Appendix Tables 3-6)

### **Discussion and Implications**

Coupled with ongoing policy efforts to achieve nationwide EHR adoption is a growing unease that our national investment in EHRs may not result in the widely anticipated improvements in quality and efficiency of healthcare delivery. While early studies showed performance gains resulting from EHR adoption in leading institutions, more recent national evidence suggests that current approaches to EHR use are not generating real value for the healthcare system. Our findings corroborate these recent studies; in a random sample of U.S. hospitals, we failed to find a relationship between EHR adoption and three measures of hospital performance for AMI patients. This raises the critical question of what else is required, beyond simply adopting the technology, to produce meaningful performance improvement. Our study is among the first to begin to answer this question. Using a validated measure of hospital management, we find that

the quality of the management modifies the relationship between EHR adoption and hospital performance. Specifically, when hospitals are poorly managed, EHRs are associated with worse efficiency – higher length-of-stay and payments – and when hospitals are well managed, having an EHR is associated with greater efficiency. These findings suggest that improving hospital management may be a critical factor to ensure that EHRs improve hospital productivity.

Our findings naturally raise the question of what well-managed hospitals may be doing differently with their EHRs relative to poorly-managed hospitals. We suspect that several factors may be at work. First, well-managed hospitals may have established a clear vision and set of performance improvement goals motivating EHR adoption while less well-managed hospitals may have adopted in response to external pressures with no clear plan for EHR-enabled improvement. In conjunction, in well-managed hospitals, the goals for EHR adoption may have been developed in partnership with end users (e.g., frontline physicians and nurses) and therefore had greater staff “buy-in” both during and after implementation.

Beyond setting goals and securing staff buy-in, well-managed hospitals may be more aggressively pursuing more advanced EHR functionalities, such as clinical decision support (CDS), and other approaches to increasing care standardization (i.e., care protocols embedded in the EHR). These approaches have been shown to result in substantial value (15-17), but require engaged managers and additional organizational investment to change workflows and overcome barriers, such as physician resistance. Finally, well-managed hospitals are likely pursuing the greatest area of opportunity to leverage EHRs to improve performance: the use of EHR data for learning through performance measurement and monitoring. EHRs offer timely, clinically-rich

data that can be analyzed in real-time; for example, EHRs can provide clinicians with information about hypertension control among their diabetic patients or show clinicians how they compare to their peers on these outcomes. Well-managed organizations are likely harnessing this valuable asset to learn what they do well, where they can improve, and how to do so. We suspect that many of these strategies are missing at poorly-managed institutions.

While a better understanding is needed of the particular management strategies that lead to improved performance following EHR adoption, a critical question for policymakers is how to expedite the process of not only identifying these strategies but also encouraging their widespread adoption. To date, the federal criteria for meaningful use of EHRs have stuck closely to EHR functionalities. Such criteria may help motivate the uptake of specific functionalities – such as broader use of clinical decision support. It is less clear whether meaningful use is a sufficiently potent force to transform hospitals and other health care delivery organizations into data-driven, learning organizations. Proposed future stages of meaningful use do markedly expand performance measurement and broader uses of EHR data. However, we suspect that more substantial changes in financial incentives tied to performance, such as current federal efforts to promote a variety of delivery reforms under the Affordable Care Act, will be required to motivate hospital leadership to focus their attention on performance improvement and realize the critical role of EHRs in supporting these changes.

There are important limitations to our work. First, for a subset of the hospitals in our sample, management data came from non-cardiac units as well and therefore, by relying on AMI outcome measures, we may not have captured the effect modification of interest. However, we

believe that this is primarily an issue of power and it would not introduce systematic bias into our results. Second, our data pre-dates much of the HITECH activity, especially the Medicare and Medicaid EHR Incentive Programs for meaningful use. Thus, our findings do not directly speak to the relationship between meaningful use of EHRs and the role of management on cost and quality performance. We see no reason, however, that the quality of management would not continue to play an important role in shaping the impact of EHRs on hospital performance. Finally, we were not able to assess causality and could only assess associations. However, the role of management in enabling IT-driven performance gains is well-established in other industries, and it is therefore very likely that it contributes, at least in part, to EHR-enabled performance improvement in healthcare organizations as well.

In summary, this paper is among the first to explain the lack of consistent relationship between EHRs and hospital performance. By focusing on the quality of management in a random sample of U.S. hospitals, we are able to observe effect modification for two key outcomes of interest: length-of-stay and payment. Our results suggest that hospitals as well as policymakers should work to bolster the extent to which managers focus their efforts on leveraging newly available EHR capabilities, with the goal of promoting performance improvement. A broader understanding of why some hospitals are successful in realizing efficiency gains from their EHR while others fail to improve will help ensure that our large national investment in EHRs translates into real productivity gains for our healthcare system.

Table 1. Summary Statistics

		N	Mean	Std. Dev.	Min	Max
AMI OUTCOMES	Length of Stay (days)	127	5.33	1.55	1.08	9.95
	30-day Risk Adjusted Mortality	191	0.19	0.17	0.00	1.03
	Payment per Discharge (\$)	190	9,070.87	5,532.91	787.00	28,133.33
FOCAL PREDICTORS	Basic Electronic Health Record	203	0.11	0.31	0.00	1.00
	Management Composite Score (1-5)	203	2.98	0.56	1.40	4.30
TEACHING	Major Teaching	203	0.05	0.23	0.00	1.00
	Minor Teaching	203	0.25	0.43	0.00	1.00
	Non-Teaching	203	0.70	0.46	0.00	1.00
OWNERSHIP	Public	203	0.29	0.45	0.00	1.00
	Private, For Profit	203	0.07	0.26	0.00	1.00
	Private, Not-for-Profit	203	0.64	0.48	0.00	1.00
SIZE	Small (<100 beds)	203	0.49	0.50	0.00	1.00
	Medium (100-399 beds)	203	0.40	0.49	0.00	1.00
	Large (>400 beds)	203	0.10	0.31	0.00	1.00
OTHER	Percent Medicare Admissions	203	0.50	0.13	0.11	0.86
	Urban	203	0.50	0.50	0.00	1.00
	System Affiliated	203	0.49	0.50	0.00	1.00

Table 2. Summary Statistics by EHR Adoption

		At least basic EHR		No basic EHR		
		Mean	Std. Dev.	Mean	Std. Dev.	P-Value
AMI OUTCOMES	Length of Stay (days)	5.21	1.84	5.35	1.51	0.744
	30-day Risk Adjusted Mortality	0.19	0.21	0.19	0.17	0.966
	Payment per Discharge (\$)	10154.46	5334.73	8928.97	5558.08	0.330
FOCAL PREDICTORS	Basic Electronic Health Record					
	Management Composite Score (1-5)	3.18	0.65	2.96	0.55	0.082
TEACHING	Major Teaching	0.14	0.35	0.04	0.21	0.058
	Minor Teaching	0.09	0.29	0.27	0.44	
	Non-Teaching	0.77	0.43	0.69	0.46	
OWNERSHIP	Public	0.09	0.29	0.31	0.46	0.072
	Private, For Profit	0.14	0.35	0.07	0.25	
	Private, Not-for-Profit	0.77	0.43	0.62	0.49	
SIZE	Small (<100 beds)	0.41	0.50	0.50	0.50	0.622
	Medium (100-399 beds)	0.50	0.51	0.39	0.49	
	Large (>400 beds)	0.09	0.29	0.10	0.31	
OTHER	Percent Medicare Admissions	0.45	0.07	0.51	0.14	0.069
	Urban	0.64	0.49	0.49	0.50	0.183
	System Affiliated	0.55	0.51	0.49	0.50	0.600

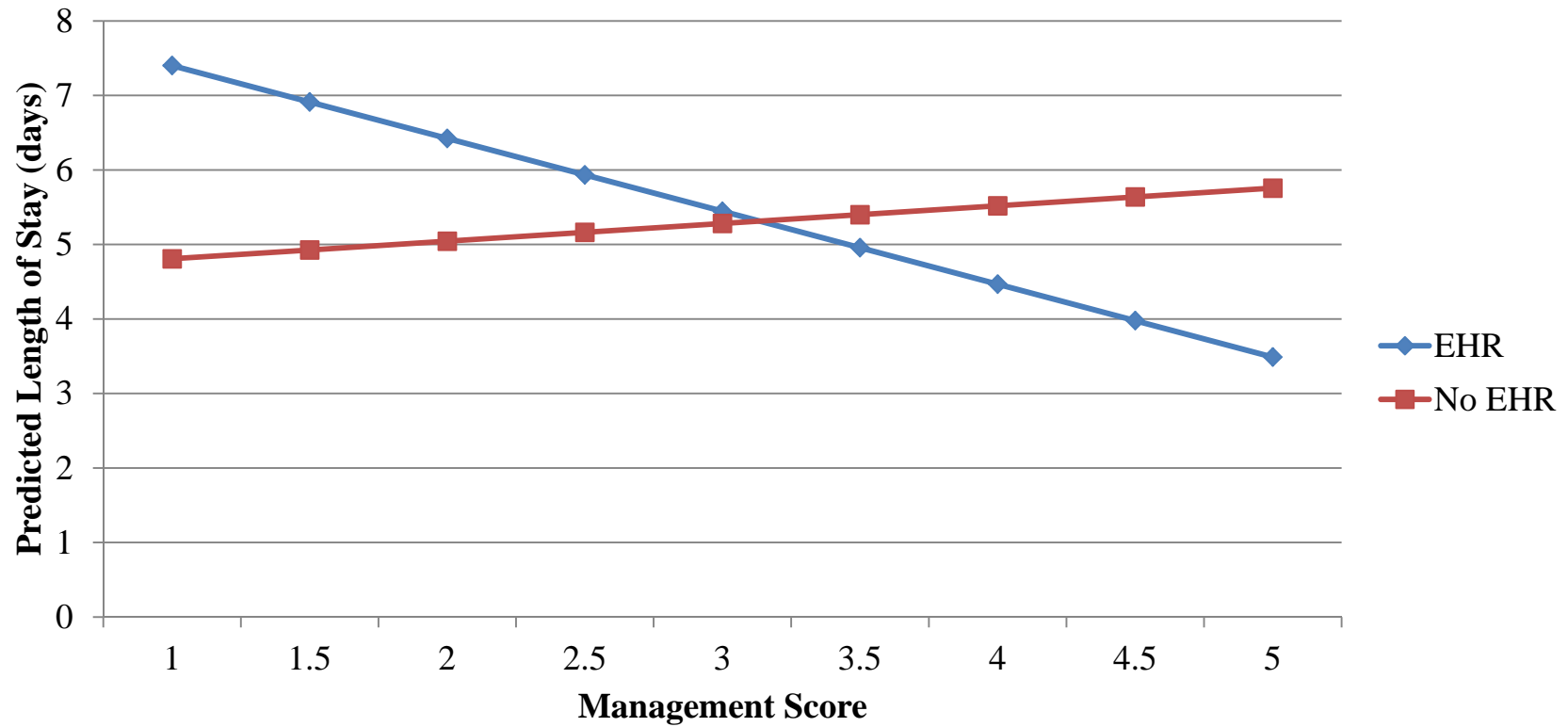
Table 3. Ordinary Least Squares Regression Results Predicting AMI Outcomes: Hospital Management and EHR Adoption

OUTCOME:	LENGTH OF STAY		30-DAY MORTALITY		PAYMENT	
	Base	Interaction	Base	Interaction	Base	Interaction
MODEL:	(1)	(2)	(3)	(4)	(5)	(6)
EHR	-0.223	3.783	0.03	0.191	164.84	12,838.89***
	[0.458]	[2.540]	[0.048]	[0.204]	[1,105.81]	[3,981.23]
MANAGEMENT	0.005	0.237	-0.045	-0.035	576.90	1,344.62**
	[0.258]	[0.266]	[0.034]	[0.041]	[585.04]	[559.71]
<b>EHR X MANAGEMENT</b>		<b>-1.215*</b>		<b>-0.052</b>		<b>-4,074.24***</b>
		<b>[0.711]</b>		<b>[0.058]</b>		<b>[1,279.88]</b>
No Teaching	Reference	Reference	Reference	Reference	Reference	Reference
Major Teaching	0.569	0.479	0.022	0.018	3,081.03**	2,786.74**
	[0.351]	[0.364]	[0.030]	[0.030]	[1,320.64]	[1,273.16]
Minor Teaching	0.318	0.301	0.041**	0.036**	1,403.71	1,019.21
	[0.327]	[0.329]	[0.018]	[0.018]	[1,048.99]	[992.54]
Not-for-Profit	Reference	Reference	Reference	Reference	Reference	Reference
Public	-0.691**	-0.636*	0.007	0.011	132.36	377.89
	[0.325]	[0.323]	[0.033]	[0.033]	[855.15]	[848.78]
For Profit	0.766	0.8	0.011	0.014	1,568.69	1,843.16
	[0.640]	[0.617]	[0.041]	[0.040]	[1,596.89]	[1,568.04]
Small (1-99 beds)	Reference	Reference	Reference	Reference	Reference	Reference
Medium (100-399 beds)	0.876**	0.951**	-0.069***	-0.065**	3,537.54***	3,856.91***
	[0.417]	[0.421]	[0.026]	[0.026]	[829.39]	[837.80]
Large (400+ beds)	2.249***	2.267***	-0.04	-0.039	5,926.65***	6,004.69***
	[0.492]	[0.496]	[0.035]	[0.034]	[1,187.98]	[1,202.41]
Proportion of Medicare Admissions	1.354	1.406	0.038	0.042	-7,585.92***	-7,176.66***
	[1.335]	[1.343]	[0.123]	[0.124]	[2,614.85]	[2,584.02]
Urban	0.311	0.289	-0.052*	-0.051*	2,030.40***	2,100.75***
	[0.334]	[0.331]	[0.030]	[0.030]	[638.29]	[643.14]
System Affiliated	0.138	0.093	0.023	0.02	961.62	746.61
	[0.257]	[0.258]	[0.028]	[0.027]	[626.98]	[619.04]

This table reports coefficients from OLS regressions. Brackets contain robust standard errors; \*\*\* p<0.01, \*\* p<0.05, \* p<0.10

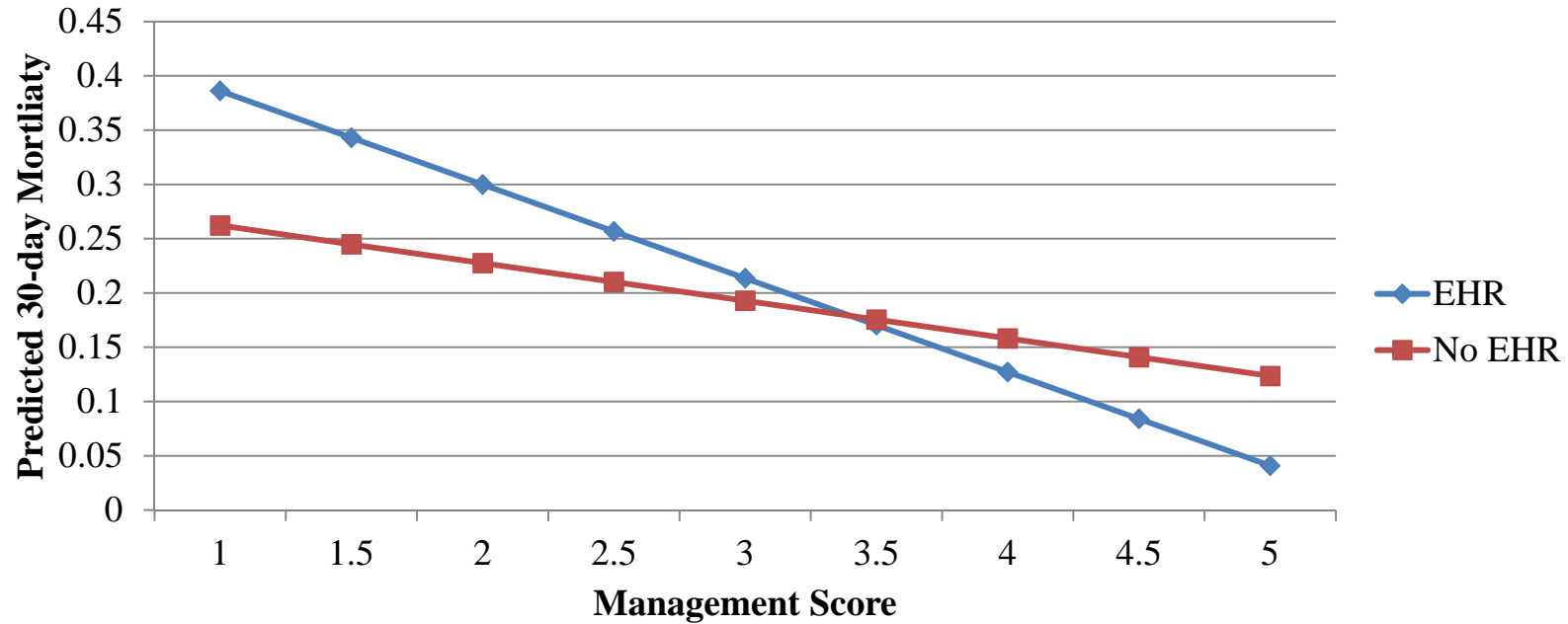


Figure 1. Relationship between Management and AMI Length of Stay among Hospitals with and without an Electronic Health Record



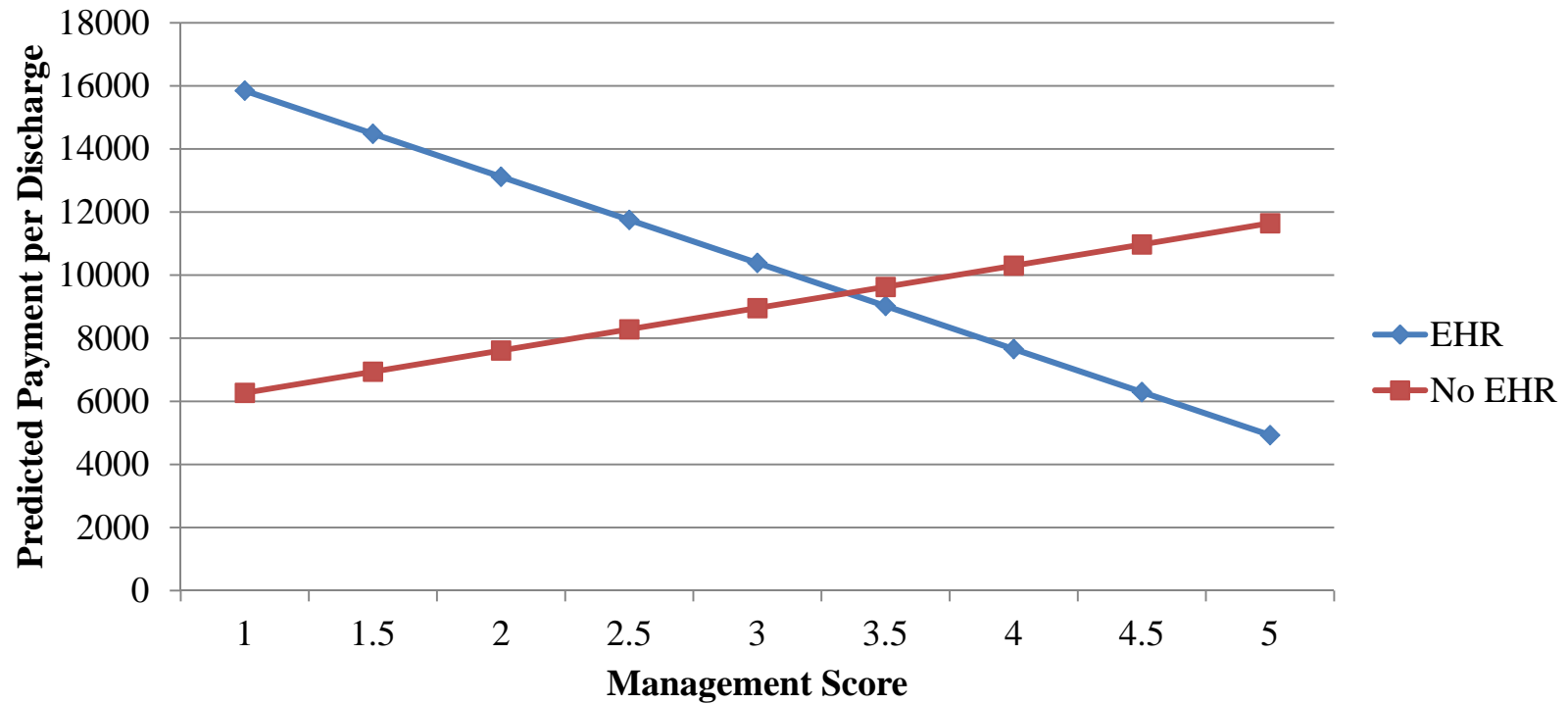
This figure displays the average predicted length of stay for AMI patients based on results of Model 2 in Table 2. Management score ranges from 1 to 5, with 1 reflecting poor management practices and 5 representing excellent management practices.

Figure 2. Relationship between Management and 30-day Risk Adjusted AMI Mortality among Hospitals with and without an Electronic Health Record



This figure displays the average predicted 30-day mortality for AMI patients based on results of Model 4 in Table 2. Management score ranges from 1 to 5, with 1 reflecting poor management practices and 5 representing excellent management practices.

Figure 3. Relationship between Management and AMI Payment among Hospitals with and without an Electronic Health Record



This figure displays the average predicted payment per discharge for AMI patients based on results of Model 6 in Table 2.

Management score ranges from 1 to 5, with 1 reflecting poor management practices and 5 representing excellent management practices.

Appendix Table 1A. World Management Survey – U.S. Hospital Dimensions

Dimension	Description
Operations Management	Operations Management is all about how effectively the patient journey and pathway management is configured: what is the motivation behind changes to operations, how standardized and integrated are clinical pathways, and are staff deployed to do what they are best qualified for?
Performance Monitoring	Performance Monitoring is all about how well your performance monitoring system informs your and your employees' day-to-day operations of your hospital: how do processes and attitudes are screened, how meaningful are your metrics in relation to how frequently they measured and reviewed, to what degree the detection of different levels of process-based performance leads to adequate and consequential process improvements?
Target Setting	Target Setting is all about how tightly your targets are linked to the hospital's wider objectives: are your targets covering a sufficiently broad set of metrics, how strongly are your short and long term targets connected, how well are they cascaded down and clarified to your employees?
Talent Management	Talent Management is all about how you manage your people: to what degree is people management emphasized within your hospital, how careful are your hiring policies, how closely are pay and promotions linked to the ability and effort of your employees, how do you deal with under-performers, and how do you retain your best-performers?

Appendix Table 1B. World Management Survey – U.S. Hospital Dimensions and Scoring Example: Operations component

<b>Operations Management</b> is about how effectively the patient journey and pathway management is configured: what is the motivation behind changes to operations, how standardized and integrated are clinical pathways, and are staff deployed to do what they are best qualified for?				
<b>1. Layout of patient flow</b>		<i>In regards to the patient journey or flow for a typical episode, how closely located are wards, theatres, diagnostics centres and consumables? How often do you run into problems with the current pathway management?</i>		
Score 1	Score 2	Score 3	Score 4	Score 5
Lay-out of hospital and organisation of workplace is not conducive to patient flow (e.g. ward is on different level from theatre or consumables are often not available in the right place at the right time).	Between 1 and 3	Lay-out of hospital has been thought-through and optimised as far as possible; work place organisation is not regularly challenged/ changed (or vice versa).	Between 3 and 5	Hospital layout has been configured to optimize patient flow; workplace organization is challenged regularly and changed whenever needed.
<b>2. Rationale for introducing standardization/pathway management</b>		<i>What is the rationale for making operational improvements to the management of the patient pathway?</i>		
Score 1	Score 2	Score 3	Score 4	Score 5
Changes were imposed topdown or because other departments were making (similar) changes; rationale was not communicated or understood.	Between 1 and 3	Changes were made because of financial pressure and the need to save money or as a (short-term) measure to achieve government and/ or external targets.	Between 3 and 5	Changes were made to improve overall performance, both clinical and financial, with buy-in from all affected staff groups; the changes were communicated in a coherent 'change story'.
<b>3. Standardisation and protocols</b>		<i>How standardized are the main clinical processes?</i>		
Score 1	Score 2	Score 3	Score 4	Score 5
Little standardisation and few protocols exists (e.g. different clinical staff have different approaches to the same treatments).	Between 1 and 3	Protocols have been created but are not commonly used because they are too complicated or not monitored adequately (e.g. may be on website or in manual only).	Between 3 and 5	Protocols are known and used by all clinical staff and regularly followed up on through some form of monitoring or oversight.
<b>4. Good use of human resources</b>		<i>With respect to your staff, what happens when different hospital areas become busier than others?</i>		
Score 1	Score 2	Score 3	Score 4	Score 5
Staff often end up undertaking tasks for which they are not qualified or over-qualified when they could be used elsewhere; staff do not move across units, even when they are generally underutilised.	Between 1 and 3	Senior staff try to use the right staff for the right job but do not go to great lengths to ensure this; staff may move but often in an uncoordinated manner.	Between 3 and 5	Staff recognise effective human resource deployment as a key issue and will go to some lengths to make it happen; shifting staff from less busy to busy areas is done routinely and in a coordinated manner, based on the documented skills.

Full instrument available at: [http://worldmanagementsurvey.org/?page\\_id=1848](http://worldmanagementsurvey.org/?page_id=1848)

Appendix Table 2. Ordinary Least Squares Regression Results Predicting AMI Outcomes: Hospital Management and EHR Adoption with Interview Controls

OUTCOME:	LENGTH OF STAY		30-DAY MORTALITY		PAYMENT	
	Base	Interaction	Base	Interaction	Base	Interaction
MODEL:	(1)	(2)	(3)	(4)	(5)	(6)
EHR	-0.211	3.862	0.035	0.175	-28.745	11,599.854***
	[0.447]	[2.415]	[0.049]	[0.201]	[1,097.131]	[3,954.798]
MANAGEMENT	0.138	0.337	-0.056	-0.049	1,191.986**	1,830.723***
	[0.282]	[0.292]	[0.043]	[0.048]	[594.436]	[545.177]
<b>EHR X MANAGEMENT</b>		-1.233*		-0.045		-3,735.577***
		[0.678]		[0.056]		[1,254.891]
No Teaching	Reference	Reference	Reference	Reference	Reference	Reference
Major Teaching	0.444	0.371	0.011	0.008	2,511.029*	2,316.924*
	[0.374]	[0.381]	[0.035]	[0.034]	[1,373.662]	[1,327.282]
Minor Teaching	0.319	0.315	0.041**	0.037**	1,246.17	921.152
	[0.326]	[0.328]	[0.019]	[0.018]	[1,072.792]	[1,023.811]
Not-for-Profit	Reference	Reference	Reference	Reference	Reference	Reference
Public	-0.702**	-0.644**	0.015	0.018	108.683	340.466
	[0.327]	[0.323]	[0.034]	[0.034]	[874.897]	[862.590]
For Profit	0.616	0.633	-0.01	-0.008	1,443.11	1,720.02
	[0.653]	[0.636]	[0.042]	[0.041]	[1,587.567]	[1,568.572]
Small (1-99 beds)	Reference	Reference	Reference	Reference	Reference	Reference
Medium (100-399 beds)	0.804*	0.883**	-0.070**	-0.066**	3,091.115***	3,411.558***
	[0.415]	[0.425]	[0.027]	[0.028]	[893.350]	[901.865]
Large (400+ beds)	2.183***	2.209***	-0.033	-0.032	5,245.179***	5,343.216***
	[0.495]	[0.512]	[0.041]	[0.040]	[1,325.737]	[1,347.794]
Proportion of Medicare Admissions	1.549	1.608	0.059	0.062	-7,038.393***	-6,691.007***
	[1.285]	[1.298]	[0.121]	[0.122]	[2,604.421]	[2,567.670]
Urban	0.327	0.313	-0.048	-0.047	2,089.663***	2,142.175***
	[0.327]	[0.322]	[0.030]	[0.030]	[631.254]	[637.675]
System Affiliated	0.151	0.108	0.032	0.03	905.179	708.642
	[0.268]	[0.269]	[0.029]	[0.028]	[654.691]	[645.021]
Reliability	-0.083	-0.069	0.011	0.011	-162.887	-140.29
Duration	[0.099]	[0.099]	[0.011]	[0.011]	[253.232]	[243.584]
Nurse	0.008	0.008	-0.001	-0.001	-16.736	-14.589
Seniority	[0.007]	[0.007]	[0.001]	[0.001]	[22.546]	[21.093]
Tenure in Position	0.384	0.354	0.057*	0.055**	352.689	198.294

Brackets contain robust standard errors; \*\*\* p<0.01, \*\* p<0.05, \* p<0.10

Appendix Table 3. Ordinary Least Squares Regression Results Predicting AMI Outcomes: Hospital Management and EHR Adoption:

**Operations**

OUTCOME:	LENGTH OF STAY		30-DAY MORTALITY		PAYMENT	
	Base	Interaction	Base	Interaction	Base	Interaction
MODEL:	(1)	(2)	(3)	(4)	(5)	(6)
EHR	-0.215	2.218	0.03	0.244	183.216	6,666.595*
	[0.452]	[2.022]	[0.049]	[0.152]	[1,067.351]	[3,695.657]
OPERATIONS	-0.057	0.126	-0.01	0.005	9.803	462.681
	[0.235]	[0.239]	[0.024]	[0.028]	[521.061]	[542.318]
<b>EHR X OPERATIONS</b>		<b>-0.733</b>		<b>-0.068</b>		<b>-2,038.414*</b>
		<b>[0.538]</b>		<b>[0.042]</b>		<b>[1,075.429]</b>
No Teaching	Reference	Reference	Reference	Reference	Reference	Reference
Major Teaching	0.564	0.54	0.025	0.022	3,015.437**	2,934.320**
	[0.354]	[0.364]	[0.027]	[0.026]	[1,334.603]	[1,314.406]
Minor Teaching	0.311	0.294	0.046**	0.039**	1,299.69	1,086.36
	[0.329]	[0.330]	[0.019]	[0.018]	[1,046.671]	[1,004.785]
Not-for-Profit	Reference	Reference	Reference	Reference	Reference	Reference
Public	-0.710**	-0.659**	0.017	0.022	-2.836	117.165
	[0.329]	[0.325]	[0.035]	[0.035]	[859.571]	[858.367]
For Profit	0.764	0.724	0.021	0.019	1,405.37	1,380.18
	[0.647]	[0.631]	[0.039]	[0.038]	[1,587.560]	[1,571.957]
Small (1-99 beds)	Reference	Reference	Reference	Reference	Reference	Reference
Medium (100-399 beds)	0.871**	0.908**	-0.074***	-0.071***	3,618.282***	3,735.324***
	[0.417]	[0.420]	[0.027]	[0.027]	[826.746]	[826.379]
Large (400+ beds)	2.263***	2.258***	-0.052	-0.052	6,131.181***	6,147.507***
	[0.495]	[0.498]	[0.035]	[0.034]	[1,181.110]	[1,184.315]
Proportion of Medicare Admissions	1.361	1.349	0.053	0.058	-7,914.462***	-7,684.164***
	[1.339]	[1.344]	[0.120]	[0.120]	[2,658.460]	[2,646.584]
Urban	0.322	0.322	-0.059*	-0.056*	2,139.922***	2,197.297***
	[0.341]	[0.338]	[0.030]	[0.030]	[654.353]	[656.527]
System Affiliated	0.139	0.116	0.018	0.015	1,036.870*	956.859
	[0.257]	[0.259]	[0.028]	[0.028]	[625.595]	[624.776]

Brackets contain robust standard errors; \*\*\* p<0.01, \*\* p<0.05, \* p<0.10

Appendix Table 4. Ordinary Least Squares Regression Results Predicting AMI Outcomes: Hospital Management and EHR Adoption:

**Monitoring**

OUTCOME:	LENGTH OF STAY		30-DAY MORTALITY		PAYMENT	
	Base	Interaction	Base	Interaction	Base	Interaction
MODEL:	(1)	(2)	(3)	(4)	(5)	(6)
EHR	-0.234	3.253	0.027	0.011	194.739	13,772.500***
	[0.456]	[2.361]	[0.049]	[0.195]	[1,096.370]	[4,193.977]
MONITORING	0.089	0.247	-0.059**	-0.059*	535.028	1,220.462**
	[0.222]	[0.240]	[0.029]	[0.035]	[537.590]	[532.122]
<b>EHR X MONITORING</b>		<b>-1.002</b>		<b>0.005</b>		<b>-4,156.677***</b>
		<b>[0.640]</b>		<b>[0.053]</b>		<b>[1,293.458]</b>
No Teaching	Reference	Reference	Reference	Reference	Reference	Reference
Major Teaching	0.568	0.482	0.026	0.027	3,028.512**	2,647.191**
	[0.352]	[0.354]	[0.032]	[0.033]	[1,349.700]	[1,208.870]
Minor Teaching	0.325	0.305	0.040**	0.040**	1,387.81	914.045
	[0.323]	[0.327]	[0.018]	[0.018]	[1,044.397]	[1,000.859]
Not-for-Profit	Reference	Reference	Reference	Reference	Reference	Reference
Public	-0.672**	-0.638*	0.005	0.005	111.366	265.755
	[0.325]	[0.325]	[0.032]	[0.032]	[846.687]	[842.106]
For Profit	0.784	0.847	0.008	0.007	1,574.01	1,939.61
	[0.646]	[0.630]	[0.040]	[0.040]	[1,609.028]	[1,555.711]
Small (1-99 beds)	Reference	Reference	Reference	Reference	Reference	Reference
Medium (100-399 beds)	0.874**	0.951**	-0.066**	-0.066**	3,523.313***	3,922.834***
	[0.419]	[0.426]	[0.026]	[0.027]	[833.482]	[851.831]
Large (400+ beds)	2.238***	2.247***	-0.04	-0.04	5,983.242***	6,032.684***
	[0.493]	[0.498]	[0.034]	[0.034]	[1,176.717]	[1,182.436]
Proportion of Medicare Admissions	1.402	1.556	0.019	0.018	-7,509.135***	-6,941.327***
	[1.335]	[1.365]	[0.124]	[0.126]	[2,560.351]	[2,527.412]
Urban	0.297	0.29	-0.050*	-0.050*	2,033.851***	2,182.096***
	[0.330]	[0.332]	[0.029]	[0.029]	[647.140]	[664.887]
System Affiliated	0.124	0.058	0.027	0.027	932.886	607.092
	[0.257]	[0.258]	[0.027]	[0.027]	[619.415]	[607.854]

Brackets contain robust standard errors; \*\*\* p<0.01, \*\* p<0.05, \* p<0.10



Appendix Table 5. Ordinary Least Squares Regression Results Predicting AMI Outcomes: Hospital Management and EHR Adoption:

**People**

OUTCOME:	LENGTH OF STAY		30-DAY MORTALITY		PAYMENT	
	Base	Interaction	Base	Interaction	Base	Interaction
MODEL:	(1)	(2)	(3)	(4)	(5)	(6)
EHR	-0.227	4.123	0.031	0.31	135.981	13,405.903***
	[0.453]	[3.172]	[0.049]	[0.250]	[1,105.721]	[4,711.635]
PEOPLE	0.017	0.169	-0.031	-0.019	608.383	1,115.031**
	[0.214]	[0.219]	[0.028]	[0.030]	[522.467]	[519.961]
<b>EHR X PEOPLE</b>		<b>-1.334</b>		<b>-0.091</b>		<b>-4,345.336***</b>
		<b>[0.898]</b>		<b>[0.071]</b>		<b>[1,534.351]</b>
No Teaching	Reference	Reference	Reference	Reference	Reference	Reference
Major Teaching	0.573	0.46	0.018	0.011	3,194.601**	2,849.375**
	[0.357]	[0.383]	[0.030]	[0.031]	[1,319.412]	[1,292.374]
Minor Teaching	0.319	0.329	0.043**	0.037**	1,407.10	1,093.40
	[0.327]	[0.329]	[0.019]	[0.018]	[1,059.850]	[986.547]
Not-for-Profit	Reference	Reference	Reference	Reference	Reference	Reference
Public	-0.689**	-0.637**	0.009	0.015	171.503	419.533
	[0.323]	[0.320]	[0.033]	[0.033]	[860.596]	[853.957]
For Profit	0.768	0.819	0.015	0.021	1,556.73	1,850.70
	[0.640]	[0.621]	[0.042]	[0.040]	[1,591.996]	[1,564.783]
Small (1-99 beds)	Reference	Reference	Reference	Reference	Reference	Reference
Medium (100-399 beds)	0.878**	0.996**	-0.074***	-0.063**	3,575.450***	4,061.201***
	[0.413]	[0.420]	[0.026]	[0.027]	[828.770]	[839.329]
Large (400+ beds)	2.246***	2.322***	-0.043	-0.038	5,872.585***	6,123.967***
	[0.497]	[0.500]	[0.034]	[0.034]	[1,184.518]	[1,195.872]
Proportion of Medicare Admissions	1.353	1.477	0.04	0.05	-7,454.689***	-6,918.147***
	[1.336]	[1.333]	[0.122]	[0.123]	[2,660.296]	[2,611.394]
Urban	0.309	0.236	-0.055*	-0.056*	2,031.678***	2,009.965***
	[0.334]	[0.331]	[0.030]	[0.030]	[637.713]	[634.126]
System Affiliated	0.138	0.124	0.02	0.017	977.413	838.584
	[0.258]	[0.255]	[0.028]	[0.028]	[624.362]	[617.889]

Brackets contain robust standard errors; \*\*\* p<0.01, \*\* p<0.05, \* p<0.10

Appendix Table 6. Ordinary Least Squares Regression Results Predicting AMI Outcomes: Hospital Management and EHR Adoption:

**Targets**

OUTCOME:	LENGTH OF STAY		30-DAY MORTALITY		PAYMENT	
	Base	Interaction	Base	Interaction	Base	Interaction
MODEL:	(1)	(2)	(3)	(4)	(5)	(6)
EHR	-0.215	2.376	0.029	0.194	181.431	8,300.028**
	[0.450]	[2.003]	[0.049]	[0.153]	[1,085.978]	[3,335.925]
TARGETS	-0.052	0.098	-0.024	-0.015	376.646	835.775**
	[0.200]	[0.200]	[0.026]	[0.029]	[406.531]	[385.073]
<b>EHR X TARGETS</b>		<b>-0.82</b>		<b>-0.055</b>		<b>-2,731.490**</b>
		<b>[0.572]</b>		<b>[0.045]</b>		<b>[1,089.913]</b>
No Teaching	Reference	Reference	Reference	Reference	Reference	Reference
Major Teaching	0.575	0.493	0.028	0.023	2,995.880**	2,747.508**
	[0.347]	[0.366]	[0.030]	[0.029]	[1,326.459]	[1,332.780]
Minor Teaching	0.314	0.287	0.044**	0.038**	1,364.58	1,062.96
	[0.326]	[0.330]	[0.019]	[0.018]	[1,044.930]	[995.790]
Not-for-Profit	Reference	Reference	Reference	Reference	Reference	Reference
Public	-0.700**	-0.672**	0.014	0.018	70.759	235.594
	[0.324]	[0.323]	[0.034]	[0.034]	[835.544]	[837.319]
For Profit	0.747	0.764	0.011	0.015	1,573.43	1,776.99
	[0.647]	[0.628]	[0.040]	[0.039]	[1,608.017]	[1,585.967]
Small (1-99 beds)	Reference	Reference	Reference	Reference	Reference	Reference
Medium (100-399 beds)	0.871**	0.883**	-0.071***	-0.068**	3,542.066***	3,675.260***
	[0.421]	[0.422]	[0.027]	[0.026]	[821.546]	[825.148]
Large (400+ beds)	2.253***	2.253***	-0.048	-0.047	6,009.277***	6,088.736***
	[0.487]	[0.492]	[0.035]	[0.034]	[1,180.798]	[1,200.405]
Proportion of Medicare Admissions	1.369	1.289	0.056	0.053	-7,879.529***	-7,994.500***
	[1.345]	[1.336]	[0.121]	[0.120]	[2,639.680]	[2,630.480]
Urban	0.325	0.338	-0.055*	-0.053*	2,063.275***	2,163.134***
	[0.342]	[0.344]	[0.030]	[0.030]	[637.151]	[639.278]
System Affiliated	0.143	0.113	0.022	0.019	968.249	839.516
	[0.256]	[0.255]	[0.028]	[0.027]	[637.651]	[632.009]

Brackets contain robust standard errors; \*\*\* p<0.01, \*\* p<0.05, \* p<0.10

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