Avoidable Mortality: The Mediating Role of Communication in Health IT

Joseph R. Buckman
J. Mack Robinson College of Business, Georgia State University
jbuckman@gsu.edu

Tiemen Woutersen
Eller College of Management, University of Arizona
woutersen@arizona.edu

Matthew J. Hashim
Eller College of Management, University of Arizona
mhashim@arizona.edu

Abstract

The adoption of health IT transforms communication between care providers and patients. Unfortunately, research on the transformation of communication has produced conflicting results, creating tension regarding its efficacy among healthcare professionals. In this paper, we propose that nurse and physician communication performance mediate the relationship between health IT implementation and patient outcomes. We test the mediating role of communication with a hospital-level data set spanning 2011 through 2015. The specific health information technologies we investigate include EMR documentation, computerized physician order entry (CPOE) systems, clinical decision support (CDS) systems, and health information exchanges (HIE). Our results provide that EMR documentation, CPOE, and HIE directly improve communication between care providers and patients as well as patient outcomes. Further, nurse-patient and physician-patient communication mediates the relationship between health IT implementation and patient outcomes. The mediating effect extends the positive benefits to patient outcomes following technology implementation. We also find that poor communication with patients directly increases mortality, decreases satisfaction, and decreases loyalty. Surprisingly, CDS has a negative relationship on

communication and patient outcomes. Our findings contribute to the information systems and healthcare literatures by demonstrating the need to account for the multidimensional nature of healthcare and by providing context for the positive and negative effects previously discovered. Furthermore, the results offer practical and theoretical implications for leveraging specific health IT adoption and for realigning federal incentive structures for hospitals.

Keywords: health IT, communication performance, mediation, patient outcomes

Avoidable Mortality: The Mediating Role of Communication in Health IT

1. Introduction

Effective communication between healthcare providers and patients is critical for conveying important health information and for operational decision making. In fact, operational measures of communication performance for nurse–patient and physician–patient communications are used to assess the efficacy of healthcare operations [1]. Communication performance is a key indicator of patients' adherence to treatment [2], understanding of medical information [3], motivation to improve their state of health [4], and overall satisfaction with their care [5]. According to the US-based Joint Commission[1], miscommunication in healthcare is attributed to nearly 80% of serious medical errors and complications, which can substantially increase the cost of care through treatment delay, inappropriate treatment, and extended length of stay in the hospital [6]. Furthermore, a recent report found that poor communication between physicians and patients is a leading cause of medical malpractice cases [7]. This fact led the National Academy of Medicine to emphasize nurse–patient and physician–patient communication in achieving its Triple Aim Initiative: improve population health, improve the care experience, and reduce the per capita costs of healthcare. As such, industry leaders and scholars have searched for practical recommendations and tools to support healthcare communication, the most prevalent of which is health information technology (health IT) because it can supply timely comprehensive information [8].

In this study, we explore the impact of health IT on nurse–patient and physician–patient communication as well as communication's role as a mediator of the effects of health IT on patient outcomes. The existing literature on communication and health IT has focused primarily on improvements to efficiency and rapport development following the adoption of electronic medical record (EMR) systems in general practitioner offices. Few studies have investigated the effects of

[1] The Joint Commission is a nonprofit organization that accredits healthcare providers' eligibility to receive Medicare and Medicaid reimbursement.

health IT on communication during clinical visits in a hospital, despite communication's importance in terms of the urgent nature of the activities, high-risk conditions, and lack of prior knowledge of patients [9]. Our research analyzes the health IT and communication relationship in hospitals in two unique ways. First, we study health IT that extends the capabilities of an EMR system, such as computerized physician order entry (CPOE), clinical decision support (CDS), and health information exchange (HIE). Second, we investigate communication's role as a mediator of the effects of health IT on patient outcomes. We investigate mediation because health IT may affect clinical care by altering operations that contribute to patient outcomes. For instance, Angst et al. [10] showed that health IT improves technical care protocols for heart attack patients, which lowers mortality. We apply this concept to the study of the effect of health IT on patient outcomes through its influence on nurse and physician communication.

Hence, we address the following research questions. (a) Does health IT improve communication between care providers and patients? (b) What is the relationship between nurse and physician communication and patient outcomes? (c) To what extent does communication extend the benefits (if any) of expanding health IT capabilities?

Our empirical strategy leverages the heterogeneity in health IT functionality across hospitals. The few studies that investigated health IT in hospitals found that there are large effects of health IT adoption when analyzing singular hospital adoption. However, effect sizes dissipate with large-scale hospital panels, which reduces the generalizability of prior findings [11,12]. We employ a multiyear panel of hospitals that accept Medicare in the U.S. to strengthen the external validity of our findings. Additionally, we focus our attention on acute care within hospitals to minimize potential bias from prior rapport development between healthcare providers and patients. That is, patients requiring acute care are likely to receive treatment from a nurse or physician with whom they are unfamiliar, thereby strengthening the identification of technology effects on communication. Finally, we include fixed

effects and control for organizational characteristics within a hospital (e.g., customized health IT solutions and prior EMR system adoption).

We find that the effects of the increased capabilities of healthcare technologies on patient outcomes are partially mediated by improved patient communication with physicians and nurses. Specifically, the indirect improvement to nurse–patient and physician–patient communication from increasing the capabilities of healthcare technologies strengthens the positive effects of health IT on patient outcomes. Furthermore, we find that EMR documentation and information exchange technologies have some of the most profound impacts on communication and patient outcomes. Greater information exchange capabilities yield significant benefits across each dimension we investigate. Surprisingly, increasing EMR documentation leads to significantly lower patient satisfaction, but this lower satisfaction is negated by the overarching improvements to communication. In contrast, the use of decision support systems in hospitals negatively affects patient outcomes by worsening nurse–patient and physician–patient communication. These findings are robust to the inclusion of time-lagged variables that control for prior levels of technology usage.

Further analysis presents a unique view of how technologies affect communication throughout a healthcare visit. We find that EMR documentation and information exchange capabilities have a positive effect on patients' perceptions of nurse and physician communication throughout a visit. In addition, order entry and decision support affect the communication of treatment medications and postdischarge care during the later stages of a visit. These results suggest that nurses are more important than are physicians in determining the quality of patient outcomes.

Our work makes several distinct contributions. First, our findings on the direct and indirect relationships among technology implementation, communication performance, and patient outcomes shed clarifying light on the conflicting results throughout the extant literature. Prior studies have shown a wide range of effects across these measures with inconclusive evidence of their overall effect on healthcare. However, we address such divisiveness in the literature by providing context as

to why technologies elicit both positive and negative effects. Second, we contribute to the health policy literature by quantifying the impact of health IT and communication in terms of reductions in mortality and improvements in patients' overall satisfaction with their care. We further contribute to the policy literature by exploring the economic incentives of health IT adoption. Our findings suggest that hospitals can maximize their utility in the current incentive structure by focusing adoption efforts on technologies that assist information documentation and sharing. Alternatively, we demonstrate the misalignment of federal incentives with the adoption of other healthcare technologies. Our study has implications for hospital management and health officials regarding the guiding of future health IT implementations.

2. Background

The U.S. healthcare industry has undergone significant change with the digitization of patients' health information using EMR systems. By and large, the health IT literature has found positive effects of digitization across a broad array of healthcare aspects [13].[2] For example, digitization has been associated with improvements in clinical efficiency, patient safety, and quality of care [14,15,16]. However, a significant concern within the literature and among health professionals is the effect of EMR and other healthcare technologies on nurse–patient and physician–patient communication during a healthcare visit [5,17,18]. Digitization alters the dynamics of interactions during a visit. Traditionally, there existed a dyadic relationship between patients and physicians that required extensive dialog from both parties. The introduction of a computing device into the environment alters the relationship to a triadic patient–physician–computer relationship, which can disrupt the communication process [19]. Healthcare providers report struggling with allocating their attention to the patient because of distractions brought about by the computing device [20]. As a result, healthcare technologies can inadvertently impose barriers to effective

[2] We do not provide an exhaustive list of the effects of EMR and health IT implementation. For further reading, see previous meta-analyses such as Buntin et al. [25] and Jones et al. [24].

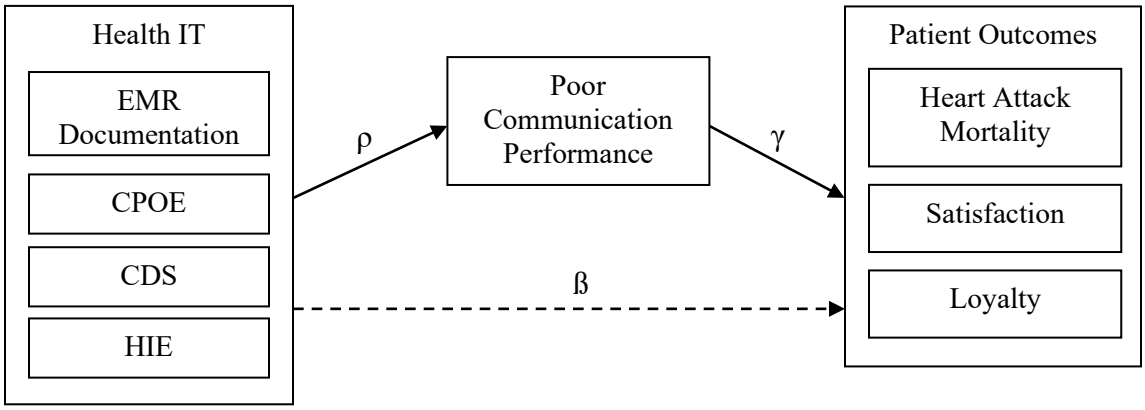
communication, leading to less information sharing because patients feel unable to ask questions or express concerns. As can be expected, these barriers can be detrimental to patient care [21,22,23].

3. Conceptual Model and Hypotheses

Our paper further explores the relationship between health IT and clinical communication by studying their dual effect on patient outcomes. Recently, scholars have encouraged consideration of the multidimensional nature of healthcare (i.e., the altering of one aspect or outcome of care requires the thorough investigation of the operational measures responsible for that aspect or outcome of care) when analyzing the effects of technology adoption [11,24]. Many studies throughout the health IT literature have focused almost exclusively on the direct relationship between technology implementation and a specific aspect of clinical care using a pre-post design. However, Venkatesh et al. [24] and Angst et al. [10] proposed models demonstrating that clinical processes and measures mediate the effects of health IT on patient outcomes. Specifically, technology adoption in healthcare has the potential to affect multiple processes and measures that support patient care and lead to changes in patient outcomes. Therefore, a technology exhibits direct and indirect relationships with aspects of care provision and patient outcomes. The indirect relationship manifests through the impact of the technology on clinical processes, further contributing to the overall effect on patient outcomes.

We propose a conceptual model using a structure-process-outcome framework similar to that of Angst et al. [10]. Within the health IT context, structures can be healthcare technologies that assist with the communication and administration of clinical care. Processes are the protocols and flow of events associated with clinical care. The clinical process in our model is the communication performance of physicians and nurses with patients. Specifically, communication performance involves collective reporting on the ability of physicians and nurses to communicate with patients, explain prescription medications, and provide postdischarge treatment instructions. We focus on times when reported communication performance is poor and inadequate. Outcomes are the end

results that can help us assess the effectiveness of clinical processes. The outcomes of interest are heart attack mortality, patient satisfaction, and patient loyalty. Our conceptual model proposes that nurse–patient and physician–patient communication performance mediates the relationship between health IT and patient outcomes. Therefore, the benefits of adopting health IT are, to some degree, reliant on how they influence nurse and physician communication. Figure 1 displays the conceptual model and lists our proposed hypotheses in the below subsections.



H1a: Poor Comm. → Mortality; $\gamma > 0$
H1b: Poor Comm. → Satisfaction/Loyalty; $\gamma < 0$
H2: Health IT → Poor Comm.; $\rho < 0$
H3a: Health IT → Poor Comm. → Mortality; $\rho^*\gamma < 0$; Health IT → Mortality (β) included to test full vs. partial mediation
H3b: Health IT → Poor Comm. → Satisfaction; $\rho^*\gamma > 0$; Health IT → Satisfaction (β) included to test full vs. partial mediation
H3c: Health IT → Poor Comm. → Loyalty; $\rho^*\gamma > 0$; Health IT → Loyalty (β) included to test full vs. partial mediation

Figure 1. Mediating Role of Communication between Health IT and Patient Outcomes

3.1 Communicating with Patients

Hospital visits across the U.S. follow a similar series of processes. First, a patient enters a healthcare setting due to a referral from another healthcare provider or, in an emergency setting, an ambulatory service. Once the patient arrives at the hospital, a receptionist performs the necessary check-in process and obtains general information (e.g., demographics, current condition, and reason for visit). After completing the check-in process, the receptionist informs the nursing staff of the patient's arrival. A nurse retrieves the patient and collects further information, including vital

information, current medications, allergies, a review of the initial documents from the check-in process, and additional details regarding the patient's reason for visit. The nurse records all information and notifies the physician that the patient is ready to be seen. The physician then reviews the collective information with the patient and makes an initial diagnosis. The physician discusses the diagnosis with the patient and informs the nursing staff of the procedures to be performed, which can include a variety of tests, injections, examinations, or prescriptions. Nurses and other hospital staff carry out the procedures instructed by the physician to confirm diagnosis and/or begin treatment. Physicians may see the patient again to finalize the care visit by submitting prescriptions, suggesting appointments with another healthcare specialist, and discussing the postdischarge plan of care. Nursing staff also address questions or clarifications regarding the physician's instructions as they begin follow-up or outside procedural scheduling. Finally, the nursing staff or a receptionist completes and documents the patient's visit.

Communication between healthcare providers and patients plays a significant role during the early stages of a healthcare visit because it lays the foundation for care [19]. The objective during the early stages of a clinical visit is to gather extensive information to improve the accuracy of diagnosis and treatment. Researchers have sought to identify communication techniques that improve information gathering while nurses and physicians review medical history with the patient and while the patient explains his or her reason for the visit. Nurses and physicians are encouraged to engage with patients by inquiring about their thoughts and feelings regarding their condition and by empathizing with them. In doing so, nurses and physicians can achieve more effective communication and collect additional information that they otherwise might not have received from the patient [1,27]. Furthermore, physicians and nurses showing a willingness to listen and ask questions fosters an environment of collaboration where patients feel acknowledged and inspired to take interest in their health [4].

The objective during the later stages of a clinical visit is to share treatment and postdischarge care instructions. Patient adherence to treatment is dependent upon communication. The risks of future complications, readmission, and death increase accordingly [2], with many cases of failed adherence resulting from communication breakdowns [28]. Alternatively, patients express greater satisfaction with and are more likely to adhere to their care when they receive specific details on the diagnosis and treatment protocol [2,29]. This additional information improves service quality and offers an opportunity for further dialog and clarification [30]. Based on the impact of communication, we expect that poor communication performance among hospital staff increases heart attack mortality and decreases patient satisfaction and loyalty. Thus, we hypothesize the following:

H1: *Poor communication performance is (a) positively associated with heart attack mortality and (b) negatively associated with patient satisfaction and loyalty.*

3.2 Technology for Healthcare Visits

The healthcare technologies on which we focus are being implemented to enhance the way healthcare providers use EMR systems such as expanded documentation, CDS systems, CPOE systems, and HIEs. The overarching goal behind these technologies is to improve operations throughout a healthcare visit, including communication between healthcare providers and patients. For instance, expanding the documentation within an EMR provides greater historical details that help healthcare providers learn historical patient information, thus facilitating the communication of current medical conditions during the early stages of a visit. CPOE (i.e., a system allowing care providers to electronically order medications and services and to pass on comprehensive medication details) facilitates communication surrounding medications and services for treatment plans during later stages of a visit. CDS (i.e., a system providing process structuration for diagnosis and treatment) analyzes data points from an EMR to generate patient-specific assessments and treatment options to be communicated to the patient. HIE (i.e., a system for handing off patient information across health

systems and care providers) expedites the sharing of patient information across healthcare providers to facilitate the communication of patients' medical history, laboratory results, and treatment referrals at the beginning and end of a healthcare visit.

Health IT has the potential to increase collective understanding among hospital staff and patients by enhancing the effectiveness of communication [5,31]. In fact, studies show that the first few minutes of dialog between a physician and patient are drastically changed following the introduction of a computing device [19]. Crampton et al. [17] demonstrated that EMR systems significantly improve nurses' and physicians' efficiency by checking and clarifying patients' medical histories and information. Bao et al. [18] showed that patient portal usage contributes to provider–patient engagement. The comprehensiveness, organization, and readability of information in digital records lead to reduced cognitive efforts across all parties [20,21]. Specifically, notes by nurses and physicians are legible and traceable, and patients are not burdened by having to recall to which medications they are prescribed. This greater efficiency allows for additional time with patients during early information exchanges such that physicians can ask broad open-ended questions to gather relevant information [32]. Health IT also provides templates and checklists for collecting information from patients, which promotes information sharing and helps ensure that physicians do not forget vital details [20]. Thus, we expect that increasing the capabilities associated with health IT decreases (i.e., improves) poor communication performance among nurses and physicians.

H2: *Increasing the capabilities of health IT is negatively associated with (i.e., improves) poor communication performance.*

We draw on and extend the prior research on the relationships among health IT, nurse–patient and physician–patient communication, and patient outcomes. The adoption of EMR systems and health IT has been associated with improvements in patient safety and care [17,33,34]. However, more recent studies have demonstrated that the benefits from such implementation do not manifest in all areas of clinical care. For instance, a meta-analysis by Shachak et al. [20] concluded that EMR

systems have a positive effect on information tasks such as data retrieval and archiving but have a negative effect on a physician's ability to develop rapport and connect with a patient. Patient rapport is linked to patient satisfaction and loyalty through the creation of an environment in which patients feel connected to the caregiving process and heightened optimism with their care. However, steady decreases in patient rapport have been attributed to the altered nurse–patient and physician–patient communication dynamics following health IT implementation [19,35].

Collectively, nurses and physicians require detailed information to support accurate diagnosis and care [22]. Interpersonal communication remains the most frequently used method through which to obtain such information [36], and health IT can facilitate the communication process by providing an extensive medical history, prescription medications, decision aids, and information regarding care transitions [17,29,37,38]. This improvement in communication then influences the positive and negative effects on clinical care that manifest from health IT implementation. In other words, communication performance mediates the relationship between health IT and patient outcomes.

The patient outcomes on which we focus are heart attack mortality, patient satisfaction, and patient loyalty. As previously mentioned, health IT implementation has been shown to improve patient safety and care. Therefore, we expect a negative relationship between health IT and heart attack mortality. The decreases in patient rapport following health IT implementation suggest that there is a negative relationship between health IT and patient satisfaction and between health IT and patient loyalty. Health IT's facilitation of communication throughout a clinical visit would then mediate each of these relationships.

H3a: *The negative impact of health IT on heart attack mortality is mediated through poor communication performance.*

H3b: *The negative impact of health IT on patient satisfaction is mediated through poor communication performance.*

H3c: *The negative impact of health IT on patient loyalty is mediated through poor communication performance.*

4. Research Data and Empirical Setup

Table 1. Variable Descriptions

Variables	Description
Dependent Variables	
Heart Attack Mortality	Death rate for heart attack patients.
Patient Satisfaction	Percent of "Patients who gave their hospital a rating of 7 or greater on a scale from 0 (lowest) to 10 (highest)."
Patient Loyalty	Percent of "Patients who reported YES, they would probably or definitely recommend the hospital."
Independent Variables	
Doctor Communication	Percent of "Patients who reported that their doctors 'Sometimes' or 'Never' communicated well."
Nurse Communication	Percent of "Patients who reported that their nurses 'Sometimes' or 'Never' communicated well."
Medication Communication	Percent of "Patients who reported that staff 'Sometimes' or 'Never' explained medicines before giving it to them."
Post-Discharge Communication	Percent of "Patients who reported that NO, they were NOT given information about what to do during their recovery at home."
Documentation	Percentage of total clinical documentation implemented.
CPOE	Percentage of total physician order entry capabilities implemented.
CDS	Percentage of total decision support system capabilities implemented.
HIE	Percentage of total health information exchange capabilities implemented.
Control Variables	
EMR	Indication that the hospital has implemented an EMR system in the hospital.
Customized IT	Indication that the hospital has implemented a customized health IT system.
Nonprofit Hospital	Indication that the hospital is not for profit.
Operating Expense	Natural logarithm of the operating expenses for a hospital.
Admissions	Natural logarithm of the number of patients admitted to the hospital.
Staffed Beds	Natural logarithm of the number of staffed beds in the hospital.

To address our research goals, we construct our dataset by merging U.S. hospital data for the years 2011 through 2015 from the American Hospital Association's (AHA's) Health IT database, CMS Hospital Compare database, CMS's Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey, and Healthcare Information and Management Systems Society (HIMSS) Analytics database. The AHA and HIMSS obtain data from hospitals using annual surveys, while CMS obtains data using a quarterly survey. Hospital responses to AHA and HIMSS surveys are optional, but U.S. federal law requires hospitals to report their measures to the CMS. AHA and

HIMSS surveys are administered during the third quarter each year, and responses are submitted in the second quarter of the following year. Therefore, we use the third quarter release of CMS data to account for time, technology, and processing lags. Similar to the prior literature, we also use these data because they contain the finalized reported measures for the prior year [10]. We merge the measures from each source according to the Medicare provider number assigned by the CMS. The following subsections discuss the specific measures we use from the sources. Table 1 provides a list of these measures.

4.1 Health Information Technologies

We obtain our measures for the capabilities of health IT from the AHA's Health IT database. In the survey, respondents mark checkboxes to indicate the capabilities they currently use with EMR documentation, CPOE, CDS, and HIE. EMR documentation refers to the individual pieces of information recorded by an EMR. The greater the amount of information recorded by an EMR is, the greater the robustness of information available for physicians and nurses. CPOE is a system that allows physicians and nurses to electronically submit requests for a variety of medical tests and prescription medications. A CDS is an application system that includes an array of tools designed to analyze large amounts of data to assist physicians and nurses with clinical workflows and decision making. HIE is a set of system capabilities that allow for the exchange of patient information with care provider groups across and outside of the hospital. Because responses are checkboxes, we use a binary indicator to represent the usage of a capability, which provides 39 documentation indicators, 5 CPOE indicators, 6 CDS indicators, and 20 HIE indicators. We then calculate the percentage of capabilities used by a hospital for each technology to generate a consistent scale.

4.2 Communication Performance

Measures for communication performance come from CMS HCAHPS responses. Following discharge from a hospital, the CMS requests that patients participate in a survey in which they indicate their attitudes and feelings regarding their care. The data reported by the CMS are the

percentage of responses for good and poor communication by physicians and nurses, as well as medication and recovery explanations. Patients indicate poor communication by responding that physicians and nurses "sometimes" or "never" communicated well, administered medication was "sometimes" or "never" explained, and patients "did not receive recovery information."

We create a performance index to capture and normalize each of these aspects of hospital communication using the following equations:

$$\sigma_{it} = \sqrt{\frac{1}{N_{it}} \sum_{j} (x_{ijt} - \mu_{it})^2}$$

$$\gamma_{ijt} = \frac{x_{ijt}}{\sigma_{it}}$$

$$\rho_{jt} = \frac{\sum_i \gamma_{ijt}}{n}$$

where σ_{it} is the standard deviation for communication measure i in year t. N_{it} is the number of observations for measure i in year t. γ_{ijt} is the communication value from dividing observation x for measure i in hospital j in year t (i.e., x_{ijt}) by the standard deviation for measure i in year t. ρ_{jt} is the communication performance index value for hospital j in year t, found by averaging the communication values for hospital j in year t over our four communication measures.

4.3 Patient Outcomes

We investigate three patient outcomes. The first outcome is heart attack mortality from CMS Hospital Compare. We choose to study heart attack mortality because it is an acute condition requiring adequate patient information to determine appropriate treatment and possible lifestyle changes [4]. Physicians and nurses are often unfamiliar with heart attack patients and rely on formal and informal communication to gather information [36]. Therefore, advances in health IT aid physicians and nurses in acute care circumstances in which they have little prior knowledge of the patient.

The second and third patient outcomes we study are patient satisfaction and loyalty from the CMS HCAHPS survey. Patient satisfaction is measured on a scale from one to ten. Patients who are satisfied with their care indicate a score of seven or greater. In this study, we use the percentage of patients who indicated satisfaction with their care as the measure for patient satisfaction. Patient loyalty is measured by asking patients about their likelihood of recommending the hospital to a friend or family member. We use the percentage of patients who indicated they "would probably" or "would definitely" recommend the hospital as the measure for patient loyalty.

4.4 Controls

Table 2. Summary Statistics

	Mortality Sample					Satisfaction and Loyalty Sample				
Variables	N	Mean	S.D.	Min	Max	N	Mean	S.D.	Min	Max
Mortality	7,871	15.00	1.57	9.40	22.60					
Satisfaction						11,286	92.10	3.78	52	100
Loyalty						11,286	95.24	2.86	68	100
Poor Comm.	7,871	2.64	0.64	0.95	8.02	11,286	3.62	1.01	0.00	11.65
Documentation	7,871	0.85	0.15	0	1	11,286	0.84	0.16	0	1
CPOE	7,871	0.84	0.35	0	1	11,286	0.81	0.37	0	1
CDS	7,871	0.85	0.28	0	1	11,286	0.83	0.30	0	1
HIE	7,871	0.63	0.31	0	1	11,286	0.59	0.32	0	1
EMR	7,871	0.99	0.07	0	1	11,286	0.99	0.09	0	1
Customized IT	7,871	0.01	0.08	0	1	11,286	0.01	0.08	0	1
Operating Exp.	7,871	19.09	0.94	15.79	22.28	11,286	18.55	1.23	14.61	22.28
Admissions	7,871	9.15	0.91	1.10	12.62	11,286	8.52	1.34	1.10	12.62
Staffed Beds	7,871	5.24	0.80	2.40	7.35	11,286	4.73	1.09	1.39	7.35
Nonprofit H.	7,871	0.74	0.44	0	1	11,286	0.68	0.46	0	1

We consider several control variables to account for various hospital and time characteristics that can also affect communication performance and patient outcomes. Our control variables are from the HIMSS Analytics databases. We control for the following: (1) whether the hospital is for-profit or nonprofit using a binary indicator, (2) hospital size using the natural logarithm of the number of staffed beds available for a given year, (3) patient turnover using the natural logarithm of the number of admissions for the given year, and (4) hospital wealth using the natural logarithm of the net operating expenses of the hospital for the given year. Additionally, we control for several health IT characteristics. The first technology characteristic is a binary indicator for whether the

hospital uses a customized, in-house IT system. The second technology characteristic we control for is the implementation of an EMR system. Because we focus on the role played by EMRs in extending health IT, we control for communication and patient outcomes benefiting from the initial EMR system implementation. We operationalize the variable using a binary indicator for whether the hospital has an EMR system in place for a given year.

Upon merging the data, we obtain two unbalanced panel datasets: a set for mortality and a set for satisfaction and loyalty. Observations are removed if they are missing any of the outcome or explanatory measures. We use two datasets because fewer hospitals report heart attack mortality compared to our other outcomes. The CMS does not require hospitals to provide a mortality rate if they admit a minimal number of heart attack patients to avoid biasing the rate, resulting in more observations being dropped among the mortality sample. Patient satisfaction and loyalty are measured across all medical conditions admitted to the hospital, and therefore, the likelihood that a hospital is dropped from the sample due to minimal responses is much lower. The dataset for heart attack mortality rates contains 7,871 observations, while that for patient satisfaction and loyalty contains 11,286 observations. See Table 2 for the summary statistics.

5. Analysis and Results

To test whether health IT, as well as physician–patient and nurse–patient communication performance, affect patient outcomes, we estimate several panel regressions with fixed effects. The panel model is as follows:

$$Outcome_{it} = \gamma PoorCommunication_{it} + \beta Technologies_{it} + \lambda Controls_{it} + \alpha_i + u_{it},$$

where $Outcome_{it}$ is the heart attack mortality rate, patient satisfaction, or patient loyalty for hospital i in year t; $PoorCommunication_{it}$ is a vector of the good and total communication performance indices; $Technologies_{it}$ is the vector of healthcare technologies; $Controls_{it}$ is the vector of control measures; α_i is the hospital fixed effect; and u_{it} is the error term.

The estimates from our models in Table 3 show that hospitals benefit from the further implementation of health IT. Alternatively, hospitals have worse patient outcomes when care providers communicate poorly. For reference, during our observation period, a 0.5-percentage-point decrease in heart attack mortality equates to two lives saved, and a 1-percentage-point increase in satisfaction or loyalty corresponds to fifty patients. We further discuss a counterfactual that illustrates the implications of the effects in the Discussion section. Models 1, 3, and 4 in Table 3 pertain to the direct effects of health IT and poor communication on patient outcomes. Consistent across models 1, 3, and 4, we find that poor communication performance negatively affects patient outcomes, which supports *Hypotheses 1a* and *1b*. Specifically, poor communication performance increases heart attack mortality rates by 0.511 percentage points and decreases patient satisfaction and loyalty by 1.142 and 0.712 percentage points, respectively. The direct effect of increasing EMR documentation capabilities is a reduction in heart attack mortality by 1.596 percentage points and a reduction in patient satisfaction and loyalty by 0.423 and 0.832 percentage points, respectively. The direct effect of increasing CPOE capabilities is a reduction in heart attack mortality rates by 0.197 percentage points and a reduction in patient satisfaction and loyalty by 0.142 and 0.112 percentage points, respectively. The direct effect of increasing CDS capabilities is an increase in heart attack mortality rates by 0.296 percentage points, and there is no significant direct effect on patient satisfaction or loyalty. The direct effect of increasing HIE capabilities is a reduction in heart attack mortality rates by 0.598 percentage points and an increase in patient satisfaction by 0.340 percentage points.

Models 2 and 5 in Table 3 concern the direct effects of health IT on poor communication performance. The estimates show mixed support for *Hypothesis 2*. Specifically, increasing EMR documentation and HIE capabilities reduces poor communication performance by 0.707 and 0.387 index points, respectively (see model 5). Increasing CDS capabilities increases poor communication performance by 0.205 index points (see model 5). Increasing CPOE capabilities has no significant

effect on poor communication performance, which suggests that communication performance does not mediate the relationship between CPOE and patient outcomes.

Table 3. Direct Effect of Communication and Technologies on Patient Outcomes

	Mortality Sample		Satisfaction and Loyalty Sample		
Variables	Mortality	Poor Comm. Performance	Satisfaction	Loyalty	Poor Comm. Performance
Poor Comm.	0.511**		-1.142**	-0.712**	
Performance	(0.053)		(0.054)	(0.041)	
Documentation	-1.596**	-0.359**	-0.423†	-0.832**	-0.707**
	(0.177)	(0.050)	(0.236)	(0.185)	(0.078)
CPOE	-0.197**	-0.043*	0.142†	-0.112†	-0.020
	(0.067)	(0.017)	(0.083)	(0.062)	(0.027)
CDS	0.296**	0.046*	0.078	0.138	0.205**
	(0.082)	(0.022)	(0.117)	(0.087)	(0.037)
HIE	-0.598**	-0.203**	0.340**	0.086	-0.387**
	(0.068)	(0.019)	(0.089)	(0.067)	(0.029)
EMR	0.989*	0.062	0.422	0.123	0.415**
	(0.401)	(0.123)	(0.385)	(0.303)	(0.120)
Customized IT	0.058	-0.236**	0.269	-0.012	-0.401**
	(0.213)	(0.109)	(0.413)	(0.278)	(0.122)
Operating	-0.645**	-0.264**	-0.049	-0.263*	-0.314**
Expense	(0.179)	(0.049)	(0.170)	(0.118)	(0.069)
Admissions	0.094†	0.046**	-0.113	-0.016	0.086**
	(0.051)	(0.016)	(0.083)	(0.073)	(0.029)
Staffed Beds	0.305*	0.121*	0.012	0.027	0.139*
	(0.148)	(0.054)	(0.184)	(0.132)	(0.057)
Nonprofit	-0.165	-0.091†	-0.026	0.023	-0.118
Hospital	(0.251)	(0.052)	(0.281)	(0.296)	(0.108)
N	7,871	7,871	11,286	11,286	11,286
Hospitals	2,381	2,381	3,479	3,479	3,479

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$

5.1 Robustness Check

For robustness, we consider that a necessary condition for mediation is a significant relationship between health IT and communication performance. Therefore, we use an alternative empirical approach to strengthen our identification of the relationship between health IT and communication performance. Specifically, we use a two-stage difference-in-differences (2SDiD) model, for which we create a new binary variable that indicates whether a hospital has adopted a specific healthcare technology (i.e., documentation, CPOE, CDS, or HIE). The binary indicator takes a value of one if the hospital has implemented the specific technology and zero otherwise. 2SDiD

controls for confounding factors over time, similar to a traditional difference-in-differences model, but it is also robust to treatment effect heterogeneity through its two-stage estimation framework [39]. In the first stage, we estimate fixed and hospital characteristic effects on poor communication performance. The second stage identifies the average treatment effect after controlling for the estimations in the first stage. We do not use this model for our main analysis because it requires estimating the effect of each health IT implementation individually.

We first estimate the 2SDiD model using all hospitals from the patient satisfaction sample (see Table 4). However, we next consider a robustness check for equal representation between hospitals. It is unlikely that hospitals implemented health IT at random but rather were guided by strategic decision making. The removal of randomization from the data-generating process can introduce selection bias and weaken the identification of our effects. The time-varying hospital characteristics and fixed effects used within our panel models minimize selection bias by accounting for the factors that may influence health IT implementation. However, we can use coarsened exact matches to group hospitals with similar characteristics and prevent selection bias from affecting our results. We match hospitals according to their size, patient admissions, and operating expenses. We then use the matched sample with our 2SDiD estimations. The results from the full and matched samples are displayed in Table 4.

Table 4. Two-Stage DiD Results

	Full Sample				Matched Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Documentation	-0.695** (0.248)				-0.462* (0.214)			
CPOE		-0.012 (0.026)				-0.046 (0.035)		
CDS			-0.124** (0.038)				-0.177** (0.052)	
HIE				-0.498** (0.069)				-0.519** (0.085)
N	11,286	11,286	11,286	11,286	5,229	5,229	5,229	5,229
Hospitals	3,479	3,479	3,479	3,479	1,949	1,949	1,949	1,949

The dependent variable is poor communication performance in a hospital. Estimates are for patient satisfaction and loyalty sample. Similar results are found with the mortality sample.
† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$.

The results from the 2SDiD estimations are consistent between the full and matched samples and show that there is a significant negative relationship between health IT and poor communication performance, except for CPOE. This finding supports our usage of communication performance as a mediator between the effects of EMR documentation, CDS, and HIE on patient outcomes. The null effect for the relationship between CPOE and communication performance further suggests that communication does not mediate the relationship between CPOE and patient outcomes. The difference in direction of the relationship between CDS and poor communication performance, which is positive in Table 3 and negative in Table 4, suggests that furthering the capabilities of CDS is detrimental to provider communication. Specifically, the 2SDiD approach estimates the pre- and postimplementation effect of CDS, whereas the panel regression estimates the effect of increasing the extent of CDS capabilities. Thus, the initial implementation of CDS has a positive effect on communication, but as capabilities grow, communication performance decreases.

5.2 Mediating Effect of Communication Performance

Tables 5, 6, and 7 consider the indirect and total effects of health IT on patient outcomes. We calculate the indirect effect by multiplying the direct effect for poor communication performance on patient outcomes (Table 3; models 1, 3, and 4) with the appropriate technology effect on communication performance (Table 3; models 2 and 5). The total effect is the sum of direct and indirect effects. We calculate bootstrapped standard errors for indirect and total effects. Our results show a significant indirect effect on patient outcomes for each technology, indicating a significant mediating effect of communication performance. This finding supports the presence of mediation for *Hypotheses 3a, 3b,* and *3c*. Specifically, the negative indirect effect for EMR documentation and HIE in Table 5 supports *Hypothesis 3a*. The positive indirect effect for EMR documentation and HIE in Tables 6 and 7 support *Hypothesis 3b* and *Hypothesis 3c*. These indirect effects provide evidence of better patient outcomes through improving communication performance. Alternatively, we find that

the indirect effects for CDS are in the opposite direction for each outcome, suggesting that CDS worsens patient outcomes by weakening communication performance.

Table 5. Indirect and Total Effects on Mortality

	Documentation	Decision	HIE
Direct Effect	-1.596**	0.296**	-0.598**
	(0.177)	(0.082)	(0.068)
Indirect Effect	-0.183**	0.023**	-0.104**
	(0.026)	(0.011)	(0.010)
Total Effect	-1.779**	0.319**	-0.702**
	(0.026)	(0.011)	(0.010)

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$

Table 6. Indirect and Total Effects on Satisfaction

	Documentation	Decision	HIE
Direct Effect	-0.423†	0.078	0.340**
	(0.236)	(0.117)	(0.089)
Indirect Effect	0.807**	-0.234**	0.442**
	(0.089)	(0.042)	(0.033)
Total Effect	0.385**	-0.156**	0.782**
	(0.089)	(0.042)	(0.033)

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$

In Tables 5 and 6, we find that the indirect and total effects of each technology on heart attack mortality and patient satisfaction are significant. Thus, the mediating effect of communication performance contributes to the effect of technology on mortality and satisfaction. In Table 5, the indirect effect of increasing EMR documentation capabilities is a reduction in heart attack mortality rates by 0.183 percentage points, resulting in a total decrease in mortality by 1.779 percentage points. The indirect effect of increasing CDS capabilities is an increase in heart attack mortality rates by 0.023 percentage points, resulting in a total increase in mortality by 0.296 percentage points. The indirect effect of increasing HIE capabilities is a reduction in heart attack mortality rates by 0.104 percentage points, resulting in a total decrease in mortality by 0.702 percentage points.

In Table 6, the indirect effect of increasing EMR documentation capabilities is an increase in patient satisfaction by 0.807 percentage points, resulting in a net increase in satisfaction by 0.385 percentage points. The indirect effect of increasing CDS capabilities is a reduction in patient

satisfaction by 0.234 percentage points, resulting in a total decrease in satisfaction by 0.156 percentage points. The indirect effect of increasing HIE capabilities is an increase in patient satisfaction by 0.442 percentage points, resulting in a total increase in satisfaction by 0.782 percentage points.

Table 7. Indirect and Total Effects on Loyalty

	Documentation	Decision	HIE
Direct Effect	-0.832**	0.138	0.086
	(0.185)	(0.087)	(0.067)
Indirect Effect	0.503**	-0.146**	0.275**
	(0.055)	(0.026)	(0.020)
Total Effect	-0.329**	-0.008	0.362**
	(0.055)	(0.026)	(0.020)

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$

In Table 7, the indirect effect of increasing EMR documentation capabilities is an increase in patient loyalty by 0.503 percentage points, resulting in a net decrease in loyalty by 0.329 percentage points. The net decrease in loyalty is 0.097 percentage points. The indirect effect of increasing CDS capabilities is a decrease in patient loyalty by 0.146 percentage points. The total effect is not significant. The indirect effect of increasing HIE capability is an increase in patient loyalty by 0.275 percentage points, leading to a total increase in loyalty of 0.362 percentage points.

5.2 Additional Analyses

Next, we open the Poor Communication Performance Index to investigate the effect of health IT on individual communication measures (see Table 8). Model 1 shows that increasing EMR documentation and HIE capabilities reduces poor nurse communication by 0.79 and 0.484 percentage points, respectively. Nurse communication worsens with increasing CDS capabilities by 0.139 percentage points. Model 2 demonstrates that physician communication also improves with advances in EMR documentation and HIE capabilities by 0.263 and 0.245 percentage points, respectively. Model 3 shows that communication regarding medication improves with increasing EMR documentation and HIE capabilities by 3.305 and 1.480 percentage points, respectively. Medication

communication worsens with increasing CDS capabilities by 0.398 percentage points. Model 4 shows that failure to discuss postdischarge instructions decreases with increasing EMR documentation and HIE capabilities by 4.547 and 2.113 percentage points, respectively. Discussing postdischarge instructions worsens by 0.404 percentage points when CDS capabilities increase.

Table 8. Effect of Technologies on Poor Communication

Variables	Nurse	Physician	Medication	Post-Discharge
Documentation	-0.790**	-0.263†	-3.305**	-4.547**
	(0.159)	(0.145)	(0.375)	(0.331)
CDS	0.139*	0.045	0.398*	0.404*
	(0.069)	(0.063)	(0.174)	(0.158)
HIE	-0.484**	-0.245**	-1.480**	-2.113**
	(0.059)	(0.059)	(0.146)	(0.130)
Hospital-Level Controls	Yes	Yes	Yes	Yes
N	11,286	11,286	11,286	11,286
Hospitals	3,479	3,479	3,479	3,479

Estimates are for satisfaction and loyalty sample. Similar results found with the mortality sample. Negative effects indicate a reduction in poor communication. Positive effects indicate an increase in poor communication.
† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$

Table 9. Effect of Poor Communication on Outcomes

Variables	Mortality	Satisfaction	Loyalty
Nurse	0.011	-0.656**	-0.500**
	(0.018)	(0.025)	(0.023)
Physician	-0.053**	-0.316**	-0.242**
	(0.019)	(0.023)	(0.022)
Medication	0.042**	-0.071**	-0.033**
	(0.008)	(0.011)	(0.008)
Post-Discharge	0.140**	-0.069**	-0.001
	(0.009)	(0.012)	(0.007)
Hospital-Level Controls	Yes	Yes	Yes
N	7,871	11,286	11,286
Hospitals	2,381	3,479	3,479

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$

Additionally, we analyze the effects of these individual communication measures on patient outcomes (see Table 9). In model 1, we find that poor medication communication and failure to provide postdischarge instructions increase heart attack mortality rates by 0.042 and 0.140 percentage points, respectively. Surprisingly, we find that poor physician communication decreases

heart attack mortality rates by 0.053 percentage points. Model 2 finds that poor nurse, physician, and medication communication and postdischarge instructions decrease patient satisfaction by 0.656, 0.316, 0.071, and 0.069 percentage points, respectively. We find in model 3 that poor nurse, physician, and medication communication decreases patient loyalty by 0.5, 0.242, and 0.033 percentage points, respectively.

6. Discussion

Overall, our study offers a significant contribution to the healthcare literature by providing empirical evidence that implementing health IT improves communication between hospital staff, thereby improving patient outcomes. Furthermore, our results demonstrate that the effects of implementing health IT on patient outcomes are mediated by hospital staff communication performance. The mediating effect results in a net positive benefit to patient outcomes under most circumstances, highlighting the complex nature of how information technologies affect healthcare. Our findings yield several practical and theoretical implications.

First, hospital management and federal policymakers should prioritize implementing health IT that improves the flow of patient information, such as EMR documentation and HIE. Our results show that further EMR documentation and HIE capabilities provide the greatest overall benefit to patient outcomes, particularly heart attack mortality. EMR documentation and HIE affect mortality due to their robust record keeping, transferability of patient records, and improvement to the communication of medication and treatment following a heart attack. The average patient admitted for a heart attack is over seventy years of age and is diagnosed with several other health-related factors [40]. Patients admitted enter an acute care setting with nurses and physicians who are typically unfamiliar with patient health history. The extensions of EMR documentation and HIE capabilities support nurses and physicians in their ability to make informed medical decisions regarding patient care (i.e., the direct effect of technologies on mortality). Our findings also suggest that EMR documentation and HIE capabilities reduce mortality by improving communication

regarding medication and postdischarge instructions. A recent study found that patients are at greater risk of a new heart attack and potential death within thirty days of discharge when medication communication and postdischarge instructions are poor [40]. Therefore, enhancing EMR documentation and HIE capabilities is impactful, as their effects can be seen in other healthcare processes.

Consider the following counterfactual to put our findings into perspective. The average heart attack mortality rate among the hospitals in our sample is 15.0% (see Table 2). Combining the direct effect of implementing all EMR documentation capabilities with the indirect effect of reducing poor communication performance yields a total reduction in heart attack mortality by 1.779%. The CMS provides that the average number of patients admitted for a heart attack to the hospitals in our sample in 2014 is 186. The average heart attack mortality rate suggests that a sampled hospital in 2014 experienced approximately 30 heart attack deaths. However, fully implementing EMR documentation capabilities reduced the number of patient deaths from heart attack to 24, a 20% decrease. Furthermore, the total effect of implementing all HIE capabilities is a reduction in the average number of patient deaths from heart attack in 2014 from 30 to 27 patients, a 10% decrease.

Currently, there is a federal mandate for hospitals to achieve specified levels of health IT implementation, but there are minimal federal guidelines that direct hospitals on technology precedence, thereby leaving the implementation decisions to the discretion of hospital management. Our results indicate that hospital management can efficiently maximize the utility of healthcare technologies by concentrating implementation and capability extension efforts on EMR documentation and HIE. Policymakers can also use our findings to revise federal incentive structures to motivate hospitals to use these technologies.

Continuing with the discussion of healthcare incentive structures, the second implication from our results involves the increase in poor communication and heart attack mortality from CDS. CMS offers incentives to hospitals and physicians to spur health IT adoption and to improve clinical

outcomes. The underlying thought is that reaching health IT incentive standards should help them move toward federal mandates and encourage them to achieve additional incentive standards because of the benefits from health IT. However, recent studies have begun to show misalignment among incentives. For instance, hospitals receive CMS incentive payments if they reduce or maintain a low average length of stay for hospital visits. Hospitals have sought to achieve these standards by adopting health IT that improves patient care and moves the patient toward speedier discharge. Unfortunately, Oh et al. [41] found evidence that health IT implementation led hospitals to meet length of stay standards but at the expense of rising readmission rates.

A prominent health IT solution associated with reducing the average length of stay in hospitals is CDS [25]. As mentioned previously, CDS is an application system designed to analyze large amounts of data to assist physicians and nurses with diagnosis and treatment plans. However, when physicians and nurses use advanced EMR capabilities, they can develop an overreliance on the system, which limits their critical thinking abilities [42]. These systems shift hospitals toward quicker discharge by increasing care efficiency, which requires healthcare providers to utilize standardized information due to lack of time with patients [36]. The capability improvements in CDS center on advising medication prescription and dosage, which should increase performance in communicating medication explanations and discharge instructions. One explanation for the observed opposite effect is that physicians and nurses underestimate the amount of information that patients desire and can comprehend [4]. Thus, the diminished time spent with patients and overreliance on system-generated scripts results in weaker communication and ultimately lower patient satisfaction. Furthermore, our results suggest that medication explanation and discharge instructions are critical for reducing heart attack mortality; hence, reductions in communication quality for these aspects of care explain the positive relationship between CDS and heart attack mortality.

Interestingly, CMS does not offer an incentive mechanism for achieving greater communication performance or patient satisfaction in hospitals. This incentive misalignment presents

a dilemma within hospitals because they are accomplishing the goals laid forth by federal oversight, but their accomplishment results in worse patient care. Healthcare officials and policy makers should consider introducing a hospital-level incentive for communication performance and patient satisfaction to potentially reverse or offset the negative effects of implementing CDS. The revised incentives encourage the synchronization of technology adoption and interpersonal communication such that technologies do not detract from communication processes. Further research should guide the formation and provision of standardized information to foster a positive relationship between efficiency and patient outcomes. Hospital management should also consider requiring communication training in conjunction with future technology implementation to improve information sharing when using this system.

The third implication of our study is that nurses experience significant improvement in communication performance with health IT implementation, which leads to better patient outcomes. Nurses are integral in effective information management and flow because they are the primary providers coordinating, delivering, and monitoring patient care. Nurses require adequate tools and documentation to better communicate and guide patient care [43]. Increases in EMR documentation and HIE capabilities facilitates necessary information transfer for nurses to effectively fulfill their role, as supported by our results.

In the case of a heart attack, nurses use the increased capabilities of EMR documentation and HIE to improve communication regarding medication and postdischarge instructions. In contrast, the relationship we find between physician communication and mortality comes from the nature of care for heart attacks. When patients are admitted to a hospital, the primary role of physicians is to stabilize them. Therefore, patients receive less front-end interaction with physicians because of situational urgency and straightforward diagnosis. Patients report that they prefer to receive information from their physician instead of a nurse following a heart attack [44], but nurses often

care for patients once they are stabilized and discuss medication and postdischarge instructions [36]. Accordingly, physicians receive higher responses of poor communication.

Finally, patients exhibit signs of dissatisfaction with implementing new or extending current health IT. For instance, increasing EMR documentation capabilities directly reduces patient satisfaction and loyalty. However, the newfound documentation capabilities improve each aspect of communication performance among nurses and physicians, which compensates for the negative direct outcome. In other words, patients express inconvenience by the new capabilities, but the technologies allow for greater efficiency and patient-centered care, resulting in heightened satisfaction and loyalty.

We acknowledge that our research is not without limitations. The use of acute heart attack mortality does not always provide an opportunity for extensive communication between physicians and patients. Therefore, communication performance for physicians may be negatively skewed in an acute setting. However, it is also possible that physician communication has positive bias in a chronic care setting because patients have extensive interactions with physicians over longer periods. The continuity of care for chronic conditions may reduce the effects of increasing health IT functionality because the physician has extensive patient knowledge. Future studies should consider investigating the initial stages of chronic care and health information technology's effects on the development of care.

7. Conclusion

We find that increasing the capability of health IT in hospitals has a positive effect on patient outcomes by improving the communication performance of hospital staff. Our results further the health IT literature by considering how health IT affects patient outcomes through the mediating role of communication. Using panel regression models with fixed effects, we find that increasing capabilities in EMR documentation and HIE have the greatest overall impacts on patient outcomes. The results show that nurses have the largest improvement in communication performance with

increases in health IT adoption. The implications of our findings offer useful insight for future research on health IT and actionable strategies for hospital management.

References

1. Ong, L., J. De Haes, A. M. Hoos, F. B. Lammes. 1995. Doctor-patient communication: A review of the literature. *Social Science and Medicine*, 40 (7), 903-918.
2. Martin, L. R., S. L. Williams, K. B. Haskard, M. R. DiMatteo. 2005. The challenge of patient adherence. *Therapeutics and Clinical Risk Management*, 1 (3), 189-199.
3. O'Hagan, S., E. Manias, C. Elder, J. Pill, R. Woodward-Kron, T. McNamara, G. Webb, G. McColl. 2014 What counts as effective communication in nursing? Evidence from nurse educators' and clinicians' feedback on nurse interactions with simulated patients. *Journal of Advanced Nursing*, 70 (6), 1344– 1355.
4. Liljeroos, M., I. M. Snellman, M. H. Esktedt. 2011. A qualitative study on the role of patient-nurse communication in acute cardiac care. *Journal of Nursing Education and Practice*, 1 (1), 17-24.
5. Shachak, A., S. Reis. 2009. The impact of electronic medical records on patient-doctor communication during consultation: A narrative literature review. *Journal of Evaluation in Clinical Practice*, 15, 641-649.
6. Haughorn, J. 2016. The importance of care management communication: Keisha's story. Available at https://www.healthcatalyst.com/importance-care-management-communication-keishas-story. (Accessed date May 3, 2020).
7. CRICO. 2015. Malpractice risks in communication failures. *2015 CRICO Strategies National CBS Report*. Available at https://www.rmf.harvard.edu/Malpractice-Data/Annual-Benchmark-Reports/Risks-in-Communication-Failures.
8. Vermeir, P., D. Vandijck, S. Degroote, R. Peleman, R. Verhaeghe, E. Mortier, G. Hallaert, S. Van Daele, W. Buylaert, D. Vogelaers. 2015. Communication in healthcare: A narrative review

of the literature and practical recommendations. *International Journal of Clinical Practice*, 69 (11), 1257-1267.

9. Boyle, D. A., W. G. Anderson. 2015. Enhancing the communication skills of critical care nurses: Focus on prognosis and goals of care discussions. *Journal of Clinical Outcomes Management*, 22 (12), 543-549.
10. Angst, C. M., S. Devaraj, J. D'Arcy. 2012. Dual role of IT-assisted communication in patient care: A validated structure-process-outcome framework. *Journal of Management Information Systems*, 29 (2), 257-292.
11. McCullough, J. S., S. T. Parente, R. Town. 2016. Health information technology and patient outcomes: The role of information and labor coordination. *The RAND Journal of Economics*, 47 (1), 207-236.
12. Jetley, G., Zhang, H. 2019. Electronic health records in IS research: Quality issues, essential thresholds and remedial actions. *Decision Support Systems*, 126, 113137.
13. Chaudry, B., J. Wang, S. Wu, M. Maglione, W. Mojica, E. Roth, S. C. Morton, P. G. Shekelle. 2006. Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. *Annals of Internal Medicine*, 144 (10), 742-752.
14. Fichman, R.G., R. Kohli, R. Krishnan. 2011. Editorial overview: The role of information systems in healthcare: Current research and future trends. *Information Systems Research*, 22 (3), 419-428.
15. Pinsonneault, A., S. Addas, C. Qian, V. Dakshinamoorthy, R. 2017. Tamblyn. Integrated health information technology and the quality of patient care: A natural experiment. *Journal of Management Information Systems*, 34 (2), 457-486.
16. Romanow, D., A. Rai, M. Keil. 2018. CPOE-enabled coordination: Appropriation for deep structure use and impacts on patient outcomes. *MIS Quarterly*, 42 (1), 189-212.

17. Crampton, N. H., S. Reis, A. Shachak. 2016. Computers in the clinical encounter: a scoping review and thematic analysis. *Journal of the American Medical Informatics Association*, 23 (3), 654-665.
18. Bao, C., Bardhan, I. R., Sing, H., Meyer, B. A., Kirksey, K. 2020. Patient-Provider Engagement and Its Impact on Health Outcomes: A Longitudinal Study of Patient Portal Use. *MIS Quarterly*, 44 (2), 699-723.
19. Duke, P., R. M. Frankel, S. Reis. 2013. How to integrate the electric health record and patient-centered communication into the medical visit: a skills-based approach. *Teaching and learning in medicine*, 25 (4), 358-365.
20. Shachak, A., M. Hadas-Dayagi, A. Ziv, S. Reis. 2009. Primary care physicians' use of an electronic medical record system: A cognitive task analysis. *Journal of General Internal Medicine*, 24 (3), 341-348.
21. Alsos, O. A., B. Dabelow, A. Faxvaag. 2011. Doctors' concerns of PDAs in the ward round situation: Lessons from a formative simulation study. *Methods Inf. Med*, 50 (2), 190-200.
22. Alsos, O. A., A. Das, D. Svanaes. 2012. Mobile health IT: The effect of user interface and form factor on doctor-patient communication. *Internal Journal of Medicine Informatics*, 81 (1), 12-28.
23. Swinglehurst, D., T. Greenhalgh, C. Roberts. 2012. Computer templates in chronic disease management: ethnographic case study in general practice. *BMJ Open*, 2 (6).
24. Jones, S. S., R. S. Rudin, T. Perry, G. Shekelle. 2014. Health information technology: An updated systematic review with a focus on meaningful use. *Annals of Internal Medicine*, 160, 48-54.
25. Buntin, M. B., M. F. Burke, M. C. Hoaglin, D. Blumenthal. 2011. The benefits of health information technology: A review of the recent literature shows predominantly positive results. *Health Affairs*, 30 (3), 464-471.

26. Venkatesh, V., X. Zhang, T. A. Sykes. 2011. “Doctors do too little technology”: A longitudinal field study of an electronic healthcare system implementation. *Information Systems Research*, 22 (3), 523-546.
27. Bansal, G., Zahedi, F., Gefen, D. 2010. The impact of personal dispositions on information sensitivity, privacy concern and trust in disclosing health information online. *Decision Support Systems*, 49 (2), 138-250.
28. Martin, L. R., M. R. DiMatteo, H. S. Lepper. 2001. Facilitation of patient involvement in care: development and validation of a scale. *Behavioral Medicine*, (27), 111-120.
29. Stewart, M., J. B. Brown, H. Boon, J. Galajda, L. Meredith, M. Sangster. 1999. Evidence on patient-doctor communication. *Cancer prevention & control: CPC= Prevention & controle en cancerologie: PCC*, 3 (1), 25-30.
30. Yang, H., Guo, X., Wu, T. 2015. Exploring the influence of the online physician service delivery process on patient satisfaction. *Decision Support Systems*, 78, 113-121.
31. Sullivan, F., J. C. Wyatt. 2005. How computers help make efficient use of consultations. *British Medical Journal*, 331 (7523), 1010-1012.
32. Johnson, K. B., J. R. Serwint, L. A. Fagan, R. E. Thompson, W. E. Wilson, D. Roter. 2008. Computer-based documentation: Effects on parent-provider communication during pediatric health maintenance encounters. *Pediatrics*, 122 (3), 590-598.
33. Angst, C. M., S. Devaraj, C. C. Queenan, B. Greenwood. 2011. Performance effects related to the sequence of integration of healthcare technologies. *Production and Operations Management*, 20 (3), 319-333.
34. Bardhan, I. R., M. F. Thouin. 2013. Health information technology and its impact on the quality and cost of healthcare delivery. *Decision Support Systems*, 55 (2), 438-449.
35. Hendrich, A., M. Chow, B. A. Skierczynski, Z. Lu. 2008. A 36-hospital time and motion study: How do medical-surgical nurses spend their time?. *Permanente Journal*, 12 (3), 25-34.

36. Propp, K.M., J. Apker, W. S. Zabava Ford, N. Wallace, M. Serbenski, N. Hofmeister. 2010. Meeting the complex needs of the health care team: identification of nurse-team communication practices perceived to enhance patient outcomes. *Qualitative Health Research*, 20 (1), 15-28.
37. Asan, O., P. D. Smith, E. Montague. 2014. More screen time, less face time – implications for EHR design. *Journal of Evaluation in Clinical Practice*, 20 (6), 896-901.
38. Sullivan, F., J. C. Wyatt. 2005. How computers can help to share understanding with patients. *British Medical Journal*, 331 (7521), 892-894.
39. Gardner, J. 2021. Two-Stage Differences-in-Differences. Technical report, http://fmwww.bc.edu/RePEc/bocode/g/Gardner_2sdd.pdf.
40. Barbayannis, G., I. Chiu, D. Sargsyan, J. Cabrera, T. E. Beavers, J. B. Kostis, N. M. Cosgrove, N. E. Michel, W. J. Kostis. 2019. Relation between statewide hospital performance reports on myocardial infarction and cardiovascular outcomes. *American Journal of Cardiology*, 123 (10), 1587-1594.
41. Oh, J., Z. Zheng, I. R. Bardhan. 2018. Sooner or later? Health information technology, length of stay, and readmission risk. *Production and Operations Management*, 27 (11), 2038-2053.
42. Kossman, S. P., S. L. Scheidenhelm. 2008. Nurses' perceptions of the impact of electronic health records on work and patient outcomes. *Computers, Informatics, Nursing*, 26 (2), 69-77.
43. Kossman, S. P., L. A. Bonney, M. J. Kim. 2013. Electronic health record tools' support of nurses' clinical judgment and team communication. *Computers, Informatics, Nursing*, 31 (11), 539-544.
44. Astin, F., S. J. Closs, J. McLenachan, S. Hunter, C. Priestley. 2008. The information needs of patients treated with primary angioplasty for heart attack: An exploratory study. *Patient Education and Counseling*, 73, 325-332.