Dual Role of IT-Assisted Communication in Patient Care: A Validated Structure-Process-Outcome Framework

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ABSTRACT: Despite the fact that about 90 percent of information transactions in hospitals are communications between patients, doctors, nurses, and other staff, little research has addressed the role that information technology (IT) plays in improving the efficiency and effectiveness of these communications-based transactions. Addressing this research gap is important considering that a substantial number of adverse hospital events stem from communication failures. Furthermore, effective communication is a major driver of patient satisfaction in hospitals. Using a structure-process-outcome (SPO) framework and guided by the strategic role of IT literature, we develop a model that includes "structure," operationalized as organizational characteristics and two different categories of IT; "process," two different communication-based processes; and "outcomes," quantified as case-mix adjusted mortality, patient loyalty, and patient

Journal of Management Information Systems / Fall 2012, Vol. 29, No. 2, pp. 257–292.

ISSN 0742–1222 (print) / ISSN 1557–928X (online)
DOI: 10.2753/MIS0742-1222290209

ratings. Specifically, we hypothesize that a subset of clinical IT (cardiology IT) will affect technical protocols of patient care, which in turn affects mortality, while administrative IT will affect interpersonal patient care, which relates to patient loyalty and ratings. Thus, IT can serve as a double-edged sword affecting both technical and interpersonal processes of care, but possibly independently and differentially. We test our hypotheses on 2,179 hospitals using data collected and matched from three different sources. Our findings suggest that different types of IT differentially affect hospital processes and these same processes influence performance metrics such as mortality and patient satisfaction. For example, cardiology IT has a greater effect on objective patient health status through improvements in the technical protocols of care. Surprisingly, administrative IT was shown to adversely affect interpersonal care processes. It could be true that the IT is intrusive and interferes in the doctor–patient relationship; however, a post hoc analysis suggests the possibility of curvilinear impacts. Thus, managers should recognize that over- and underinvestment in IT can potentially have negative effects on performance and these results vary by IT type. Both technical and interpersonal processes yielded significant relationships to their respective outcomes and some cross-outcome effects were found, further suggesting that the mediating role of processes is an important link between IT and value.

Key words and phrases: business value of IT, health information technology, operational IT, strategic IT, structure-process-outcome.

> If information is the lifeblood of healthcare, then communication is the heart that pumps it.
>
> —Toussaint and Coiera [103, p. 779]

The majority of information transactions within a hospital are communications between patients, doctors, nurses, and the staff [30], yet little research has addressed the role that information technology (IT) can play in improving the efficiency and effectiveness of these communication-based transactions and the processes that must incorporate them. Gaining a better understanding of the potential of IT to improve communication in hospitals is important because many adverse hospital events, such as medical errors, patients missed on rounds, and incorrect patient documentation, have been linked to communication failures [93, 110]. Communication transactions take many forms in hospitals, ranging from complex directives given by clinicians orchestrating what procedures to undertake in emergency situations, to simple patient requests for medication or creature comforts, to interactions between clinicians and automated decision support systems. Beyond the internally focused aspects of communication within hospitals, patients and their families are also key informants when it comes to spreading information about the quality of care they receive during an in-patient stay. So while hospital executives have to consider the effect that IT has on employees with respect to providing communication tools to increase productivity, efficiency, and quality, they also must consider the impact of these tools on patients, which will potentially be very different. For example, the use of a computer in an exam room may offer doctors a more efficient means of documentation but could be viewed by patients as highly intrusive to the doctor–patient relationship [75, 92].

It is our contention that the intent of the adopter or context under which the IT was adopted determines what "success" really is. Although hospital administrators are surely interested in curtailing costs while growing revenues, their primary interest is in providing the best patient care possible with the resources they have [77]. With respect to the acquisition of IT, our paper builds on the premise that while financial viability is a key attribute of performance for hospitals, an even more important criterion for decision makers is how IT affects quality of patient care. Thus, the intent of IT adoption for decision makers is to successfully provide excellent quality relative to the context and objectives.

In this paper, we investigate the link between IT, processes, and context-specific value. As noted, we examine the role that IT plays in a communication process in a collaborative work environment through multiple pathways and test the impact these processes have on important outcomes such as mortality and patient loyalty and ratings. As others have suggested [114], hospitals are settings for shared cognition that involve the coordination between individuals, artifacts, and the environment. A characteristic of shared cognition settings is that cognitive processes are distributed across the members of a social group [59]. In hospitals, many work activities are distributed across individuals and their environment and carried out jointly by people with their tools. We view IT as a tool that facilitates shared cognition for these collaborative activities by improving communication processes. In particular, using the structure-process-outcome (SPO) framework [38] and guided by the literature in the strategic IT domain [115], we develop a model that includes organizational characteristics, different categories of IT, two different communication-based processes, and several outcomes. Several challenges remain with respect to linking IT to value in the health-care sector, yet the importance of resolving this link cannot be overstated. In most IT-value studies, the left side of this model consists of variables that in some way represent "IT"—whether it be a count, investment, utilization, or another quantity-based measure. On the right side, researchers typically employ an outcome measure (or a set of outcomes) that is theorized to co-vary with the variables on the left-hand side. The challenging part for researchers is deciding which variables (and their operationalizations) are the most representative of reality [64]. The dependent variables in health care are particularly troublesome because many believe that "outcomes" are too far removed from the structure and operation of the organization to be linked or actionable. For example, while it would be beneficial for society if a direct statistical link between IT adoption and mortality existed, the reality is that this relationship is highly complex, and it is difficult to account for all the person- and environmental-level variables that affect mortality. So what can be done to overcome this limitation in the right-hand side of the model? One suggestion originates from the seminal work of Avedis Donabedian, dating back to the 1960s. His work attempts to resolve the debate surrounding the question, "What is 'quality' in medical care?" He insightfully notes that quality is one of the key objectives in hospitals, irrespective of whether it is conceptualized as a process or an outcome. He then introduces a model that incorporates elements of both. In this paper, we draw from Donabedian's [38] model for evaluating quality using a process and outcome framework and extend beyond his model by positioning this within the context of a communication-based environment.

While studies of business value and IT use abound, extant research examining the influence of IT on processes *and* processes on outcomes is limited. From a theoretical perspective, our work extends the IT-value literature by incorporating intermediate communication-based, process-related steps that might offer insight into the link between IT and outcomes. More specific to the health-care domain, we investigate the differential effects resulting from adoption of administrative and clinical IT (specifically, cardiology IT) in the communication-based hospital environment. In doing so, we examine the important intermediary role of processes of care.

The findings from this study hold important practical implications for health-care management. Investigation of the business value of IT in the health-care industry is sparse and business leaders are increasingly being called upon to demonstrate return on investment. At the same time, there is tremendous pressure from external entities to implement more IT as a means of improving care and reducing cost. Results from this study can be used to more fully elaborate the important mechanisms for achieving superior hospital performance.

In subsequent sections of this paper we draw from the SPO framework to examine the IT-value question in health care, specifically at the hospital level of analysis but focusing on the role that the highly consequential cardiology department plays in affecting communication-based processes, which in turn affect hospital outcomes. We chose to focus on cardiology because:

- heart failure is the most common noncancer primary admission diagnosis and the number one discharge diagnosis [25];
- heart failure is the primary reason for 6.5 million hospital visits each year, and more Medicare dollars are spent for the diagnosis and treatment of heart disease than for any other diagnosis (www.cardiosmart.org) [25];
- research indicates that a sizable percentage of hospital malpractice claims involve cardiac or chest pain issues [23, 110];
- and finally, from a practical standpoint, we chose cardiology because of the availability of data on protocol measures.

As a result, cardio-related care presumably has a strong influence on patients' overall perceptions of hospitals. In the next section, we present a brief review of relevant literature and discuss in greater detail the SPO framework and how it applies to our work. This is followed by a theoretical and conceptual discussion of what constitutes health IT. Next, we combine our interpretation of IT into the SPO framework, develop hypotheses, and test a model incorporating a broad set of organizational characteristics and processes and outcomes related to the delivery of patient care. We conclude with a discussion of implications for practice and theory.

Literature Review

The business value of IT literature is replete with examples describing relationships between IT and various types of value and suggestions as to what to control, how to measure, and when to measure [5, 32, 33, 54, 55]. What seems apparent from this stream of research is that "context" matters. Yet, as researchers, we do not often delve into key contextual questions such as "Why does a hospital adopt information technology?" Is it out of competitive necessity, mimetic behavior, or the belief that there is value associated with the use of IT? Or is it simply the federal and state mandates that drive adoption? These and other explanations have been used to explain why firms, in general, adopt IT; but as we noted earlier, the intent of the adopter or context under which the IT was adopted determines what "success" really is. Our paper builds on the premise that financial viability is a key attribute of performance for hospitals but an even more important criterion for decision makers is how IT affects quality of patient care—but what is *quality* patient care?

Structure-Process-Outcome Framework

In the health-care context, Donabedian defines quality as "a reflection of values and goals current in the medical care system and in the larger society of which it is part" [35, p. 167]. He follows up by noting that more than 80 criteria have been provided to assess quality in patient care [64], concluding that it is likely not a unitary concept [35, 79]. Instead, Donabedian argues for a broader framework within which to evaluate quality that includes elements of structure, process, and related outcomes. In his assessment, structure should facilitate the actual care delivered, which manifests in outcomes that are the result of the processes employed [26, 38]. In 1980, Donabedian wrote that *high-quality* care was "that kind of care which is expected to maximize an inclusive measure of patient welfare, after one has taken account of the balance of expected gains and losses that attend the process of care in all its parts" [36, p. 6]. More recently, the Institute of Medicine (IOM) published its own definition of quality, which resulted from a literature review of more than 100 previously used definitions of quality. Widely regarded as the most exhaustive evaluation of quality, the IOMs definition is "[t]he degree to which health services for individuals or populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" [73, p. 21]. What is apparent in these characterizations, either implicitly or explicitly, is the inclusion of structure, process, and outcomes in the assessment of quality.

The above framework is consistent with the structure-conduct-outcome (SCO) framework [46] in the marketing and sociology literature. In organizational contexts, the SCO framework posits a sequence from structure to conduct to outcome. Structure refers to patterned or regularized aspects of relationships, conduct refers to patterns of behavior, and outcome refers to the results of relationships in the firm [46]. Thus, both the SPO and the SCO frameworks provide guiding frameworks to support the flow of logic from structure to process to outcomes.

Structure

Structure, in this instance, is defined as the setting in which the processes and outcomes under consideration are occurring [37]. Prior literature suggests that structure should assess things such as the adequacy of facilities and equipment, the qualifications of the medical staff and the hospital, management structure, and financials [26, 38]. From a health IT perspective, implicit in this definition is that structure can include administrative and clinical technologies that support the administering of patient care. In this vein, and consistent with descriptions of IT in the health-care literature [83], we focus specifically on administrative and clinical IT in this study. However, as discussed in detail later, we incorporate a wide array of other organizational structural characteristics in an attempt to isolate the effect of IT.

Clinical IT is used to capture, store, and acquire notes, records, and test results by cross-referencing the patient's name and unique identifier with their personal medical information. Clinical IT also can provide order entry and decision support [2]. The term "clinical IT" is often used interchangeably with the more recent term, "health information technology" or HIT [2]. As we discuss in greater detail below, we focus on a subset of clinical IT that includes cardiology IT. While clinical or health IT is synonymous with the health-care industry, administrative IT that is used in hospitals is not dramatically different from administrative IT used within any firm. For example, management reporting systems, transaction processing systems, administration and registration systems are all included under the umbrella of administrative IT. The differentiating factor between administrative and clinical IT is primarily based on how the data are used by end users. This background information is important because in the next section of this paper, we argue that hospitals adopt administrative and clinical ITs for specific reasons that affect processes and outcomes differently.

Process

Processes in health care are defined by the actual delivery and receipt of care [26]. Processes can be any number of things but often tend to focus on reliability, technical competence, coordination and continuity of care, and responsiveness to needs [28, 38, 86]. They often involve both technical protocols of care and interpersonal care [16]. Technical protocols, sometimes referred to as simply "clinical care," refer to the application of efficacy-based standards of care. When the clinician makes the appropriate decision about care and skillfully executes the plan [17], this constitutes high technical quality and has been described as "Doing the right thing right" [16, p. 892]. In contrast, interpersonal care has been viewed as social and psychological interactions between the patient and care provider and has been operationalized as communication [16], understanding and empathy [16], and responsiveness [27]. Not surprisingly, some health-care providers have argued that technical protocols of care are more reliable measures of performance because patient assessments of interpersonal care do not account for whether the patient has the necessary domain knowledge to assess technical quality [16].

Outcome

The question of "what" to assess is (or should be) highly dependent on the process measures. For example, if quality programs are implemented in the emergency room, one should consider metrics that assess the outcome of emergency room visits. Typical outcomes in hospital care are mortality, recovery, and restoration of function [38]. The certainty of these measures makes them attractive to researchers, yet the appropriateness of these metrics has been questioned because even under ideal conditions, when state-of-the-art evidence-based medicine is employed, results may not be entirely consistent [26, 38].

A second set of outcomes can be described as patient perceptions of care. While these may or may not be correlated with health outcomes (for a meta-analytical review, see [97]), in terms of the objectives to which a hospital ascribes, they are certainly important measures of performance. As noted earlier, patient loyalty and overall ratings are key performance indicators for hospital administrators.

Conceptual Model and Hypotheses

Not unlike other service organizations, hospitals seek to balance the demands of multiple stakeholders. For example, there is timely feedback from patients regarding their perceptions of care related to interpersonal interactions that are noted in patient ratings and measures of loyalty. Yet hospitals are also measured on their technical protocols of care, which we argue manifest in objective outcomes such as mortality. In both situations, prior literature suggests that IT plays a role in influencing these process-related variables through communication (both verbal and nonverbal) enhancements. In fact, one could argue that during the entirety of a hospital stay, patients are being presented with messages about the quality of care they are receiving in the form of overt and discreet communication cues from their doctors, nurses, staff, and others [87, 88]. In Figure 1, we suggest parallel, yet interacting, routes of IT influence. We do not hypothesize a direct link from IT adoption to outcomes but, instead, suggest that this relationship is mediated by processes of care.

Prior research suggests that *structure* includes not only IT but also various elements of other organizational characteristics [26, 38]. Because the focus of our study is on the role that IT plays in processes and outcomes, we have chosen to control for these factors but not to specifically hypothesize for these effects. We discuss this in greater detail in the Methods section.

Structure and Its Relationship to Process—The Role of IT

It has been suggested that IT can provide both strategic benefits and operational efficiencies and that more successful firms will find a balance between strategic and operational IT [82]. Some have suggested that there is a duality to technology such that it can be used to replace human labor, thus functioning in an operational capacity. IT can also serve a strategic role by generating information about the process and

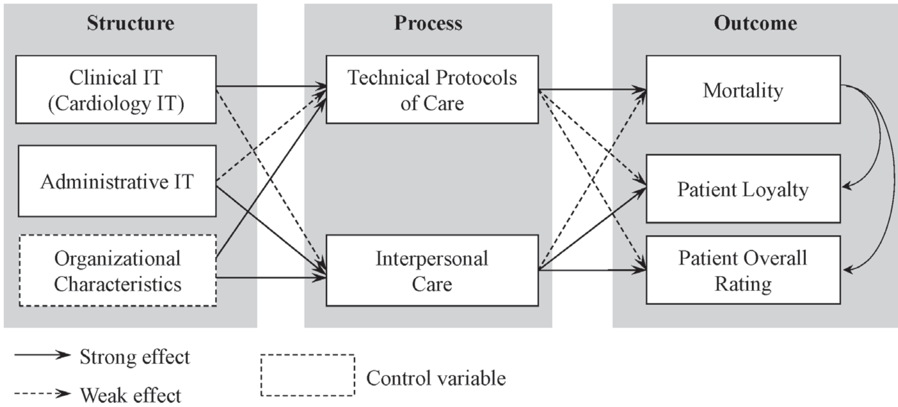

Figure 1. Conceptual Model of SPO in a Communication-Based Context

potentially feeding data into other systems or providing information to individuals across the organization [7, 31, 94, 115]. Both administrative and clinical IT can be operationally or strategically focused.

Dating back to the 1960s, the view has consistently been that IT for operational functions is lower risk and is often related to cost control and that strategic IT is a key driver of value generation [7, 15, 115]. Thus, to the extent that more process functions are strategic, prior research suggests that greater performance should result. Examining the technologies that make up administrative IT (see Appendix A), it is apparent that these IT systems are more mature and are much lower-risk acquisitions [83]. Further, the administrative ITs more closely represent the transformation of human labor into technology-assisted functions. The clinical IT, however, are far more complex, involving technologies that are known to create workflow disruptions [1, 43, 48, 106, 107] and which are more closely tied to performance gains or losses, yet these relationships still are not well understood [8, 12, 53, 65]. Because prior literature argues that studies should examine the relationship between IT and associated processes, we use a subset of clinical IT—cardiology IT (see Appendix A). Because administrative IT spans a wide variety of departments and includes hospital-wide systems, it is not possible to isolate only those administrative IT that relate to the cardiology function, therefore all administrative IT in the hospital are counted.

As noted earlier, we posit a direct relationship between IT and process. More specifically, we propose that the previously described types of IT contribute differentially to process gains. The processes, in this case, are essentially communication-based services that are being offered by clinicians to patients. How well or effectively the clinicians and staff provide this service is an assessment of service quality [93]. Prior research [88] suggests that IT can play a significant role in affecting the marketing and perceptions of these services and that there are two types of marketing-related processes—internal and interactive—that take place during a patient's stay at a hospital [87]. *Internal* marketing involves the hospital's administration viewing its clinicians and staff as its customers and thus offering a suite of tools and support structure that provide them with what they need to provide external support to patients [66, 87]. *Interactive* marketing takes place during the clinician–patient interaction during which time the patient (consumer) is evaluating how he or she is being treated. The role that IT plays in this relationship is one of facilitation or opening new channels, and to the extent that these linkages can be managed effectively, the marketing of services will improve [88]. Yet the specific mechanisms through which these advantages manifest is currently unknown. For example, extending a vignette from Parasuraman and Grewal [88] to the health-care context, the IT–clinician interactions may affect perceptions of care such that some patients may believe that because a clinician is using state-of-the-art computing technology it is a signal of high-quality care, while others may view the technology as intrusive and disruptive to care. We draw from the perspective suggesting that the processes, technical and interpersonal, are akin to internal and interactive marketing efforts, respectively, both of which are communication-based transactions that are aided by IT and craft our study in a way to capture the unique contributions of different suites of IT.

Administrative IT and Interpersonal Care

Earlier, we established that while both administrative and clinical IT provide operational and strategic functions, in the hospital context, administrative IT is more directed toward operational than strategic. Because operational IT is known to eliminate or reduce wasted effort by using technology in place of human effort [14, 76, 89], it follows that care providers should have more time for value-added activities such as explaining diagnoses, listening and responding to patient concerns, and answering questions about treatment options, thus increasing the richness of the interpersonal interaction while marketing the service level of the clinical staff and the hospital [56]. The health IT literature supports this reasoning. For example, prior research investigated the efficacy of an electronic scheduling and sign-out system for nurses that automated several administrative tasks [104]; nurses that were randomly assigned the tool reported significant efficiencies, including a 40 percent increase in preround time available to see and talk to patients, a 50 percent reduction in time spent copying data, and their own improved perceptions of patient care. In other studies (for a review, see [93]), the introduction of administrative IT solutions such as automated sign-out sheets and electronic document templates was associated with improved communication and continuity of care during hospitalist handoffs (i.e., the transfer of patient care from one physician or nurse to another during shift change).

Research on decision making further suggests that operational IT can help improve information communication and team decision making [113]. To the extent that this can afford clinicians with opportunities to deliver more personalized care, it should manifest in improved interpersonal care. The Hospital Consumer Assessments of Healthcare Providers and Systems (HCAHPS) surveys are the de facto standard for assessing various aspects of the clinician (and/or staff)–patient interaction. Because a hospital's aggregate report is available to anyone who wishes to examine it, consumers can easily compare hospitals on various indicators. Prior research suggests that most complaints from patients are related not to the "technical" provision of care, but instead to the functions for which administrative IT offers benefits [99]. For example, communication issues such as poor explanation of test results, help requested and not received, and wait-time are known to negatively affect interpersonal care [99, 102]. To the extent that more digitization of administrative tasks is undertaken, we believe communication of care will improve. At the same time, we acknowledge the counterargument that administrative IT may actually *increase* the administrative burden on clinicians and thus divert attention away from the patient. For example, the move from a paper-based to electronic patient admissions database may force clinicians to enter data into a computer while talking to patients, thus reducing the "deepness" of clinician–patient interaction. That being said, we contend that if you consider the gamut of all the different kinds of administrative IT that are used in hospitals, of which patient admissions databases are only one kind, then by and large having access to administrative IT will save the clinician time and potentially improve his or her decision making [106]. In cases where the clinician is not interacting with the administrative IT directly, we submit that any administrative task that takes burden off clinicians is in fact benefiting the clinician and has the potential to increase bedside interpersonal care. This leads to the following hypothesis:

> *Hypothesis 1: Adoption of administrative IT is positively associated with improved interpersonal care.*

Clinical IT and Technical Protocols of Care

Hospitals must satisfy not only their patients but also their staff, clinicians, and government agencies. With reporting requirements recently becoming mandated, hospitals cannot be successful unless clinicians and staff are provided the hardware and software to systematically report their data [112]. Furthermore, because hospitals are required to report the frequency with which they adhere to specific protocols—and these are standardized across all hospitals—in a sense the administration is marketing its quality publicly, whether they are pleased with the results or not.

Clinical IT provides a means for digitizing some elements of patient care, and it is typically designed with the goal of facilitating the reporting process [71]. Clinical IT also provides functions such as alerts and reminders for things such as drug interactions. Clinical IT also has workflow templates that can be customized to prompt clinicians to follow predetermined procedures and the data in clinical IT are structured in useful ways to enable clinicians to quickly view flowsheets that are chronologically ordered by the time and date of treatment or occurrence. Clinical IT systems such as electronic medical records (EMR) and computerized physician order entry (CPOE) reduce opportunities for miscommunication between clinicians and staff and are a conduit for process improvements in clinical care [100]. To this end, research has linked physicians' use of clinical IT to improved treatment, better access to patient medical records, and reduced medication errors [53, 78]. Although we acknowledge that clinical IT has potential drawbacks (e.g., physician learning curves, workflow disruptions [9]), the bulk of empirical evidence points to the benefits of clinical IT, especially in terms of improved process quality [78]. Thus, we argue that the adoption of more clinical IT will result in positive changes to technical processes of care, which are metrics that assess the frequency with which "best practice" routines are conducted. We test this hypothesis in the context of the cardiology department, which is a specific process within the hospital, therefore,

Hypothesis 2: Adoption of cardiology IT is positively associated with compliance with technical protocol processes.

Cross-Process Links

Tangential benefits may result such that the adoption of one form of IT may be related to nonhypothesized process improvements. We have represented these paths as dotted lines in Figure 1 and suggest that these relationships will be weaker than those posited earlier. The justification for this is twofold. First, prior literature notes the trade-offs and competing objectives of strategic and operational IT, which should result in differential effects on processes [76, 98]. Second, anecdotal evidence and some empirical research suggest that clinical IT should affect technical processes more directly and interpersonal processes less directly [2, 57]. The reasoning behind this statement is that clinical IT should improve delivery of care through better decision support and error reduction. Yet one recent study conducted in an outpatient setting suggests that examination room computers had positive effects on physician–patient interactions related to medical communication; however, no measures of delivery of care were assessed [56], thus a relative strength of relationship could not be determined.

Processes and Their Relationship to Outcomes

Campbell and colleagues [26] note that the effectiveness of processes in the health-care domain result in two distinct outcomes—health status and user evaluations of care. Two important sets of measures have been used in prior literature to capture process of care constructs, albeit not simultaneously as we have. The "technical" portion of the process construct originated in July 2002 with the Joint Commission on Accreditation of Healthcare Organizations' (JCAHO) issuance of standardized performance measures. We discuss these in greater detail below, but briefly the intent of these metrics is to improve the quality of health care by tracking and monitoring key indicators of performance that have been established as best practices. Moreover, the reporting of these metrics is required for hospital accreditation, thus there is almost universal compliance to provide this information annually [112].

The second process we label "interpersonal care," and it is often assessed using the HCAHPS instrument. The HCAHPS data, captured through surveys of recently discharged patients, is intended to offer patients and providers a means of comparing quality between hospitals [86]. The survey, which has been validated in prior literature (e.g., [70]) assesses doctors, nurses, and other staff members on key indicators of patient-centered interpersonal care such as respect for preferences, communication and information, and physical comfort [47].

Interpersonal Care Process and Its Relationship to Patient Loyalty and Overall Rating

Somewhat surprisingly, cost and quality competition among hospitals is quite high, especially in more concentrated urban regions [44, 45]. Whether in response to competitors' transparency or as a means of assessing and improving internal performance, most hospitals have chosen to participate in industry standard surveys that measure interpersonal care. Irrespective of the industry, the goal of these types of processes is to improve consumer satisfaction and ultimately create a loyal base of customers [49, 88]. It is well documented that breakdowns in communication between clinicians and patients result in process failures and ultimately dissatisfied customers. For example, in 26 percent to 31 percent of malpractice cases, communication problems were listed as contributing factors [13, 110]. We expect a positive linear relationship between the interpersonal care process and patient loyalty and overall hospital ratings and test the following:

> *Hypothesis 3: Interpersonal care process is positively related to patient loyalty.*
>
> *Hypothesis 4: Interpersonal care process is positively related to patient overall rating.*

Technical Protocols of Care and the Relationship to Mortality

A significant body of research suggests that process improvement activities lead to improved performance [58, 62, 81]. Extrapolating from this literature, we argue that the technical protocols construct is essentially a set of process improvement activities that standardize and operationalize what are thought to be best practices. Research investigating the link between process measures and objective outcomes, such as short-term mortality, has been conducted; however, the majority of these studies have examined the direct relationship between single procedural measures (e.g., prescribed an angiotensin receptor blocker at discharge) and mortality, often with mixed results [20, 42, 112]. We take a more holistic approach to the technical process measures and suggest that while individual procedures may be weakly or not significantly correlated with objective outcomes as noted in prior studies, taken as a whole, these measures represent an overall procedural indicator of process quality. Recall that these process measures are meant to change the behavior of clinicians [26] and while some individuals may perform specific procedures less frequently than prescribed, across a broader sample of clinicians it should be the case that an aggregate measure would level the extremes. Therefore, we combine several cardiac-related process measures and hypothesize that these together will be related to mortality such that the mortality rate will drop with improved compliance with technical protocols of care, therefore, *Hypothesis 5: Compliance with technical protocols of care is negatively related to mortality rate.*

Cross-Outcome Links

Scholars continue to debate whether objective or subjective outcome metrics are more appropriate reflections of the process of care received. Again, we note that cross-outcome effects may exist such that technical protocols lead to improved loyalty and ratings or that interpersonal care translate into improved health status. We have not hypothesized these relationships but do include them within the model as dotted lines in Figure 1 and we report these results.

Methods

Sample

The data from the sample of hospitals included in this study come from three sources. First, data on the adoption of IT, both clinical (and the subset cardiology IT) and administrative, come from a nationwide, annual survey of hospitals in the United States conducted by HIMSS Analytics℠ (derived from the Dorenfest IHDS+ Database™). The HIMSS Analytics data include information on the types of information systems (IS) used by hospitals, the year in which the systems were deployed, and the vendor who developed the system. Second, measures of process of care as well as cardiology-related case-mix index adjusted (i.e., how complicated the cases are) mortality rates were obtained from Hospital Compare, which is a program that is sponsored by the Centers for Medicare and Medicaid Services (CMS). Finally, we obtained data on communication effectiveness between the patient and nurses/doctors/staff, loyalty, and overall hospital rating data from the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey, also available from CMS. We matched the data across sources using the hospital's Medicare ID as a key. Our final sample included 2,179 observations, which is more than 40 percent of the total population of hospitals in the United States. Hospitals were eliminated if data were not available from all three sources. We conducted a sample-bias test in an attempt to confirm that our 2,179 observations were representative of the national population of U.S. hospitals and found no statistically significant differences.

Measures Used in the Study

There were three categories of measures used in the study: *structure,* which is conceptualized as organizational structure and IT infrastructure (variable names are $ITAdm_{t-2}$ and $ITCard_{t-2}$); *process,* which is conceptualized as interpersonal care and technical protocols of care (IP_Care_t and TP_Care_t, respectively); and *outcome,* which is conceptualized as CMI-adjusted mortality, patient loyalty, and hospital overall rating as perceived by the patient ($Mort_t$, $Loyal_t$, and $Rating_t$). We lagged the IT variables

($ITAdm_{t-2}$ and $ITCard_{t-2}$) by two years to account for the learning curve associated with the use of IT in organizations (we also tested a one-year lag and results were largely unchanged). This approach is supported in the business value of IT literature [24]. Interpersonal care is quantified as communication of clinicians and staff with patients. We chose to focus on one department within a hospital (cardiology) and its related performance metrics as a means of isolating the effect of application-specific IT, that is, those technologies that are used directly in the treatment of cardiology patients, such as cardiology IT and radiology IT.

Structure Measures—Cardiology and Administrative IT Adoption and Organizational Structure

Following extant literature on the categorization of IT in health care [4, 80, 83], we first classify the range of technologies used as administrative and clinical. In order to categorize the technologies in the HIMSS Analytics database, we reviewed each description provided and coded the technologies appropriately (see Appendix Table A1). In addition, we sought the opinion of two chief information officers of major hospitals and the senior IT executive at a regional health information exchange. The results of an interrater reliability analysis of the data from these experts yielded an overall percentage agreement of 93.5 percent and a Cohen's kappa of 0.87. This exercise provided further face validity to our categorization of technologies.

Given that we identified process and outcome measures for the functional area of cardiology, we focus on technologies associated with cardiology. This operationalization is in line with recent calls in research to observe IT effects at the process or functional level and to account for lagged effects to enhance the opportunity to observe the true impact of IT [91, 101]. Because IT is typically used for specific functions within distinct departments, performance at the departmental level is likely to be more representative of reality [6, 11]. The HIMSS Analytics database lists the IT application name, category representing the type of application, whether it is live and operational, and the date of implementation if it has been adopted. A tally of the number of technologies that have been adopted by the hospital within each of these categories represents our measure of IT adoption.

Conceivably, hospital performance may be affected by factors other than IT such as a wide array of organizational characteristics including the age of the hospital, number of beds, not-for-profit or for-profit status, type of geographic region serviced, net operating expense, number of hospitals in the health-care system [69], type of ownership [109], and IS strategy type. Firm size is typically considered an important variable in studies of organizational effects of technology [50, 63, 68]. Because it is possible that larger hospitals might have systematically better performance as a result of the resources available to them [41], we use a control variable for hospital size—the number of staffed beds in the hospital. Research in the not-for-profit space has examined if there are differences in performance levels of not-for-profit vis-à-vis for profits [19]. Because of the inherently different objectives in the management of not-for-profit versus for-profit hospitals, we include profit status and employ a 0–1 indicator variable to capture the not-for-profit/for-profit status of hospitals.

Age of the hospital (in years) can be an important variable for several reasons. Newer hospitals might be technologically more advanced and preferred by a segment of patient population. By contrast, older hospitals might be more established and have a more loyal customer base, which proxies for the maturity of the hospital. For these reasons, we include the age of the hospital in our estimation models. Finally, we include the number of hospitals in the health system as a proxy for social influences, RUCA (rural urban commuting area) to account for geographic and regional characteristics, operating expense as a proxy for resource constraints, and type of ownership and IS strategy to control for management control and strategic mind-set, respectively (see Table 1). We aggregate these individual measures into a more complex latent "formative" construct that we call *Organizational Structure.* We do this for purposes of succinctness and modeling clarity because our intent is to isolate the influences of the role of IT beyond these organizational structural characteristics.

Latent constructs have traditionally been viewed as reflective in nature, suggesting that each of the measures are "caused" by the underlying latent construct. In a formative construct, each of the measures (or indicators) contributes uniquely to the formation of a single underlying construct [74]. What this means in practical terms is that the indicators are likely to be completely uncorrelated, but at the same time predictive of the same construct. In our case, there is no reason to believe that any of the characteristics listed in Table 1 should be related, yet each individually describes the organization and collectively we believe they *fully* describe the organization. This is important because one of the criteria for creating a formative construct is the recognition that removal of one of the indicators could result in an incomplete specification [10, 60]. Finally, the sign of the indicator itself is irrelevant to the validity of the formative construct as long as each indicator is a meaningful predictor [18, 85]. In Table 1, we provide summary statistics and specify the "content" [34] of the formative construct—Organizational Structure—as the maturity, size, business strategy, market served, resource constraints, social influence, management control, and strategic mind-set specifically related to process performance.

Process Measures—Technical Protocols of Care and Interpersonal Care

Using the HospitalCompare quality measures, we calculated an overall cardiology quality measure. We initially focused on the ten indicators that made up the original "starter set" [108] because these have been shown to be good indicators for outcomes such as mortality rates [61]. In addition, the original ten indicators are reported more consistently because of the strong financial incentive provided, thus there is more complete information. Of the ten measures, we chose only those related to cardiac care, which resulted in five indicators and all loaded on the same factor (see Table 2, Panel A). These measures assess whether specific cardio-related activities are carried out and the frequency with which they occur. For example, an aspirin is to be

Table 1. Measures of Organizational Structure and Descriptions

Indicator	Description	Proxy for	Path coefficient to formative construct[a]
Age	Number of years the hospital has been operating	Maturity of hospital	0.328***
Beds	Number of staffed beds	Size of hospital	0.450***
NFP	Not-for-profit status 0 = Not-for-profit 1 = For profit	Business strategy orientation	0.290**
RUCA (rural urban commuting area)	Zip code-based 1–7 scale 1 = Urban core 2 = Other urban 3 = Large rural core 4 = Other large rural 5 = Small rural core 6 = Other small rural 7 = Isolated rural	Market served	–0.563***
NETOPEXP	Natural log of net operating expense	Resource constraints	0.123*
HOSPINSY	Number of hospitals in the health system	Social influence	0.357***
OWNCODE	Ownership 1 = Owned 2 = Managed 3 = Leased	Management control	0.052[b]
STRATEGY	IS strategy being pursued 1 = No strategy given 2 = Focused on self-developed technology 3 = Migrating toward a single vendor 4 = Migrating toward best of breed approach throughout organization 5 = Migrating toward best of suite/cluster throughout the organization	Strategic mind-set	0.048[b]

Notes: [a] Weights (paths) should be greater than 0.1 [72] or 0.2 [29] and significant at the 0.05 level at a minimum. In addition, bivariate correlations should be significantly less than 1.0 [40] and indicator collinearity should be low. Our analysis yielded no correlations greater than 0.45 and the maximum variance inflation factor (VIF) was 1.47, significantly below the threshold of 10. [b] Even though these values are lower than the recommended cutoff [29, 72], we chose to include them as indicators of the formative construct because they provide information that the other indicators do not and thus help to isolate the effects of IT in our study. Furthermore, the relationship between the formative construct and the process variables does not change substantively if OWNCODE and STRATEGY are included. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table 2. Factor Analysis Process Measures

Variable	Factor*	Cronbach's α if item deleted
Panel A: Technical protocols of care items		
Heart attack patients given aspirin at arrival	0.783	0.663
Heart attack patients given aspirin at discharge	0.806	0.629
Heart attack patients given beta blocker at arrival	0.756	0.646
Heart attack patients given beta blocker at discharge	0.821	0.624
Heart attack patients given ACE inhibitor or ARB for LVSD	0.544	0.810
Overall reliability measure Cronbach's α = 0.714		
Panel B: Interpersonal care items		
Doctors sometimes or never communicated well	0.836	0.915
No, staff did not give patients this information	0.752	0.913
Nurses sometimes or never communicated well	0.937	0.902
Pain was sometimes or never well controlled	0.897	0.905
Patients sometimes or never received help as soon as they wanted	0.929	0.894
Room was sometimes or never clean	0.762	0.911
Sometimes or never quiet at night	0.671	0.924
Staff sometimes or never explained	0.900	0.897
Overall reliability measure Cronbach's α = 0.919		

Notes: ACE = angiotensin-converting enzyme; ARB = angiotensin II receptor blockers; LVSD = left ventricular systolic dysfunction. * Results shown are for a single factor analysis with all the items included. Factor loading is the correlation between an observed variable and an underlying factor. Values greater than 0.4 indicate a strong loading.

administered to all cardiac patients at admission in all but exceptional cases, thus a hospital desires to conduct these activities 100 percent of the time (note: exceptional cases are noted and removed from the calculation). In theory, if appropriate processes are in place within hospitals, these activities should happen as part of the hospitals' standard operating procedure. In reality, clinicians are often very busy and they may forget to conduct the activity or believe it was done by someone else. Recent advancements in clinical IT provide a means of countering some of these process challenges. For example, electronic reminders within systems and aggregated views of patients across multiple systems and departments provide a means of more carefully monitoring activities surrounding patients.

For each hospital in our sample, we were able to obtain data on the effectiveness of the interpersonal care process between patients and the doctors, nurses, and staff members. This was computed as the percent of affirmative responses to questions related to the patient's experience at the hospital relative to interpersonal issues (see Table 2, Panel B). A factor analyses of these eight scores yielded a single factor

Table 3. Measures Used in Study

Measure	Abbreviation	Date range sampled	Source
CMI-adjusted mortality 2008	$Mort_t$	July 2007–June 2008	Hospital Compare
CMI-adjusted mortality 2007	$Mort_{t-1}$	July 2006–June 2007	Hospital Compare
Interpersonal care 2008	IP_Care_t	July 2007–June 2008	HCAHPS
Interpersonal care 2007	IP_Care_{t-1}	July 2006–June 2007	HCAHPS
Technical protocols of care 2008	TP_Care_t	July 2007–June 2008	Hospital Compare
Technical protocols of care 2007	TP_Care_{t-1}	July 2006–June 2007	Hospital Compare
Loyalty 2008	$Loyal_t$	July 2007–June 2008	HCAHPS
Loyalty 2007	$Loyal_{t-1}$	July 2006–June 2007	HCAHPS
Overall rating 2008	$Rating_t$	July 2007–June 2008	HCAHPS
Overall rating 2007	$Rating_{t-1}$	July 2006–June 2007	HCAHPS
IT adoption administration 2006	$ITAdm_{t-2}$	Up to January 2006	HIMSS Analytics
IT adoption cardiology 2006	$ITCard_{t-2}$	Up to January 2006	HIMSS Analytics

solution, so we compiled a composite measure of the interpersonal care process [86], and labeled it IP_Care (Cronbach's alpha of 0.919). Prior literature using these metrics notes that summary measures may be used when the items are strongly associated and substantively similar [52, 86].

Outcome Measures—Mortality, Patient Loyalty, and Patient Overall Rating

We used three types of performance outcome measures as dependent variables in our model (see Table 3). In keeping with the theme of examining performance at the application-specific level, we focused on heart-related metrics. First, we used data on CMI-adjusted 30-day mortality for heart attack patients. This is defined as the number of patients who died within 30 days of their heart-related procedure. The ratio of this number to the total number of heart-related patients is then used as the dependent variable ($Mort_t$). Next, we used data on patient responses to questions about their loyalty to the hospital and overall satisfaction with their health-care experience. The loyalty measure reflects the percentage of patients in the hospital who responded yes to the following question: "Would you recommend the hospital to family and friends?" ($Loyal_t$). The overall rating measure is a weighted index of all the patient respondents in a hospital capturing their assessment of the hospital. It is the summation of the product of the percentage of patients and the rating (1–10). For example, if all the patients rated a hospital 10, the score would be 100 percent times 10. This served as the overall satisfaction score ($Rating_t$).

Control Variables

Consistent with other research, we control for prior-year IT measures ($ITAdm_{t-1}$, $ITCard_{t-1}$), prior-year outcomes ($Mort_{t-1}$, $Loyal_{t-1}$, $Rating_{t-1}$), and prior-year process performance (IP_Care_{t-1}, TP_Care_{t-1}). In addition, we include paths from mortality to both loyalty and rating as there is potentially a link between high mortality rates and negative patient perceptions.

Results

We implemented our research model using structural equation modeling (SEM) with the software program SmartPLS. The PLS (partial least squares) approach is adept at analyzing mixed models containing both formative and reflective constructs, and the SmartPLS program provides a rich set of statistics for analysis. We present the descriptive statistics and bivariate correlations between the variables in Table 4. As can be observed from Figure 2, the relationship between administrative IT ($ITAdm_{t-2}$) and interpersonal process of care (IP_Care_t) is marginally significant, but negative ($\beta_{H1} = -0.027$, $p < 0.10$). The relationship between technical protocols of care (TP_Care_t) and cardiology IT ($ITCard_{t-2}$) is positive and statistically significant ($\beta_{H2} = 0.146$, $p < 0.001$). This provides support for H2 but rejects H1. We discuss this surprising finding in more detail in the next section. We also note a significant cross-process impact of cardiology IT on interpersonal care ($ITCard_{t-2}$ to IP_Care_t) with higher adoption levels being associated with improved interpersonal care ($\beta = 0.029$, $p < 0.001$). Our second set of hypotheses test the relationships between processes and outcomes. H3 and H4 posit a positive relationship between interpersonal care and two outcomes—loyalty and overall hospital ratings. Both relationships are positive and significant, supporting Hypotheses 3 and 4 ($\beta_{H3} = 0.380$, $p < 0.001$ and $\beta_{H4} = 0.507$, $p < 0.001$, respectively, for IP_Care_t to $Loyal_t$ and IP_Care_t to $Rating_t$). H5 posited a negative relationship between technical protocols of care and mortality (TP_Care_t to $Mort_t$) such that greater levels of compliance with technical processes are related to reductions in mortality rates. This hypothesis was supported ($\beta_{H5} = -0.087$, $p < 0.001$). Finally, we note that cross-outcome effects are present such that compliance with technical processes are positively associated with both loyalty (TP_Care_t to $Loyal_t$) and ratings (TP_Care_t to $Rating_t$) ($\beta = 0.089$, $p < 0.001$ and $\beta = 0.110$, $p < 0.001$, respectively). There was not a significant effect between interpersonal care and mortality (IP_Care_t to $Mort_t$, $\beta = -0.004$, n.s. [not significant]).

We controlled for prior-year process performance and outcomes and, as expected, all the respective measures were significant. In addition, we included paths from mortality to loyalty and rating, and the relationship with rating was significant but the one with loyalty was not ($\beta = -0.036$, $p < 0.001$ and $\beta = -0.019$, n.s., respectively), indicating that consumers do in fact rate hospitals lower that have higher than average mortality rates. Finally, organizational structure (OrgStr) was positively related to technical protocols of care and negatively associated with interpersonal care ($\beta = 0.403$, $p < 0.001$ and $\beta = -0.047$, $p < 0.001$, respectively). This is an unexpected and intrigu-

Table 4. Descriptive Statistics and Correlations

	Variable	Mean	Standard deviation	1	2	3	4	5	6	7	8	9
1	$ITCard_{t-2}$	6.88	3.62	1.00								
2	$ITAdm_{t-2}$	30.93	7.66	0.34	1.00							
3	TP_Care_{t}	82.65	15.27	0.39	0.26	1.00						
4	TP_Care_{t-1}	92.83	8.33	0.26	0.17	0.48	1.00					
5	IP_Care_{t}	87.24	3.41	0.01	–0.11	–0.16	–0.04	1.00				
6	IP_Care_{t-1}	86.97	3.88	–0.02	–0.10	–0.19	–0.10	0.86	1.00			
7	$Mort_{t}$	16.34	1.80	–0.12	–0.09	–0.17	–0.12	0.02	0.03	1.00		
8	$Mort_{t-1}$	16.03	1.15	–0.08	–0.08	–0.12	–0.07	0.01	0.01	0.71	1.00	
9	$Loyal_{t}$	93.74	4.35	0.15	–0.02	0.03	0.09	0.63	0.54	–0.06	–0.04	1.00
10	$Loyal_{t-1}$	93.66	3.82	0.13	–0.02	0.00	0.05	0.76	0.84	–0.07	–0.05	0.65
11	$Rating_{t}$	859.42	24.27	0.13	–0.01	0.02	0.08	0.80	0.69	–0.07	–0.06	0.63
12	$Rating_{t-1}$	857.89	26.17	0.08	–0.01	–0.03	0.02	0.74	0.85	–0.06	–0.05	0.57
13	Age	37.89	36.87	0.07	–0.04	0.03	0.01	0.10	0.11	–0.05	–0.03	0.14
14	Beds	260.73	196.79	0.39	0.23	0.49	0.27	–0.22	–0.23	–0.19	–0.11	–0.01
15	NFP	0.68	0.47	0.18	0.07	0.11	0.15	0.14	0.10	–0.10	–0.05	0.18
16	RUCA	1.84	1.43	–0.34	–0.27	–0.50	–0.32	0.33	0.35	0.17	0.12	0.06
17	NETOPEXP	18.46	2.26	0.21	0.14	0.28	0.15	–0.09	–0.09	–0.07	–0.03	0.03
18	HOSPINSY	23.45	43.57	–0.09	0.06	0.14	0.07	–0.29	–0.31	0.08	0.03	–0.26
19	OWNCODE	1.07	0.33	–0.08	–0.01	–0.07	–0.03	–0.05	–0.06	0.03	0.02	–0.11
20	STRATEGY	3.69	1.13	0.16	0.21	0.14	0.09	–0.03	–0.05	–0.04	–0.01	0.01

	Variable	10	11	12	13	14	15	16	17	18	19
1	$ITCard_{t-2}$										
2	$ITAdm_{t-2}$										
3	TP_Care_{t}										
4	TP_Care_{t-1}										
5	IP_Care_{t}										
6	IP_Care_{t-1}										
7	$Mort_{t}$										
8	$Mort_{t-1}$										
9	$Loyal_{t}$										
10	$Loyal_{t-1}$										
11	$Rating_{t}$	0.74									
12	$Rating_{t-1}$	0.86	0.81								
13	Age	0.18	0.07	0.09							
14	Beds	–0.01	–0.02	–0.04	0.13						
15	NFP	0.21	0.16	0.11	0.12	0.13					
16	RUCA	0.15	0.09	0.12	0.01	–0.45	–0.07				
17	NETOPEXP	0.03	–0.01	–0.02	0.13	0.34	0.13	–0.24			
18	HOSPINSY	–0.36	–0.25	–0.27	–0.30	–0.03	–0.35	–0.11	–0.02		
19	OWNCODE	–0.11	–0.05	–0.06	–0.12	–0.07	–0.10	0.05	–0.37	0.02	
20	STRATEGY	0.01	0.04	0.02	–0.06	0.16	0.04	–0.15	0.08	–0.11	0.09

Note: All absolute values greater than 0.04 are significant at $p = 0.05$ or below.

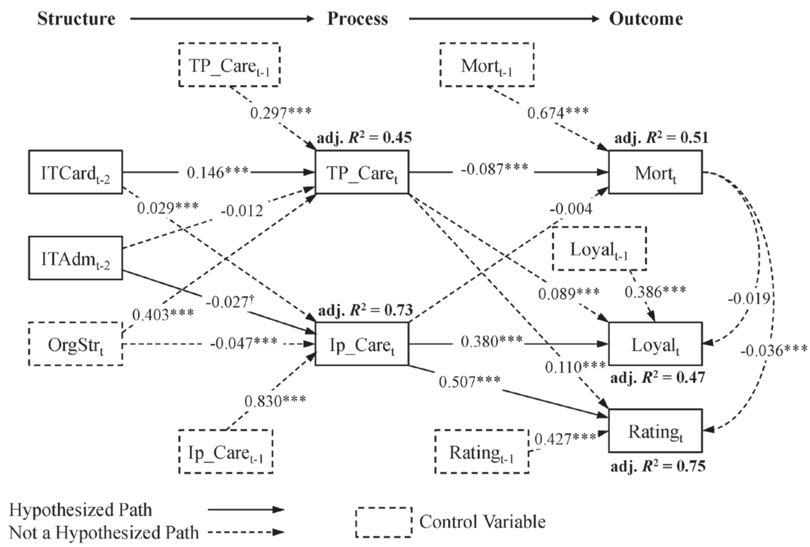

Figure 2. Results of the Structural Model Analysis

Notes: t = time (year). * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

ing finding and therefore we examined more closely the individual items that make up the organizational structure formative construct. As shown in Table 1, the primary determinants of OrgStr, in order of path strength are RUCA, Beds, HOSPINSY, Age, NFP, and NETOPEXP. While the coefficients of the items in a formative construct do not directly translate to the impact that each item has on the subsequent dependent variable (in this case, TP_Care and IP_Care), the product of the item coefficient and the path coefficient are representative of the relationship [60]. For example, Age has a positive item-level coefficient of 0.328 as it relates to the formative construct OrgStr and OrgStr is positively related to TP_Care, and since both are significant and positive, it is true that Age positively relates to TP_Care. This is akin to the formative construct acting as a mediator between the individual items that make it up and the dependent variable [111]. In this same vein, it can be said that Beds, HOSPINSY, Age, NFP, and NETOPEXP are all positively related to technical protocols of care and their effect outweighs the negative effect of RUCA. The opposite is true of the relationship to interpersonal care. Because the path from OrgStr to IP_Care is negative and RUCA is negative, the effect of RUCA on IP_Care is positive. Essentially what this means is that rural hospitals do a better job with interpersonal care and a poorer job with technical protocols of care.

Finally, we also note the high levels of explained variance in our model ($R^2_{\text{TP\_Care}} = 0.45$, $R^2_{\text{IP\_Care}} = 0.73$, $R^2_{\text{Mort}} = 0.51$, $R^2_{\text{Loyal}} = 0.47$, and $R^2_{\text{Rating}} = 0.75$) and attribute some of this to the use of prior-year process performance and outcomes. However, when we removed prior-year measures, we still had substantive levels of explained variance in many of the dependent variables (with the notable exception of mortality) and the direction and significance of the paths did not change (variance explained with prior-year predictors removed $R^2_{TP\_Care} = 0.38$, $R^2_{IP\_Care} = 0.19$, $R^2_{Mort} = 0.03$, $R^2_{Loyal} = 0.42$, and $R^2_{Rating} = 0.67$). This suggests that our model is specified appropriately.

Discussion and Limitations

Discussion

IT HAS BEEN SHOWN TO AFFECT VALUE IN A VARIETY OF DIFFERENT WAYS, but the role it plays in improving communication-based services [39] such as internal and interactive marketing has not been explored in detail. In the health-care context, we found that cardiology and administrative IT differentially influence hospital processes within a cardiology setting. While the specific mechanisms through which these relationships occur requires further investigation, we surmise that different forces may be acting. For example, we found that cardiology IT improves technical protocol processes. One could conclude from this that cardiology IT provides functions that make reporting the data easier, more efficient, or simply that the clinicians are responding to electronic reminders to complete the protocol. Drawing upon the marketing lens again, it also could be that because of the transparency of this quality information, hospital administration is forcing its clinicians to abide by the protocol, even if they are not in agreement with the procedure because they know that they are being evaluated and competitively compared with other hospitals on their scores.

In their review of a dominant logic in the marketing literature, Vargo and Lusch [105] note that one school of thought from a service-centered view of marketing is that the consumer is a co-producer of value in the marketing exchange [84]. We had expected to see this situation manifest in a significant relationship between administrative IT and interpersonal interactions such that administrative IT would free up time for clinicians and staff to engage with the patient and in a sense, market their services to the patient. While we did find a marginally significant relationship, it was negative, suggesting that more administrative IT leads to lower levels of interpersonal care. This could be explained if clinicians and clinical staff do not utilize administrative IT to a great enough extent to warrant any advantages in terms of time savings. It also may be the case that hospitals are adopting IT for institutional reasons such as legitimacy but failing to fully capitalize on their benefits because they are not substantively integrating the technology into their workflow. Another explanation is that IT (either administrative or cardiology) is perceived by some patients as intrusive and diminishing of the doctor–patient relationship. Finally, we also considered and later conducted post hoc testing at the extreme values of administrative IT adoption and found a significant curvilinear relationship such that very low and very high levels of adoption yielded reduced performance while moderate adoption yielded superior interpersonal interaction performance ($ITAdm^2$, $\beta = -0.084$, $p = 0.000$). To the extent that administrative IT provides functions that are related to perceptions of quality, it may be the case that the more-is-better mantra truly is false and that the requirements of the administrative IT are either too demanding and take time away from the patient or the increased requirements tax the patient. As noted by several researchers, clinical care should be appropriate and necessary and not overused or underused [21, 22, 26]. Ironically, the opposite effect was found in the relationship between cardiology IT and technical protocols. When cardiology IT is low or high, quality is better ($ITCard^2$, $\beta = 0.366$, $p = 0.000$). There is also a logical explanation for this in that hospitals with high levels of clinical IT (including cardiology IT) tend to be academic/teaching hospitals and highly innovative. Those hospitals with moderate levels of clinical IT may seek to mimic the highly innovative hospitals but are not yet proficient in the use of these advanced ITs and thus their performance falters. Hospitals that have adopted very little clinical IT do not suffer these learning-curve losses and therefore may have superior performance in the short term. If this finding is confirmed through future research, it would hold important practical implications. For example, administrators should recognize that over- and underinvestment in IT can potentially have negative effects on performance, and these results vary by IT type. In both cases, our results generally suggest that a minimum threshold must be achieved before the benefits (or negative effects) begin to accrue to the hospital. This also suggests that prior studies of IT adoption in health care that found unintended or negative consequences may not have accounted for the effect of these extremes. However, without a more detailed analysis of these curvilinear effects, we cannot say for certain what the overall impact is.

We also note the nonsignificant path between administrative IT and technical protocols of care, suggesting that it may be the case that clinical IT is the only technology to directly affect the care that patients receive. More to the point, this enhances prior arguments that application-specific IT (e.g., cardiology IT) is more likely to show effects at the application level. Finally, the only other path that was not significant is the link between interpersonal care and mortality rate, which is understandable considering that the "comfort" of the stay at the hospital is not likely to translate to a reduction in fatalities after being discharged.

From a research standpoint, the results of our study have several implications. First, this study further validates the growing base of knowledge suggesting that IT affects processes directly and outcomes indirectly. Second, most studies of IT impact in health care have examined the impact of total IT investment on various measures of hospital performance. In our study, we separate IT into a subset of clinical (cardiology) and administrative IT and obtain insights about the differential impact of these forms of IT on performance. Finally, we empirically demonstrate the application of the SPO framework in the context of health-care IT. Such a lens can be beneficial for addressing other research issues in our field.

Interaction Effects and IT Strategy and Self-Selection Bias

While we did not hypothesize any interaction effects, in a post hoc analysis we explored the question of whether pursing the strategy of deploying more cardiology and administrative IT, simultaneously, would contribute to performance. We operationalized this as a multiplicative interaction between $ITAdm_{t-2}$ and $ITCard_{t-2}$. We found a negative, marginally significant relationship between the IT interaction term and

Mortality ($\beta_{\text{ITInteract to Mort}} = -0.132$, $p < 0.10$), a positive signification relationship to Overall Rating ($\beta_{\text{ITInteract to Rating}} = 0.124$, $p < 0.05$), and a nonsignificant relationship to Loyalty ($\beta_{\text{ITInteract to Loyal}} = 0.051$, $p = 0.48$). We also tested the relationship between the IT interaction and the mediating process variables and found a nonsignificant relationship to technical protocols and a significant positive relationship to interpersonal care ($\beta_{\text{ITInteract to TP\_Care}} = 0.065$, $p = 0.434$; $\beta_{\text{ITInteract to IP\_Care}} = 0.104$, $p < 0.001$). While most of the interaction coefficients are large relative to the main effects, the effect size is quite low in magnitude because of the size of the multiplicative interaction terms. In addition, the variance explained showed no meaningful increase when the interaction was included. Further research should be conducted to more fully explore interaction effects; however, preliminary evidence suggests that complementing cardiology IT with administrative IT does not negatively affect performance but that the positive effects may be minimal. Finally, we did create an interaction term using the process variables (Technical Protocols of Care and Interpersonal Care), but this did not result in any significant relationships with the outcome variables.

Shaver [95] notes that self-selection bias should be accounted for in studies that posit relationships between strategy and performance because firms will choose specific strategies that align with their capabilities and time-sensitive industry conditions. He outlines an econometric method for examining the effects of self-selection bias that was originated by Heckman [51]. While a detailed description of this methodology is beyond the scope of this paper, we provide a short description and summary statistics in Appendix B. The conclusion we draw from the Heckman test is that while the self-selection correction variable is significant in all three models (we separately tested all three of our dependent variables), the coefficients of the independent variables of interest are largely unchanged when the correction is used. Moreover, the adjusted R^2 value does not change significantly either. Therefore, we believe that our findings are robust irrespective of self-selection, but further acknowledge the importance of conducting tests for self-selection in studies examining relationships between IT strategy and performance.

Limitations

Our study has several limitations that offer promising avenues for future research. First, we acknowledge the problems associated with aggregate counts of IT [90]. Intuitively, the IT measure that should be most "pure" in its relation to value is "meaningful use," since owning IT is several steps removed from meaningfully using IT. For example, the transition from ownership to meaningful use proceeds like this: purchase IT (count) $\rightarrow$ deploy IT (count) $\rightarrow$ use IT (count and/or intensity) $\rightarrow$ meaningfully use IT (intensity with respect to intended purpose). At each transition point, there can be departures or detours. For example, there are instances where IT is purchased but never deployed or deployed to a much smaller extent than originally envisioned. Even once it is deployed, many potential users decide not to use the application. Use of IT does not necessarily translate into it being used meaningfully or in the spirit for which it was intended. While such an analysis is clearly outside the scope of our research design, this is certainly an interesting direction for future research.

Unfortunately, at this point in time, we often do not have and cannot acquire better measures of hospital IT than counts. From a statistical standpoint, we realize our count measure is not optimal and that meaningful use would be better; however, the estimate we obtain is actually downward biased, as noted by Anderson et al. [3] in their study of IT investment and firm performance. The fact that IT is significant suggests that this effect will actually be stronger if there is meaningful use. The obvious strength of our data is the large number of hospitals in our sample, which possibly makes up for what we lose in more granular measures of IT. Some have tested the relationship between performance and the amount of time that firms have the technologies in use [57], while others argue for a weighted value that in some way incorporates the industry concentration of a variety of technologies [96]. Because of space limitations, we do not elaborate on our findings, but we did calculate time-weighted measures of IT adoption and a Saidin index [96] incorporating industry concentrations and found no significant differences in the relationships we report in our study and these weighted IT metrics. Because our results are stronger when looking at a subset of IT (i.e., cardiology IT) than the basket of IT contained in the administrative cluster, future research might consider examining specific technologies within the administrative cluster that are likely to be more closely related to process outcomes.

We understand that clinical IT affects not just technical and interpersonal processes but also plays a role in many procedures and protocols in the hospital. We also recognize the potential changes that IT brings to internal communications in general. Yet it is unclear how to quantify these benefits given the data we have. What we can ascertain is that IT affects outcomes through the processes we have identified (interpersonal and technical), but it is likely that other relationships exist in which certain processes mediate the relationship to outcomes. For example, we know that IT engenders new forms of communication between doctors and nurses and also creates linkages between disciplines [67]. Future research should examine different types of processes that might be influenced by IT.

One challenge with working with large data sets is that it is often not possible to acquire matched behavioral data, such as managerial skill, and therefore, we cannot account for differences in skills. We also do not have information related to the qualifications of the medical staff; however, the very nature of medicine suggests that there is likely less variation in qualifications at the level of the doctors and nurses than there would be in other industries that do not require advanced degrees or certifications to practice. Our last limitation is that we focus exclusively on the functional area of cardiology so that we can isolate its impact. Future studies can examine these relationships in broader contexts or in other functional areas.

Conclusion

The investigation of the value of health-care IT is becoming increasingly important. In 2004, President George W. Bush issued an executive order that encouraged the adoption of various forms of health-care IT. In the 2008 U.S. presidential campaign, nearly all the candidates mentioned health-care IT in their campaign speeches and debates. And more recently, President Barack Obama's economic stimulus plan was implemented with approximately $20 billion earmarked for the introduction of IT into the health-care system. Interestingly, while most studies suggest that there is value in the adoption of these technologies, the results are not entirely conclusive, suggesting that either: (1) there is too much error in the current state of research measurement, or (2) value is heterogeneously distributed among firms and results are highly contingent upon context. Our goal in this study was to take a highly focused approach to IT value by examining application-specific technologies and their influence on related processes and outcomes. The processes in this case are essentially communication based and in one form or another related to the marketing of services. Because the care of patients in hospitals is highly contingent upon communication-based processes, we thought that this was an appropriate context to study. To the extent that IT can offer complementary value to these processes, there is reason to believe that patient perceptions of care and possibly health outcomes can be enhanced. While more work remains to be done, we hope that this study provides some guidance to researchers, practitioners, and policymakers with respect to improving health quality and care.

References

1. Als, A.B. The desk-top computer as a magic box: Patterns of behaviour connected with the desk-top computer; GPs' and patients' perceptions. *Family Practice, 14,* 1 (1997), 17–23.

2. Amarasingham, R.; Plantinga, L.; Diener-West, M.; Gaskin, D.J.; and Powe, N.R. Clinical information technologies and inpatient outcomes: A multiple hospital study. *Archives of Internal Medicine, 169,* 2 (2009), 108–114.

3. Anderson, M.C.; Banker, R.; and Hu, N. The impact of information technology spending on future performance. In S.T. March, A. Massey, and J.I. DeGross (eds.), *Proceedings of the Twenty-Fourth International Conference on Information Systems.* Atlanta: Association for Information Systems, 2003.

4. Angst, C.M.; Agarwal, R.; Sambamurthy, V.; and Kelley, K. Social contagion and information technology diffusion: The adoption of electronic medical records in U.S. hospitals. *Management Science, 56,* 8 (2010), 1219–1241.

5. Angst, C.M.; Devaraj, S.; Queenan, C.; and Greenwood, B. Performance effects related to the sequence of integration of healthcare technologies. *Production and Operations Management, 20,* 3 (2011), 319–333.

6. Aral, S.; Brynjolfsson, E.; and Van Alstyne, M.W. Information, technology and information worker productivity: Task level evidence. Working Paper no. 13172, National Bureau of Economic Research, Cambridge, MA, June.

7. Armstrong, C.P., and Sambamurthy, V. Information technology assimilation in firms: The influence of senior leadership and IT infrastructures. *Information Systems Research, 10,* 4 (1999), 304–327.

8. Ash, J.S.; Berg, M.; and Coiera, E. Some unintended consequences of information technology in health care: The nature of patient care information system related errors. *Journal of the American Medical Informatics Association, 11,* 2 (2004), 104–112.

9. Ash, J.S.; Dean, F.S.; and Poon, E.G. The extent and importance of unintended consequences related to computerized provider order entry. *Journal of the American Medical Informatics Association, 14,* 4 (2007), 415–423.

10. Bagozzi, R.P. Structural equation models in marketing research: Basic principles. In R.P. Bagozzi (ed.), *Principles of Marketing Research.* Oxford: Blackwell, 1994, pp. 317–385.

11. Barua, A.; Kriebel, C.H.; and Mukhopadhyay, T. Information technologies and business value: An analytic and empirical investigation. *Information Systems Research, 6,* 1 (1995), 3–23.

12. Bates, D.W.; Cohen, M.; Leape, L.; Overhage, J.M.; Shabot, M.; and Sheridan, T. Reducing the frequency of errors in medicine using information technology. *Journal of the American Medical Informatics Association, 8,* 4 (2001), 299–308.

13. Beckman, H.B.; Markakis, K.M.; Suchman, A.L.; and Frankel, R.M. The doctor–patient relationship and malpractice: Lessons from plaintiff depositions. *Archives of Internal Medicine, 154,* 12 (1994), 1365–1370.

14. Benner, M., and Tushman, M. Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review, 28,* 2 (2003), 238–256.

15. Berger, P.L., and Luckmann, T. *The Social Construction of Reality.* New York: Anchor Books, 1966.

16. Blumenthal, D. Quality of care—What is it? *New England Journal of Medicine, 335,* 12 (1996), 891–894.

17. Blumenthal, D., and Scheck, A.C. *Improving Clinical Practice: Total Quality Management and the Physician.* San Francisco: Jossey-Bass, 1995.

18. Bollen, K.A. Multiple indicators: Internal consistency of no necessary relationship? *Quality and Quantity, 18,* 4 (1984), 377–385.

19. Bond, C.; Raehl, C.; Pitterle, M.; and Franke, T. Health care professional staffing, hospital characteristics, and hospital mortality rates. *Pharmacotherapy, 19,* 2 (1999), 130–138.

20. Bradley, E.H.; Herrin, J.; Elbel, B.; McNamara, R.L.; Magid, D.J.; Nallamothu, B.K.; Wang, Y.; Normand, S.-L.T.; Spertus, J.A.; and Krumholz, H.M. Hospital quality for acute myocardial infarction: Correlation among process measures and relationship with short-term mortality. *Journal of the American Medical Association, 296,* 1 (2006), 72–78.

21. Brook, R. Managed care is not the problem, quality is. *Journal of the American Medical Association, 278,* 19 (1997), 1612–1614.

22. Brook, R.; McGlynn, E.A.; and Cleary, P.D. Quality of health care, Part 2: Measuring quality of care. *New England Journal of Medicine, 335,* 12 (1996), 966–970.

23. Brown, T.W.; McCarthy, M.L.; Kelen, G.D.; and Levy, F.L. An epidemiologic study of closed emergency department malpractice claims in a national database of physician malpractice insurers. *Academic Emergency Medicine, 17,* 5 (2010), 553–560.

24. Brynjolfsson, E., and Hitt, L. Paradox lost? Firm-level evidence on the returns to information systems spending. *Management Science, 42,* 4 (1996), 541–558.

25. Caffrey, C.; Sengupta, M.; Moss, A.; Harris-Kojetin, L.; and Valverde, R. Home health care and discharged hospice care patients: United States, 2000 and 2007. *National Health Statistics Reports,* no. 38, April 27, 2011.

26. Campbell, S.; Roland, M.; and Buetow, S. Defining quality of care. *Social Science & Medicine, 51,* 11 (2000), 1611–1626.

27. Carmel, S., and Glick, S. Compassionate-empathic physicians: Personality traits and social-organizational factors that enhance or inhibit this behavior pattern. *Social Science & Medicine, 43,* 8 (1996), 1253–1261.

28. Chen, J.; Radford, M.; Wang, Y.; Marciniak, T.; and Krumholz, H. Do "America's best hospitals" perform better for acute myocardial infarction? *New England Journal of Medicine, 340,* 4 (1999), 286–292.

29. Chin, W.W. The partial least squares approach to structural equation modeling. In G.A. Marcoulides (ed.), *Modern Methods for Business Research.* Mahwah, NJ: Lawrence Erlbaum, 1998, pp. 295–336.

30. Coiera, E. When conversation is better than computation. *Journal of the American Medical Informatics Association, 7,* 3 (2000), 277–286.

31. Dehning, B.; Richardson, V.; and Zmud, R.W. The value relevance of announcements of transformational information technology investments. *MIS Quarterly, 27,* 4 (2003), 637–656.

32. Devaraj, S., and Kohli, R. Information technology payoff in the healthcare industry: A longitudinal study. *Journal of Management Information Systems, 16,* 4 (Spring 2000), 41–67.

33. Devaraj, S., and Kohli, R. Performance impacts of information technology: Is actual usage the missing link? *Management Science, 49,* 3 (2003), 273–299.

34. Diamontopoulos, A., and Winklhofer, H.M. Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research, 38,* 2 (2001), 269–277.

35. Donabedian, A. Evaluating the quality of medical care. *Milbank Memorial Fund Quarterly, 44,* 3 (1966), 166–206.

36. Donabedian, A. *The Definition of Quality and Approaches to Its Assessment: Explorations in Quality Assessment and Monitoring.* Ann Arbor, MI: Health Administration Press, 1980.

37. Donabedian, A. The quality of care: How can it be assessed? *Journal of the American Medical Association, 260,* 12 (1988), 1743–1748.

38. Donabedian, A. Evaluating the quality of medical care. *Milbank Quarterly, 83,* 4 (2005), 691–729.

39. Duncan, T., and Moriarty, S. A communication-based marketing model for managing relationships. *Journal of Marketing, 62,* 2 (1998), 1–13.

40. Ebert, T. *Trust as the Key to Loyalty in Business-to-Consumer Exchanges: Trust Building Measures in the Banking Industry.* Wiesbaden: Gabler, 2009.

41. Ferrier, G., and Valdmanis, V. Rural hospital performance and its correlates. *Journal of Productivity Analysis, 7,* 1 (1996), 63–80.

42. Fonarow, G.; Abraham, W.; Albert, N.; Stough, W.; Gheorghiade, M.; Greenberg, B.; O'Connor, C.; Pieper, K.; Sun, J.; and Yancy, C. Association between performance measures and clinical outcomes for patients hospitalized with heart failure. *Journal of the American Medical Association, 297,* 1 (2007), 61–70.

43. Ford, E.W.; Menachemi, N.; and Phillips, M.T. Predicting the adoption of electronic health records by physicians: When will health care be paperless? *Journal of the American Medical Informatics Association, 13,* 1 (2006), 106–112.

44. Gaynor, M.S. Competition and quality in health care markets. *Foundations and Trends in Microeconomics, 2,* 6 (2006), 441–508.

45. Gaynor, M.S., and Vogt, W. Competition among hospitals. *RAND Journal of Economics, 34,* 4 (2003), 764–785.

46. Geyskens, I.; Steenkamp, J.-B.E.M.; and Kumar, N. A meta-analysis of satisfaction in marketing channel relationships. *Journal of Marketing Research, 36,* 3 (1999), 223–238.

47. Goldstein, E.; Farquhar, M.; Crofton, C.; Darby, C.; and Garfinkel, S. Measuring hospital care from the patients' perspective: An overview of the CAHPS® hospital survey development process. *Health Services Research, 40,* 6 pt. 2 (2005), 1977–1995.

48. Greatbatch, D.; Heath, C.; Campion, P.; and Luff, P. How do desk-top computers affect the doctor–patient interaction? *Family Practice, 12,* 1 (1995), 32–36.

49. Gronholdt, L.; Martensen, A.; and Kristensen, K. The relationship between customer satisfaction and loyalty: Cross-industry differences. *Total Quality Management & Business Excellence, 11,* 4 (2000), 509–514.

50. Hannan, T.H., and McDowell, J.M. The determinants of technology adoption: The case of the banking firm. *RAND Journal of Economics, 15,* 3 (1984), 328–335.

51. Heckman, J. Sample selection bias as a specification error. *Econometrica, 47,* 1 (1979), 153–161.

52. Hibbard, J.H.; Stockard, J.; and Tusler, M. Does publicizing hospital performance stimulate improvement efforts? *Health Affairs, 22,* 2 (2003), 84–94.

53. Hillestad, R.; Bigelow, J.; Bower, A.G.; Girosi, F.; Meili, R.; Scoville, R.; and Taylor, R. Can electronic medical record systems transform healthcare? An assessment of potential health benefits, savings, and costs. *Health Affairs, 24,* 5 (2005), 1103–1117.

54. Hitt, L.M., and Brynjolfsson, E. Productivity, business profitability, and consumer surplus: Three different measures of information technology value. *MIS Quarterly, 20,* 2 (1996), 121–142.

55. Hitt, L.M.; Wu, D.J.; and Zhou, X.G. Investment in enterprise resource planning: Business impact and productivity measures. *Journal of Management Information Systems, 19,* 1 (Summer 2002), 71–98.

56. Hsu, J.; Huang, J.; Fung, V.; Robertson, N.; Jimison, H.; and Frankel, R. Health information technology and physician–patient interactions: Impact of computers on communication during outpatient primary care visits. *Journal of the American Medical Informatics Association, 12,* 4 (2005), 474–480.

57. Hunt, D.L.; Haynes, R.B.; Hanna, S.E.; and Smith, K. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: A systematic review. *Journal of the American Medical Association, 280,* 15 (1998), 1339–1346.

58. Hunton, J.; Lippincott, B.; and Reck, J. Enterprise resource planning systems: Comparing firm performance of adopters and nonadopters. *International Journal of Accounting Information Systems, 4,* 3 (2003), 165–184.

59. Hutchins, E. How a cockpit remembers its speeds. *Cognitive Science, 19,* 3 (1995), 265–288.

60. Jarvis, C.B.; MacKenzie, S.B.; and Podsakoff, P.M. A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research, 30,* 2 (2003), 199–218.

61. Jha, A.; Orav, E.J.; Li, Z.; and Epstein, A. The inverse relationship between mortality rates and performance in the hospital quality alliance measures. *Health Affairs, 26,* 4 (2007), 1104–1110.

62. Kaynak, H. The relationship between total quality management practices and their effects on firm performance. *Journal of Operations Management, 21,* 4 (2003), 405–435.

63. Kennedy, M.T., and Fiss, P.C. Institutionalization, framing, and diffusion: The logic of TQM adoption and implementation decisions among U.S. hospitals. *Academy of Management Journal, 52,* 5 (2009), 897–918.

64. Klein, M.; Malone, M.; Bennis, W.; and Berkowitz, N. Problems of measuring patient care in the out-patient department. *Journal of Health and Human Behavior, 2,* 2 (1961), 138–144.

65. Koppel, R.; Metlay, J.; Cohen, A.; Abaluck, B.; Localio, A.R.; Kimmel, S.E.; and Strom, B.L. Role of computerized physician order entry systems in facilitating medication errors. *Journal of the American Medical Association, 293,* 10 (2005), 1197–1203.

66. Kotler, P. *Marketing Management: Analysis, Planning, Implementation, and Control.* Englewood Cliffs, NJ: Prentice Hall, 1994.

67. Kuruzovich, J.; Angst, C.M.; Faraj, S.; and Agarwal, R. Wireless communication's role in patient response time: A study of Vocera integration with a nurse call system. *Computers, Informatics, Nursing, 26,* 3 (2008), 159–166.

68. Lai, V.S., and Guynes, J.L. An assessment of the influence of organizational characteristics on information technology adoption decision: A discriminative approach. *IEEE Transactions on Engineering Management, 44,* 2 (1997), 146–157.

69. Levin, D.Z., and Christmann, P. Institutionalism, learning, and patterns of decoupling: The case of total quality management. Working Paper, Management and Global Business Department, Rutgers Business School, Rutgers University, New Brunswick, 2006.

70. Levine, R.; Fowler, F., Jr.; and Brown, J. Role of cognitive testing in the development of the CAHPS® hospital survey. *Health Services Research, 40,* 6 pt. 2 (2005), 2037–2056.

71. Likourezos, A.; Chalfin, D.; Murphy, D.; Sommer, B.; Darcy, K.; and Davidson, S. Physician and nurse satisfaction with an electronic medical record system. *Journal of Emergency Medicine, 27,* 4 (2004), 419–424.

72. Lohmoller, J.-B. *Latent Variable Path Modeling with Partial Least Squares.* Heidelberg: Springer, 1989.

73. Lohr, K.N. *Medicare: A Strategy for Quality Assurance.* Washington, DC: National Academy Press, Institute of Medicine, 1990.

74. MacCallum, R.C., and Browne, M.W. The use of causal indicators in covariance structure models: Some practical issues. *Psychological Bulletin, 114,* 3 (1993), 533–541.

75. Makoul, G.; Curry, R.H.; and Tang, P.C. The use of electronic medical records: Communication patterns in outpatient encounters. *Journal of the American Medical Informatics Association, 8,* 6 (2001), 610–615.

76. March, J.G. Exploration and exploitation in organizational learning. *Organization Science, 2,* 1 (1991), 71–87.

77. McCracken, M.J.; McIlwain, T.F.; and Fottler, M.D. Measuring organizational performance in the hospital industry: An exploratory comparison of objective and subjective methods. *Health Services Management Research, 14,* 4 (2001), 211–219.

78. McCullough, J.S.; Casey, M.; Moscovice, I.; and Prasad, S. The effect of health information technology on quality in U.S. hospitals. *Health Affairs, 29,* 4 (2010), 647–654.

79. McGlynn, E. Six challenges in measuring the quality of health care. *Health Affairs, 16,* 3 (1997), 7–21.

80. Menon, N.M.; Yaylacicegi, U.; and Cezar, A. Differential effects of the two types of information systems: A hospital-based study. *Journal of Management Information Systems, 26,* 1 (Summer 2009), 297–316.

81. Morey, J.; Simon, R.; Jay, G.; Wears, R.; Salisbury, M.; Dukes, K.; and Berns, S. Error reduction and performance improvement in the emergency department through formal teamwork training: Evaluation results of the MedTeams Project. *Health Services Research, 37,* 6 (2002), 1553–1581.

82. Mukhopadhyay, T., and Kekre, S. Strategic and operational benefits of electronic integration in B2B procurement processes. *Management Science, 48,* 10 (2002), 1301–1313.

83. Nenonen, M., and Nylander, O. A theoretical framework for health information systems. *International Journal of Healthcare Technology and Management, 4,* 6 (2002), 467–477.

84. Normann, R., and Ramirez, R. From value chain to value constellation: Designing interactive strategy. *Harvard Business Review, 71,* 4 (1993), 65–77.

85. Nunnally, J.C., and Bernstein, I.H. *Psychometric Theory,* 3d ed. New York: McGraw-Hill, 1994.

86. O'Malley, A.; Zaslavsky, A.; Hays, R.; Hepner, K.; Keller, S.; and Cleary, P. Exploratory factor analyses of the CAHPS Hospital Pilot Survey responses across and within medical, surgical, and obstetric services. *Health Services Research, 40,* 6, pt. 2 (2005), 2078–2095.

87. Parasuraman, A. Understanding and leveraging the role of customer service in external, interactive and internal marketing. Paper presented at the Frontiers in Services Conference, Nashville, TN, October 3–5, 1996.

88. Parasuraman, A., and Grewal, D. The impact of technology on the quality-value-loyalty chain: A research agenda. *Journal of the Academy of Marketing Science, 28,* 1 (2000), 168–174.

89. Porter, M. What is strategy? *Harvard Business Review, 74,* 6 (1996), 61–78.

90. Queenan, C.; Angst, C.M.; and Devaraj, S. Doctors' orders—If they're electronic, do they improve patient satisfaction? A complements/substitutes perspective. *Journal of Operations Management, 29,* 7–8 (2011), 639–649.

91. Ray, G.; Barney, J.B.; and Muhanna, W.A. Capabilities, business processes, and competitive advantage: Choosing the dependent variable in empirical tests of the resource-based view. *Strategic Management Journal, 25,* 1 (2004), 23–37.

92. Ridsdale, L., and Hudd, S. Computers in the consultation: The patient's view. *British Journal of General Practice, 44,* 385 (1994), 367–369.

93. Riesenberg, L.A.; Leitzsch, J.; Massucci, J.L.; Jaeger, J.; Rosenfeld, J.C.; Patow, C.; Padmore, J.S.; and Karpovich, K.P. Residents' and attending physicians' handoffs: A systematic review of the literature. *Academic Medicine, 84,* 12 (2009), 1775–1787.

94. Schein, E.H. The role of the CEO in the management of change: The case of information technology. In T.A. Kochan and M. Useem (eds.), *Transforming Organizations.* Oxford: Oxford University Press, 1992, pp. 80–95.

95. Shaver, J.M. Accounting for endogeneity when assessing strategy performance: Does entry mode choice affect FDI survival? *Management Science, 44,* 4 (1998), 571–585.

96. Spetz, J., and Maiuro, L. Measuring levels of technology in hospitals. *Quarterly Review of Economics and Finance, 44,* 3 (2004), 430–447.

97. Stewart, M. Effective physician–patient communication and health outcomes: A review. *Canadian Medical Association Journal, 152,* 9 (1995), 1423–1433.

98. Subramani, M. How do suppliers benefit from information technology use in supply chain relationships? *MIS Quarterly, 28,* 1 (2004), 45–73.

99. Sun, B.; Adams, J.; Orav, E.; Rucker, D.; Brennan, T.; and Burstin, H. Determinants of patient satisfaction and willingness to return with emergency care. *Annals of Emergency Medicine, 35,* 5 (2000), 426–434.

100. Sykes, T.A.; Venkatesh, V.; and Rai, A. Explaining physicians' use of EMR systems and performance in the shakedown phase. *Journal of the American Medical Informatics Association, 18,* 2 (2011), 125–130.

101. Tallon, P.; Kraemer, K.L.; and Gurbaxani, V. Executives' perceptions of the business value of information technology. *Journal of Management Information Systems, 16,* 4 (Spring 2000), 145–173.

102. Taylor, D.; Wolfe, R.; and Cameron, P. Complaints from emergency department patients largely result from treatment and communication problems. *Emergency Medicine, 14,* 1 (2002), 43–49.

103. Toussaint, P., and Coiera, E. Supporting communication in health care. *International Journal of Medical Informatics, 74,* 10 (2005), 779–781.

104. Van Eaton, E.G.; Horvath, K.D.; Lober, W.B.; Rossini, A.J.; and Pellegrini, C.A. A randomized, controlled trial evaluating the impact of a computerized rounding and sign-out system on continuity of care and resident work hours. *Journal of the American College of Surgeons, 200,* 4 (2005), 538–545.

105. Vargo, S., and Lusch, R. Evolving to a new dominant logic for marketing. *Journal of Marketing, 68,* 1 (2004), 1–17.

106. Ventres, W.; Kooienga, S.; Vuckovic, N.; Marlin, R.; Nygren, P.; and Stewart, V. Physicians, patients, and the electronic health record: An ethnographic analysis. *Annals of Family Medicine, 4,* 2 (2006), 124–131.

107. Warshawsky, S.S.; Pliskin, J.S.; Urkin, J.; Cohen, N.; Sharon, A.; Binztok, M.; and Margolis, C.Z. Physician use of a computerized medical record system during the patient encounter: A descriptive study. *Computer Methods and Programs in Biomedicine, 43,* 3–4 (1994), 269–273.

108. Werner, R.M.; Bradlow, E.T.; and Asch, D.A. Healthcare organizational performance measures: Does hospital performance on process measures directly measure high quality care or is it a marker of unmeasured care? *Health Services Research, 43,* 5 (2008), 1464–1484.

109. Westphal, J.D.; Gulati, R.; and Shortell, S.M. Customization or conformity? An institutional and network perspective on the content and consequences of TQM adoption. *Administrative Science Quarterly, 42,* 2 (1997), 366–394.

110. White, A.A.; Wright, S.W.; Blanco, R.; Lemonds, B.; Sisco, J.; Bledsoe, S.; Irwin, C.; Isenhour, J.; and Pichert, J.W. Cause-and-effect analysis of risk management files to assess patient care in the emergency department. *Academic Emergency Medicine, 11,* 10 (2004), 1035–1041.

111. Wilcox, J.B.; Howell, R.D.; and Breivik, E. Questions about formative measurement. *Journal of Business Research, 61,* 12 (2008), 1219–1228.

112. Williams, S.; Schmaltz, S.; Morton, D.; Koss, R.; and Loeb, J. Quality of care in U.S. hospitals as reflected by standardized measures, 2002–2004. *New England Journal of Medicine, 353,* 3 (2005), 255–264.

113. Wright, M.C., and Kaber, D.B. Effects of automation of information-processing functions on teamwork. *Human Factors, 47,* 1 (2005), 50–66.

114. Xiao, Y.; Schenkel, S.; Faraj, S.; Mackenzie, C.F.; and Moss, J. What whiteboards in a trauma center operating suite can teach us about emergency department communication. *Annals of Emergency Medicine, 50,* 4 (2007), 387–395.

115. Zuboff, S. *In the Age of the Smart Machine: The Future of Work and Power.* New York: Basic Books, 1988.

Appendix A

Table A1. List of Clinical, Administrative IT, and Cardiology IT

Category and application	Clinical	Admin	Cardio
Business office			
Document management—business office		1	
Electronic forms—business office		1	
Cardiology and PACS (Picture Archiving and Communication System)			
Cardiology—cath lab	1		1
Cardiology—CT (computerized tomography)	1		1
Cardiology—echocardiology	1		1
Cardiology—intravascular ultrasound	1		1
Cardiology—nuclear cardiology	1		1
Cardiology information system	1		1
ED/operating room/respiratory			
Emergency department IS (EDIS)	1		
Operating room (surgery)—perioperative	1		
Operating room (surgery)—postoperative	1		
Operating room (surgery)—preoperative	1		
Respiratory care information system	1		
OR scheduling		1	
Electronic medical record (EMR)			
Clinical data repository	1		
Clinical decision support	1		
Computerized practitioner order entry (CPOE)	1		
Order entry (includes order communications)	1		
EMR	1		
Physician documentation	1		
Financial decision support			
Business intelligence		1	
Financial modeling		1	
Budgeting		1	
Contract management		1	
Cost accounting		1	
Data warehousing/mining—financial		1	
Executive information system		1	
General financials			
General ledger		1	
Accounts payable		1	
Health information management (HIM)			
Dictation		1	
Dictation with speech recognition		1	
Encoder	1		
Chart deficiency	1		
Chart tracking/locator		1	

(continues)

Table A1. Continued

Category and application	Clinical	Admin	Cardio
Abstracting	1		
In-house transcription		1	
Document management—HIM	1		
Electronic forms—HIM	1		
Outsourced transcription	1		
Human resources			
Personnel management		1	
Benefits administration		1	
Time and attendance		1	
Payroll		1	
Document management—human resources		1	
Electronic forms—human resources		1	
Information sharing			
E-mail		1	
Turnkey portal		1	
Single sign-on		1	
Laboratory			
Blood bank		1	
Anatomical pathology		1	
Microbiology		1	
Laboratory information system		1	
Nursing			
Intensive care/medical surgical	1		
Intensive care	1		
Obstetrical systems (labor and delivery)	1		
Nursing documentation	1		
RFID (radio-frequency identification)—patient tracking	1		
Nurse acuity		1	
Nurse staffing/scheduling		1	
Electronic medication administration record (EMAR)		1	
Staff scheduling		1	
Pharmacy			
Pharmacy management system		1	
Radiology and PACS			
Radiology information system	1		1*
Telemedicine—radiology	1		1
Radiology—angiography	1		1
Radiology—CR (computed radiography)	1		1
Radiology—CT (computerized tomography)	1		1
Radiology—DF (digital fluoroscopy)	1		1
Radiology—digital mammography	1		1
Radiology—DR (digital radiography)	1		1

Category and application	Clinical	Admin	Cardio
Radiology—MRI (magnetic resonance imaging)	1		1
Radiology—nuclear medicine	1		1
Radiology—US (ultrasound)	1		1
Radiology—orthopedic	1		1
Revenue cycle management			
Enterprise master person index (EMPI)		1	
Patient billing		1	
Patient scheduling		1	
Eligibility		1	
Electronic data interchange (EDI)		1	
Credit/collections		1	
Admit discharge transfer/registration		1	
Bed management	1		
Supply chain management			
Enterprise resource planning		1	
RFID—supply tracking		1	
Materials management		1	
Utilization review/risk management			
Case mix management		1	
Data warehousing/mining—clinical		1	
Outcomes and quality management		1	

* Radiology IT is typically used in the cardiology department; therefore, it is included in the count of cardiology IT.

Appendix B: Discussion of Self-Selection Bias

Shaver [95] describes a method for testing self-selection bias that involves extracting predicted values from an equation that is used to predict a dichotomous strategy variable. In our case, we use a ratio to determine whether firms are pursuing more clinical IT than administrative IT. We then code a clinical IT strategy as 1 and administrative as 0 and use several theoretically justifiable variables to predict clinical IT strategy (see Table B1). Using the predicted coefficients from this regression and a number of other explanatory variables from our original model, we predict performance. In our case, we test relationships with all three of our dependent variables (see Table B2). Model 1 in Table B2 reflects the case in which no self-selection correction is entered. In Model 2, the self-selection criteria are added and the coefficients from Model 1 and Model 2 are compared and there is very little change. In Models 3a and 3b the data are split such that only those hospitals pursuing a clinical IT strategy are used in 3a and only those pursuing an administrative IT strategy are used in 3b. The self-selection correction is used in both models and the regression coefficients and variance explained are still stable.

Table B1. Regression Model Used to Generate Predicted Self-Selection Values

	β	Standard error	Significance
Age	0.002	0.001	0.249
FTE	0.000	0.000	0.058
NFP	0.247	0.123	0.044
RUCA	–0.132	0.044	0.003
HOSPINSY	–0.002	0.001	0.074
NETOPEXP	0.000	0.000	0.778
OWNCODE	–0.705	0.287	0.014
STRATEGY	–0.131	0.047	0.006
Constant	0.193	0.387	0.617

Notes: Clinical IT is the dependent variable. FTE = full-time equivalents; NFP = not for profit.

Table B2. Regression Coefficients Predicting Performance with Self-Selection Correction

	Model 1	Model 2	IT clinical Model 3a	IT admin Model 3b
Dependent variable: $Mort_t$				
IP_Care_t	0.005	0.003	–0.010	0.007
TP_Care_t	–0.114***	–0.097***	–0.073*	–0.106***
$Mort_{t-1}$	0.678***	0.665***	0.680***	0.657***
Clinical IT	–0.018	–0.002		
Correction for self-selection		–0.083***	–0.094**	–0.077***
Adj. R^2	0.49	0.49	0.51	0.48
Dependent variable: $Loyal_t$				
IP_Care_t	0.432***	0.444***	0.537***	0.427***
TP_Care_t	0.099***	0.072***	0.132***	0.063**
$Loyal_{t-1}$	0.392***	0.363***	0.395***	0.360***
Clinical IT	0.039**	0.030*		
Correction for self-selection		0.067***	0.124***	0.051*
Adj. R^2	0.60	0.59	0.76	0.56
Dependent variable: $Rating_t$				
IP_Care_t	0.479***	0.480***	0.537***	0.427***
TP_Care_t	0.115***	0.094***	0.132***	0.063**
$Rating_{t-1}$	0.455***	0.454***	0.395***	0.360***
Clinical IT	0.004	0.002		
Correction for self-selection		0.052***	0.124***	0.051*
Adj. R^2	0.76	0.77	0.66	0.80

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.