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An examination of the antecedents and consequences of organizational IT innovation in hospitals

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ABSTRACT

The healthcare industry is widely recognized as information-intensive and IT is considered to be an intrinsic component of the success of healthcare organizations such as hospitals. While both researchers and practitioners have argued that hospitals should aspire to be IT innovators, most tend to be IT laggards. An understanding of the factors that drive hospitals to become IT innovators remains an important phenomenon of interest. However, there is a lack of theory-driven empirical research that systematically investigates the factors that influence a hospital's strategic choice to be an IT innovator and the influence of IT innovation on hospital performance. This study bridges the extant gaps in the literature by developing and testing an integrated model that seeks to understand why certain hospitals are IT innovators. Using IT innovation theory as our theoretical foundation, we examine three antecedents, including the chief information officer (CIO) strategic leadership, the top management team's (TMT) attitude toward IT, and the hospital's climate. Further, we examine the influence of IT innovation on the impact of IT within the hospital and the influence of IT impact on the hospital's financial performance. The research model was tested using both survey and archival data from 70 matched pairs of hospital CIOs and executives. The quantitative analysis is supplemented with by interviews with 10 participating CIOs to further examine the relationship of the CIO to hospital IT innovation. The results suggest that the CIO strategic leadership and the TMT's attitude toward IT are key factors that influence IT innovation; however, the influence of a hospital's climate on organizational IT innovation is contingent upon the CIO's level of strategic leadership. The results also suggest that hospitals that are IT innovators can generate greater impact from IT, which in turn results in greater performance for the hospital. Theoretical and practical implications as well as future research directions are discussed.

1. Introduction

Chief information officers (CIO) regularly face difficult decisions concerning whether, or not, to pursue information technology (IT) innovations. Whereas on the one hand, the innovative use of IT, relative to competitors, can help a firm achieve competitive advantage with IT (Li et al., 2006; Mata et al., 1995), on the other hand, IT innovations that are either unsuccessfully implemented or that do not achieve the anticipated benefits may result in the IT department losing credibility with top management, skepticism regarding future IT investments, or even CIO turnover (Leidner and Mackay, 2007). Decisions concerning IT innovation are particularly agonizing in the healthcare industry because even though the Board of Directors, the

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CEO, and the major user groups (physicians and nursing staff) may agree on the importance of healthcare IT, they nevertheless have difficulty justifying the costs of systems whose benefits largely accrue to external parties, such as patients and insurance providers (Thielst, 2007). Not surprisingly then, many healthcare organizations continue to be IT laggards despite considerable evidence of IT's impact on the quality of care, patient safety, and operational performance (Middleton, 2005). In addition, the healthcare industry trails other information-intensive industries in its use of IT; in fact, in terms of IT expenditure as a percent of revenue, the healthcare industry measures much closer to the agricultural industry than the information-intensive banking and finance sectors (Adams, 2008; Menon and Lee, 2000). Because the healthcare industry remains one of the largest and fastest growing, consuming more than 10% of the GDP in most developed countries (and over 15% in the United States), because of the importance of IT-based innovation to help control healthcare costs and improve healthcare quality, and because of the unique environment characterizing the healthcare industry (Scott, 2005), we believe that it is important to consider the nature of IT innovation within this industry. Examining IT phenomena within an industry context helps both diffuse IS theory more broadly and to increase general IS knowledge (Chiasson and Davidson, 2005).

In spite of the apparent lag with regard to IT expenditures in the healthcare industry compared to other industries, the importance of IT initiatives in healthcare is widely recognized, as for example in the creation of the Wired for Health Care Quality Act (8.1418), unanimously passed by the US Senate on November 18, 2005, which provides competitive grants to providers to facilitate the widespread adoption of healthcare IT initiatives. More recently, the adoption of healthcare information technologies has emerged as a key issue of the United States (US) healthcare policy. The current presidential administration created the Office of the National Coordinator for Health Information Technology (ONCHIT) to provide leadership and strategic planning for the development and nationwide implementation of an interoperable health information technology infrastructure to improve the quality, safety and efficiency of health care (Brown, 2008). Furthermore, the Health Information Technology for Economic and Clinical Health (HITECH) Act was recently passed in 2009. The HITECH Act has provided provisions and economic incentives to health care providers to adopt and implement electronic medical records (Vines, 2010). Specifically, the HITECH Act has allocated more than $40 billion in funding for the development of a national health information infrastructure, including Medicare and Medicaid incentive payments to eligible hospitals and health professionals who demonstrate "meaningful use" of electronic health records (Kenny, 2010).

Indeed, the healthcare industry in developed nations around the world has developed a dependence on IT for maintaining and improving both clinical and business operations (Bernstein et al., 2007). Both academic case studies (e.g., Bhattacherjee et al., 2007; Devaraj and Kohli, 2000; Menon and Lee, 2000; Menon et al., 2000) and popular press descriptions (e.g., Adams, 2008; Austin and Hornberger, 2000; McGinnis et al., 2004; Menachemi et al., 2006; Middleton, 2005), highlight the positive benefits of IT innovations in healthcare organizations. While specific innovations have been the focus of case studies, as have the complexities and contradictions related to the implementation of IT innovations in the healthcare industry (Cho et al., 2007), there is a dearth of theory based empirical research that examines the determinants of IT innovation in hospitals or other healthcare organizations. Using a mixed-method approach (Mingers, 2001), our study seeks to investigate antecedents and consequences of hospital IT innovation. Specifically, we employ a survey to understand the relationship between three antecedents – CIO strategic leadership, TMT support for IT, and Hospital decision-making climate – and hospital IT innovation as well as the relationship between hospital IT innovation and hospital performance. In addition, we employ interviews to dig deeper into the relationship of the CIO and hospital IT innovation.

The remaining sections of the paper proceed as follows. The following section describes the development of the research model and provides support for the hypotheses. The details of the research methodology are then provided, followed by a presentation of the data analysis results. The last section provides a detailed discussion of the results, addresses limitations of the study, identifies implications of our findings, and suggests directions for future research.

2. Theoretical development

2.1. Background

Healthcare information technology is the application of computers to clinical and administrative work in healthcare facilities (Greenhalgh et al., 2009). Many consecutive years of annual double-digit increases in healthcare costs as well as increases in the numbers of healthcare mistakes resulting in patient injuries have led to the promotion of healthcare information technologies as a means of improving the efficiency, cost-effectiveness, quality and safety of medical care deliver (Shekelle et al., 2006). In particular, seven information based innovations in healthcare are considered to offer large potential benefits to providers and patients: electronic communication between patients and providers, electronic prescribing, electronic records with ambulatory computerized physician order entry, e-records with inpatient computerized physician order entry, regional data sharing, electronic intensive care unit surveillance, and disease management systems (First Consulting Group, 2003). These systems have been shown to have various benefits including decreased wait time for patients, reduced error in prescriptions, reduction in the ordering of unnecessary lab tests, better monitoring of chronic illnesses, more flexible monitoring of ICU patients, reduced hospitalizations resulting from improved disease management (such as sending reminders to individuals with chronic ailments to get the yearly flu and pneumococcal vacinnations), and improved billing (Shekelle et al., 2006; Bento, 2002). In spite of the potential benefits offered by these emerging technologies, the vast majority of healthcare providers continue to deliver care, manage information and conduct clinical transactions through the use of

paper-based systems (Shekelle et al., 2006). For example, less than 10% of hospitals make use of computerized physician order entry (Shekelle et al., 2006). And even of those 10% that do have CPOE, less than 5% require its use. There are many reasons for the reluctance of healthcare organizations to invest in innovative IS, including the lack of vendor maturity, cultural resistance, high costs, and the lack of reliable information on costs and benefits (First Consulting Group, 2003). One reason in particular is unique to the healthcare industry: the misalignment of costs and benefits. Many systems intended for healthcare providers offer benefits to patients and insurance companies, but not necessarily the providers themselves. For example, one study found that by using a physician order entry system with decision support, redundant laboratory tests were decreased resulting in a savings of $35,000 in laboratory charges. But neither the user of the system – the doctors – nor the provider of the system – the hospital – directly benefits from the system use. Rather, the payer for the service – the insurance companies – most directly benefit (Shekelle et al., 2006). In this sense, the productivity paradox is alive and well in the healthcare field: those using systems designed to improve the performance of the healthcare system as a whole may experience a decrease in their own personal productivity (e.g., physicians and nurses may spend more time entering data and less time in more productive patient-centric tasks). This suggests that the successful implementation of IS innovations in healthcare is very challenging, requiring not only adequate resources, vision and commitment, but also strong leadership and an enabling culture (Greenhalgh et al., 2009). Our model, developed next, will focus on the leadership and climate dimensions as they relate to the innovative use of IS in hospital settings.

2.2. Research model

The healthcare industry is characterized as complex, turbulent, fragmented, and tightly coupled (Shekelle et al., 2006; Greenhalgh et al., 2009). To succeed in such an environment, complex leadership as opposed to transactional and even transformational leadership may be required (Ford, 2009). Complex leadership involves gaining competency in fostering networks at the bottom, middle, and top of the organization in catalyzing bottom-up participation and innovation, and in nurturing systemic thinking (Ford, 2009). Ford found that complex leadership in healthcare organizations helped create a climate conducive for knowledge sharing and innovative problem solving. Hospital CEOs must be adept at complex leadership behaviors. Because we are interested in hospital IT innovations in hospitals, we will look in particular at CIO leadership and its relationships to IT innovation. IT innovation, as defined by Swanson (1994), is "innovation in the organizational application of digital computer and communications technologies." Hospital IT innovation is the implementation and use of innovative (e.g., new to the adopting organization (Swanson, 1994)) healthcare IT for clinical or administrative tasks. Specifically, we develop an integrated model that examines both the antecedents of hospital IT innovation and the influence of such innovation on hospital performance outcomes. To keep the model within a testable scope, we consider the most salient antecedent and consequent variables identified from the extant bodies of literature. The research model is presented in Fig. 1.

The antecedents in this model are identified and linked to hospital IT innovation through three theoretical perspectives: the visionary leadership perspective (for H1), the upper echelons perspective (for H2), and organizational climate theory (for H3). Furthermore, the resource-based view (RBV) of the firm provides theoretical support for the link between hospital IT innovation (H4) and hospital performance (H5).

2.3. CIO strategic leadership

A wide body of research exists on CEO power (see for example, Eisenhardt and Bourgeois (1988), Haleblian and Finkelstein (1993) and Michel and Hambrick (1992)) and studies of TMT power have also emphasized the power of the CEO (Smith et al., 2006). In the context of hospital top management power, Smith et al. (2006) found that unevenly distributed power across TMT members was associated with higher hospital performance. They also found that hospitals with two powerful TMT members with a shared agenda outperformed those with only a single powerful executive so long as the two held

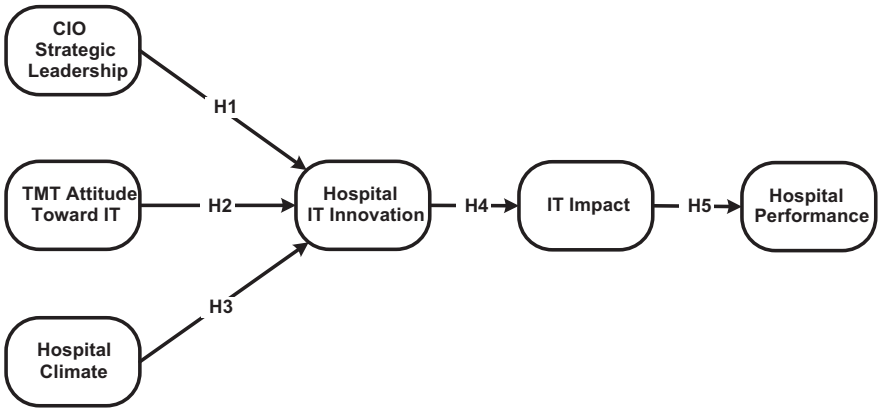

Fig. 1. Research model.

higher power than other members of the TMT. The authors conclude that while the CEO might be primarily engaged in managing external relations, there is a need for another executive, from a different background, to be engaged in the particular internal operations without being burdened with involving all other TMT in agenda management (Smith et al., 2006). In the context of decisions regarding IT innovation in hospitals, one would expect the CIO to be the most appropriate dyad to share power with the CEO. CIOs in hospitals must be concerned not only with the financial impact of IT but also the operational outcomes. Thus, not only do hospital CIOs need adequate business/industry knowledge and technical knowledge, they also must have a certain understanding of the clinical context in which proposed systems will be used (Salas et al., 2007). Given the implications that IT decisions can hold for hospital operations and quality of care, there is a particular need for hospital CIOs to provide strong leadership regarding IT decisions.

It is not known which style of leadership – transaction, transformational, or complex, is most effective for CIOs in the hospital industry. While executive leadership can be conceptualized along multiple theoretical dimensions (Yukl, 2002), we focus on the CIO strategic or visionary leadership because the visionary leadership perspective (Hambrick and Fukutomi, 1991) provides a theoretical base from which the CIO leaders can influence organizational IT innovation. Visionary leadership refers to the ability to create and articulate a realistic, credible, and attractive vision of the future for an organization (Elenkov et al., 2005; Nanus, 1992; Sashkin, 1988). Strategic or visionary leadership behaviors have been found to have strong positive effects on the levels of innovation, risk taking, and creativity within business units (Elenkov et al., 2005; Howell and Avolio, 1993). In the current study, CIO strategic leadership denotes how the CIO creates a vision of IT investment and deployment, shapes and informs the expectations of the IT-enabled values, and weaves business and IT strategies together. All of these influential processes reflect the core IT functional capabilities that deliver strategic value to the firm (Earl and Feeny, 1994; Feeny and Willcocks, 1998). In addition, CIOs shape the IT agenda by providing thought leadership to other top executives making them aware of the potential for IT to support and enhance the strategy of the firm (Enns et al., 2007). CIOs who are capable visionary leaders will be granted the ability to take part in the strategic decision-making processes for the organization and can thereby have greater influence on strategic choices (Chan et al., 2006; Yetton and Bottger, 1982). As such, a CIO who is an effective strategic leader and visionary is able to facilitate the innovative use of IT which in turn allows for impact on organizational outcomes (Sambamurthy et al., 2003). Thus, we posit:

H1. CIO strategic leadership is positively associated with the hospital's level of organizational IT innovation.

2.4. TMT's attitude toward IT

Within a hospital there are numerous organizational actors that can influence organizational strategy including physicians, nurses, staff, administrators, and board members. There are typically more stakeholders involved in the adoption of healthcare IT than in the adoption of IT in other industries (Mantzana et al., 2007). In fact, Mantzana et al. (2007) developed a methodology to aid in the identification of stakeholders in healthcare IT adoption decisions, of which they count some 15 stakeholder groups. As a result of the number and importance of the stakeholders in a hospital, it is not uncommon to find a chief medical officer (CMO) and chief nursing officer (CNO) on the top management team, in addition to the traditional top administrative executives (CEO, COO, CFO, etc.). The CMO and CNO bring with them a good understanding of the key users' view toward hospital IT and are able to influence the response of physician and nursing groups to innovative IT. Having powerful members of the medical staff supporting an innovative IS can be critical to the successful implementation (Kohli and Kettinger, 2004).

Both theoretical discussions and empirical investigations have indicated that organizational acceptance and promotion of innovation requires top management support (Drucker, 1985; Elenkov et al., 2005; Ireland and Hitt, 1999; Jassawalla and Sashittal, 2000). In a prior research study, Hage and Dewar (1973) found that the values of the organization's TMT explained more of the variance in organizational innovation than any single structural dimension. The role of the TMT's attitudes are of particular importance when examining IT innovation at an organizational level since the strategic purpose of IT is often not clearly defined and is contingent upon direction from the TMT (Preston and Karahanna, 2009). The upper echelons perspective contends that an organization's strategic choices are primarily reflections of the TMT's attitudes and that background characteristics and general beliefs help form specific attitudes that are then reflected in strategic choices for the organization. As such, we examine a more proximal factor, the TMT's attitude toward IT, that we posit influences the choice of IT innovation.

Researchers have found that the TMT's attitude toward IT is the most important factor that contributes to the success of IT deployment in the organization (Earl and Feeny, 1994; Jarvenpaa and Ives, 1991). The TMT's attitude toward IT is what provides a guideline for IT strategic initiatives (Jarvenpaa and Ives, 1991). A strong positive orientation toward IT from the TMT is needed to provide an environment within the organization that is conducive for developing IT applications for competitive advantage (Jarvenpaa and Ives, 1990). Such an orientation from the TMT will promote an organizational environment as one in which innovations in IT are welcome or even required. For the organization to be an IT innovator, the TMT must view IT as a component of corporate strategy and provide a salient attitude that IT initiatives are instrumental to the success or failure of the organization (Jarvenpaa and Ives, 1990, 1991). In a hospital setting, to the extent that this collective TMT (top medical and top administrative executives) exhibit strong support toward IT, IT innovation would expected to follow. We thus posit,

H2. The hospital TMT's attitude toward IT is positively associated with the hospital's level of IT innovation.

2.5. Hospital decision-making climate

An organizational climate for innovation can be defined as the extent to which the values and norms of an organization emphasize innovation (West and Anderson, 1996; West and Wallace, 1991). A major theme in the innovation literature is that innovation is more likely to occur in an organizational climate in which key organizational members are encouraged to be innovative and innovative attempts are rewarded rather than punished (West and Anderson, 1996). Executives and organizational decision-makers will base their behavior and the judgment of other's behavior on the norms and values provided by their organization (Ashford et al., 1998; Dutton et al., 2002; Neal et al., 2005). In this study, we assess hospital decision-making climate as the shared perception of the degree to which an organization encourages its executives to be assertive and act independently to take initiative.

Although hospitals are often portrayed as risk-averse and bureaucratic organizations (O'Brien, 2008) and thus not prone to climates that foster innovation (Denison et al., 1995), there is emerging evidence that hospitals that are able to inculcate internal environments that encourage executives to innovate experience greater IT innovation. Extant research also suggests that the hospital climate exerts a strong influence over the degree to which IT innovations are diffused through the hospital (Wainwright and Waring, 2007), the level of group-level resistance to IT innovations (Lapointe and Rivard, 2005), and the degree to which organizational-level inertia can be overcome (Lapointe and Rivard, 2007). Hospital norms that foster an environment that encourages and rewards assertive behavior by its executives provide the incentives for its executives to be more innovative in all functional areas. Thus, we posit:

H3. A hospital's climate that encourages its executive management to be assertive is positively associated with the hospital's level of organizational IT innovation.

2.6. The impact of IT innovation on hospital performance

Much work has investigated the impacts of specific healthcare IS innovations. In an analysis of over 100 studies of information-based healthcare technology, the Massachusetts Technology Collaborative details the financial and quality of care related benefits of implementing such systems. In s report prepared by the First Consulting Group (2003), disease management tools are projected to enable $710 million in annual savings for the state of Massachusetts and inpatient computerized order entry, almost $1 billion. The report also projects major savings from e-prescription, e-ICU, and regional data sharing systems. However, Greenhalgh et al. (2009), in a meta-analysis of electronic health record research, notes that there are as many studies that conclude that large-scale IT in healthcare does not pay off as there are that conclude that such systems do pay off. And in their extensive review of 256 healthcare IS articles, Shekelle et al. (2006) conclude that based upon the existing published studies, it is impossible to make firm conclusions about which systems are most likely to provide certain health benefits. This inconclusiveness is in part related to the complexity of the industry but may also be related to the length of time required for payback. Shekelle et al. (2006) estimate that the payback period for major healthcare IS ranges from 6 to 13 years. Studies might conclude prematurely that there is no financial impact when the impact has simply not had time to be realized.

Other research has examined the relationship between what might be labeled general IT adoption – that is, IT for clinical and administrative uses as opposed to specific healthcare applications such as e-prescription technology – and hospital performance (Bhattacherjee et al., 2007; Menachemi et al., 2006). IT for clinical and administrative uses in hospitals has been shown to have a positive association with hospital financial performance (Menachemi et al., 2006) and the use of clinical IT systems have been shown to be positively associated with hospital operational performance (Bhattacherjee et al., 2007). One explanation as to why hospital IT innovation with clinical and administrative systems might influence performance is that hospitals that are able to successfully implement IT develop valuable skills relating to IT implementation and change management. These skills can then be appropriated for future IT implementations, enabling the hospital to implement new IT with less cost and effort than hospitals that have not developed these IT skills. As such, hospitals may be able to obtain superior performance returns through constant IT innovation, which is widely recognized as an important organizational capability which creates value to the firm (Ross et al., 1996).

In accordance with the RBV perspective, technological innovations which are unevenly transferrable across firms allow for different IT capabilities that can have pervasive effects on various aspects of the organization (Bharadwaj, 2000). Due to the malleable nature of IT, innovative configurations and uses of IT enhance the organizational capabilities to leverage IT to create opportunities and digital options for companies to achieve strategic differentiation and thereby competitive advantage (Karahanna and Watson, 2006; Porter and Millar, 1985; Sambamurthy et al., 2003). These IT capabilities, though hard to measure directly, can be observed through increasing IT impact on various organizational performance metrics (Premkumar and King, 1992; Saunders and Jones, 1992) which ultimately result in superior financial performance of the organization. Therefore, based on the resource-based view of IT management literature, we propose that hospital IT innovation directly facilitates the IT impact, which consequently influence the financial performance of the hospital. We thus hypothesize:

H4. The hospital's level of organizational IT innovation is positively associated with IT impact.

H5. The impact made via IT is positively associated with the performance of the hospital.

3. Research methodology

To test the research model and hypotheses, we collected survey and interview data from a sample of US based hospitals. Survey data were collected through a field study approach from CIOs and their matched hospital executives using a questionnaire. Interview data was gathered from interviews with ten CIOs of hospitals and healthcare systems.

3.1. Survey measures

CIO Strategic Leadership defined as the degree that the organization's CIO is a key strategic leader within the organization, is measured as the degree to which the CIO is an effective: strategic leader; strategic business planner; and visionary (Smaltz et al., 2006). The assessment of CIO leadership is based on the responses of hospital executives, rather than CIOs, to reduce CIO self reporting bias. The *TMT's Attitude toward IT*, defined as the degree to which the TMT views IT as an essential component of the organizational success, is measured as the degree to which the TMT: has a favorable attitude toward IT, believes that IT initiatives can positively impact organizational outcomes, supports the view that IT is critical to the success of the organization. These measures were derived from our executive interviews. The assessment of the TMT's attitude toward IT is based on the responses of CIOs. The CIO was chosen as the respondent for these measures to reduce self reporting bias. In addition, the CIO can gauge if the TMT's attitude toward IT is recognized through the organization since a vision will have the greatest effect if it is understood by other organizational members (Elenkov et al., 2005). *Hospital Decision-making Climate* defined as an organizational climate that encourages its executives to be assertive and independently take action, is measured as the organization's encouragement of its executives to: have a "take charge" attitude; develop their own solutions to pressing organizational problems; independently introduce new structures, technologies, or approaches to improve efficiency; take the initiative to institute new effective work methods (Morrison and Phelps, 1999; Neal et al., 2005; Parker et al., 2006; Patterson et al., 2005). The assessment of the hospital decision-making climate is based on the responses of hospital executives.

Hospital IT Innovation defined as the degree that the hospital's IT strategy is to be industry innovator, is measured as the degree to which the hospital is a leading IT innovator; believes in being first in the industry in developing new IT initiatives even if not all of these efforts prove to be highly profitable; responds rapidly to early signals concerning areas of opportunity for IT; IT initiatives are often emulated by competitors in the industry (Conant et al., 1990; Li et al., 2006; Segev, 1987). In this study, the hospital's level of organizational IT innovation is assessed based on the average of the CIO and hospital executive responses[1]. As such, these measures were developed so that either the CIO or a hospital executive could be a valid respondent.

IT Impact is defined as the impact that IT makes on hospital performance and is measured as the degree to which IT contributes to the following performance measures of the hospital: return on investment, market share increase, and process improvement. These measures were derived from Premkumar and King (1992) and Saunders and Jones (1992). For the same reason of reducing CIO self reporting bias, the hospital executives were chosen as the respondent to assess the IT impact for these items.

Finally, *Hospital Performance* was defined as the financial performance of the hospital and thereby measured by objective archival data. We use two variables to measure financial performance: return on assets (ROA), return on equity (ROE). Each of these measures has been widely used to assess hospital performance (Brown et al., 1995; Douglas and Ryman, 2003; Westphal et al., 1997). ROA focuses on the overall performance of the firm (Li and Ye, 1999) and is calculated by dividing net income by total assets. ROE provides an alternative measure of how effectively a firm has utilized its financial capital and is related to the economic value added (Hitt and Brynjolfsson, 1996). ROE is calculated by dividing net income by the total assets minus liabilities. The data used to calculate each of these financial measures were derived from the American Hospital Directory (AHD). Each of these three measures of hospital performance for each hospital was calculated by averaging the end of the reporting year from 2007–2008. Financial performance is of high relevance to both for-profit and not-for-profit hospitals. However, we control for the profit status of the hospital when we test the research model.

3.2. Survey administration

The final items and scales used to measure the various constructs are presented in Appendix A. The target respondents include both CIOs and hospital executives. A summary of key informants for each construct is provided in Appendix C.

A matched sampling strategy consisting of two stages was employed for the distribution of the CIO and hospital executive surveys. In the first stage, a total of 720 surveys were sent to a list of CIOs from hospitals in the United States. The CIO contact information was derived from the Dun and Bradstreet Million Dollar Database (D&B Database) and from the American Hospital Directory (AHD). A total of 149 CIO surveys were returned for a total response rate of 20.7%. The identity of the CIO was tracked by coding the survey. This first stage of the sampling was conducted from September 2006 through December 2006. In the second stage, a second instrument was sent to select hospital executives of each organization for which we had received a completed CIO questionnaire. Hospital executives included the CEO, other traditional C-level executives (e.g., chief

[1] The agreement between the CIO and hospital executives was assessed via r_{wg} (James et al., 1984). The mean and median agreement levels were 0.88 and 0.94, respectively, indicating substantial agreement between the CIO and hospital executives. In addition, 64 of the 70 matched pairs (91.4%) had a high level of agreement ($r_{wg} > 0.70$, James et al., 1984).

operating officer, chief financial officer) and other individuals with traditional executive titles within the hospital (e.g., chief medical officer, chief nursing officer, vice-president, executive director, etc.). Hospital executives were identified through secondary data sources (e.g., D&B Database, AHD, and corporate websites). Respondents were asked about their membership in the TMT and the reporting structure of the organization in the survey. This second stage of the sampling was conducted from December 2006 through March 2007.

A total of 70 of the 149 organizations returned at least one usable hospital executive survey yielding an organizational response rate of 47.0%. Of the 70 firms with matched CIO-hospital executive responses, 43 (61.4%) had a single hospital executive respondent. Multiple responses from hospital executives were obtained from several of responding organizations. We obtained responses from two hospital executives in 27 (38.6%) and three hospital executives in 10 (14.3%) of the organizations. Therefore, we received a total of 107 hospitals executive respondents across the 70 organizations. Within-firm agreement was assessed and found to be acceptable, which suggests substantial agreement among the hospital executives within the organization.[2] This assessment provides support for combining these hospital executives' assessments to produce averaged, aggregated scores for respective firms (Waldman et al., 2001). Therefore, we evaluated multiple hospital executives' responses through a consensus evaluation by taking the mean of answers from all responding TMT members within the same organization. This approach also provides additional evidence showing that data obtained from these single hospital executive respondents are valid reflections of team and organizational phenomena (Armstrong and Sambamurthy, 1999; Smaltz et al., 2006).

Non-response bias was examined using two approaches for both stages of the survey distribution. We first assessed non-response bias by comparing the total annual revenues and number of employees (via ANOVA) of the 70 responding hospitals to that of all non-responding hospitals (based on the NAICS code listed in the D&B Database). Our assessment revealed no significant differences between responding and non-responding hospitals. Next, we compared the average measures (via ANOVA) for each of the study's constructs between early and late respondents. This assessment revealed no significant differences between early and late respondents. The test results suggest that non-response bias was not a significant concern for our data sample. The characteristics of the CIO respondents, hospital executive respondents, and their organizations are summarized in Appendix B. Summary statistics for CIO and hospital executive responses to each questionnaire item are provided in Appendix C.

3.3. Interview data

Interviews were conducted with ten CIOs of hospitals and healthcare systems. A semi-structured interview protocol was followed, wherein the CIOs were asked about their background and asked to describe specific IT-innovations undertaken in the hospital during their tenures. Questions concerning the role of the CIO in the innovation, as well as the role of other TMT, and medical and clinical staff were asked to all CIOs. Follow-up questions were asked to understand the nature and extent of the innovation as well as to find out whether the innovation was an industry first-in-kind or an example of an innovation that was new to the hospital but not new to the industry.

To analyze the interview data, for each hospital, we first coded the statements of the interviewees into several high-level categories, including innovation type, innovation process, innovation initiator, and innovation members. We then further coded into more specific categories within each of the high-level categories. For innovation type, we initially coded for radical versus incremental innovation (Dewar and Dutton, 1986) but quickly noted that an innovation could be radical for the hospital and yet very standard for the industry, leading us to adopt a modified categorization of local versus industry innovation. Local versus industry innovation – a reflection of the innovativeness of the innovation – was a major theme that arose in our interviews with roughly half the CIOs experiencing local innovation and the other half, experiencing industry innovation where the former form of innovation takes existing innovations present in other hospitals and applies locally whereas the latter seeks new innovations not widely diffused in the hospital industry. For innovation process, we wrote down notes describing the interviewees' characterization of the process. This led to the more precise coding of whether the CIO and IT department were driving innovation or receiving innovation directives from others in the organization. For innovation members, we noted which organizational members/teams were involved in the innovation process, including the CIO, CEO, TMT, and the Board. We noted quickly the mention of the Board as a major player in innovation, which was not something we anticipated. We had not specifically asked the CIOs about the role of the Board of their hospitals, yet each voluntarily discussed the issue. We therefore treated the role of the Board as an important construct. Our final innovation coding related to the individuals involved in the innovation process: we coded each interview for the major initiator of innovation. Finally, we coded for information about the CIO characteristics, noting such details as the length of time the CIO had worked in the hospital, the CIO's professional background, of which we noted some with a medical background, some with a finance/accounting background, and some with an IT-background, and the length of time the CIO had served as the firm's top IS executive. Following these codings of the interview transcripts, we composed innovation profiles of each hospital. These were in essence mini-cases describing the innovation process of each hospital. We then conducted a cross-profile analysis to determine the factors that appeared most significant in differentiating innovation processes across the hospitals.

[2] For organizations where we obtained multiple responses, we assessed respondent agreement with r_{wg} (James et al., 1984) for the variables (CIO strategic leadership, organizational climate, IT innovation, and IT impact) for which the hospital executive was a key respondent. In all cases, median and mean responses on level of agreement were above 0.80.

4. Data analysis and results

4.1. Survey results

To establish the nomological validity of the research model, we analyzed the survey data using partial least squares (PLS) with a two-step analytic approach. First, the measurement model was evaluated to assess the validity and reliability of the measures. Second, the structural model was evaluated to assess the strength of the hypothesized links among the variables. The psychometric properties of all scales were assessed within the context of the structural model through an assessment of discriminant validity and reliability.

4.2. Measurement model

IT impact was modeled as a formative construct based on the following established criteria (Jarvis et al., 2003): (1) the indicators are viewed as defining characteristics of the construct; (2) changes in the indicators are expected to cause changes in the construct; (3) changes in the construct are not expected to cause changes in the indicators; (4) eliminating an indicator may alter the conceptual domain of the construct; (5) a change in the value of one of the indicators is not necessarily expected to be associated with a change in all of the other indicators. Our IT impact measures cover aspects of performance that represent profitability, market share, and productivity and are therefore formatively modeled (Petter et al., 2007). All other variables were modeled as reflective constructs. The psychometric properties of the scales were assessed in terms of item loadings, internal consistency, and discriminant validity. Item loadings and internal consistencies greater than 0.70 are generally considered acceptable (Fornell and Larcker, 1981). As can be observed from the factor analysis results (Table 1) and composite reliability scores (Table 2), scales used in the study meet these guidelines. To assess discriminant validity, we followed the guidelines set by Chin (1998): (i) indicators should load more strongly on their corresponding construct than on other constructs in the model; and (ii) the square root of the average variance extracted (AVE) should be greater than the inter-construct correlations. As displayed in Table 1, items loaded more highly on their own construct than on other constructs. Also, as shown by comparing the inter-construct correlations and AVE (shaded leading diagonal) in Table 2, all of the constructs shared more variance with their indicators than with other constructs. Thus, these results support the discriminant validity of the constructs in the model.

4.3. Structural model

Since the measurement validity and reliability were supported, in the next step, we employed partial least squares (PLS) to test the structural model. The significance of the paths was determined using the *T*-statistic calculated with the bootstrapping technique. In accordance with the extant literature, we included a series of organizational variables (organizational size, organizational age, geographic location, and profit/non-profit status) in the analysis as control variables for both IT innovation and hospital performance. This set of organizational variables was included to control for potential differences in organizational characteristics that could potentially influence either the organization's level of innovation or performance. Through the inclusion of these control variables we were able to focus on the relationships in our research model while establishing baseline controls for organizational differences. When included in the model, none of these control variables had a significant impact on the IT innovation and hospital performance and were thereby dropped from the model as

Table 1
Results of factor analysis.

	CIO strategic leadership	TMT attitude	Hospital climate	IT innovation	IT impact	Hospital performance
CIOlead1	**0.921**	0.088	0.235	0.285	0.533	0.231
CIOlead2	**0.954**	0.012	0.092	0.425	0.559	0.134
CIOlead3	**0.968**	0.017	0.187	0.395	0.566	0.172
TMTatt1	0.042	**0.924**	0.047	0.381	0.126	0.042
TMTatt2	0.020	**0.706**	0.183	0.130	0.108	0.077
TMTatt3	0.024	**0.938**	0.132	0.333	0.068	0.006
HospClim1	0.153	0.045	**0.874**	0.281	0.191	0.312
HospClim2	0.071	0.015	**0.784**	0.044	0.079	0.049
HospClim3	0.131	0.156	**0.821**	0.184	0.157	0.118
HospClim4	0.151	0.146	**0.735**	0.098	0.240	0.126
ITinnov1	0.387	0.380	0.206	**0.931**	0.458	0.177
ITinnov2	0.350	0.238	0.183	**0.896**	0.578	0.148
ITinnov3	0.399	0.345	0.324	**0.903**	0.582	0.199
ITinnov4	0.315	0.353	0.189	**0.926**	0.551	0.241
Impact1	0.582	0.134	0.172	0.576	**0.970**	0.319
Impact2	0.397	0.005	0.272	0.499	**0.829**	0.262
Impact3	0.531	0.133	0.197	0.445	**0.753**	0.253
ROA	0.147	0.051	0.192	0.177	0.300	**0.918**
ROE	0.178	0.005	0.260	0.196	0.270	**0.828**

Table 2
Inter-construct correlations.

	Composite reliability (# items)	CIO strategic leadership	TMT attitude	Hospital climate	IT innovation	IT impact	Hospital perform
CIO strategic leadership	0.964 (3)	**0.948**					
TMT attitude	0.895 (3)	0.035	**0.862**				
Hospital decision-making climate	0.867 (4)	0.171	0.113	**0.789**			
IT innovation	0.953 (4)	0.398	0.361	0.250	**0.913**		
IT impact	N/A (3)	0.383	0.111	0.220	0.595	**0.821**	
Hospital performance	0.865 (2)	0.181	0.032	0.250	0.210	0.327	**0.940**

Notes: (a) N/A: formative items – reliability measures are not relevant and (b) the bold numbers on the leading diagonal are the square root of the AVE.

controls for hospital IT innovation. In addition, we included prior hospital performance, measured as the average of the previous three years of ROA and ROE, as a control variable for hospital performance. Prior hospital performance was found to be significant and was retained in the model as a control for hospital performance. The path coefficients and explained variances in the dependent variables for the structural model are shown in Fig. 2. Table 3 presents a summary of the hypothesis testing results. We note that the mean value for hospital IT innovation within our sample was 2.85 (scale from 1.00 to 5.00) with a standard deviation of 0.77 and a range extending from 1.25 to 4.15 (Appendix C). We found that the percentage of hospitals above and below the neutral level of IT Innovation (3.00 out of 5.00) was 54.3% and 45.7%, respectively. Therefore, we found that the hospitals tend to be normally distributed with respect to IT innovation.

The results indicate that CIO strategic leadership and the TMT's attitude toward IT are significant antecedents of IT innovation while hospital decision-making climate is not a significant antecedent. We also observe that hospital IT innovation significantly influences the impact of IT within the hospital, which in turn significantly influences the financial performance of the hospital.

4.4. Interview results

The survey results provide support for the importance of the CIO in hospital IT innovation, but do not provide insights into the nature of this relationship and how the hospital CIO is able to effectuate IT innovation. Our interviews provide insights into ways that hospital CIOs are able to spearhead successful IT innovations. From our analysis of the profiles developed based upon the interviews, we derived four types of CIO innovators, depicted in Fig. 3.

4.5. The board-informing CIO innovators

The Board-informing CIO innovators, among which there were 3, refer to CIOs who work in hospitals with a relatively IT-unsavvy Board and who typically engage in local rather than industry innovation. One CIO, who had a clinical background and was well familiar both with IT and with medical processes, characterized the IT-background of the Board as one of "disenlightenment." The Board in these hospitals relies upon the CIO as an informer and educator on existing industry innovations moreso than for new ideas ("new" in the sense of being new to the industry). Said one CIO, "the need for the visionary part is not as strong. It's more operational rather than figuring out what is the next thing out there." The CIOs them-

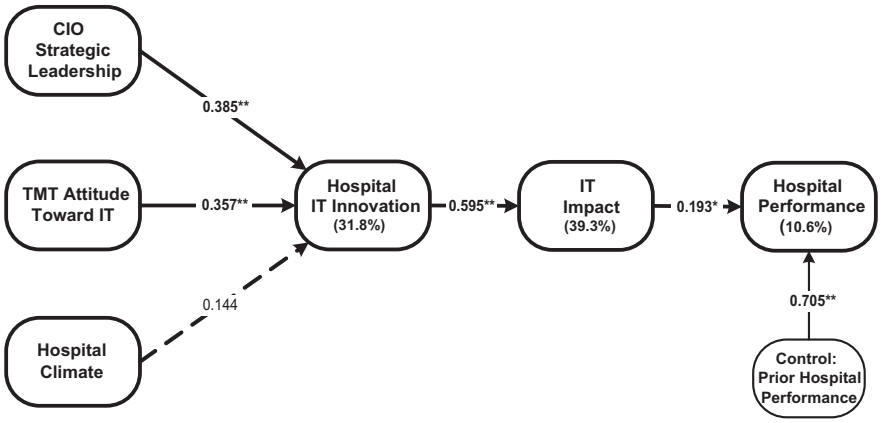

Fig. 2. Structural model. Note: ** Significant at 0.01; *Significant at 0.05; IT Impact individually and collectively with Prior Hospital Performance, respectively, explains 10.6% and 58.6% of the variance in Hospital Performance.

Table 3
Summary of hypothesis tests.

Hypotheses	Support for hypotheses
H1: CIO strategic leadership → Hospital IT innovation	**Supported****
H2: TMT attitude toward IT → Hospital IT innovation	**Supported****
H3: Hospital climate → Hospital IT innovation	Not Supported
H4: Hospital IT innovation → IT impact	**Supported****
H5: IT impact → Hospital performance	**Supported***

Note: **Significant at 0.01.

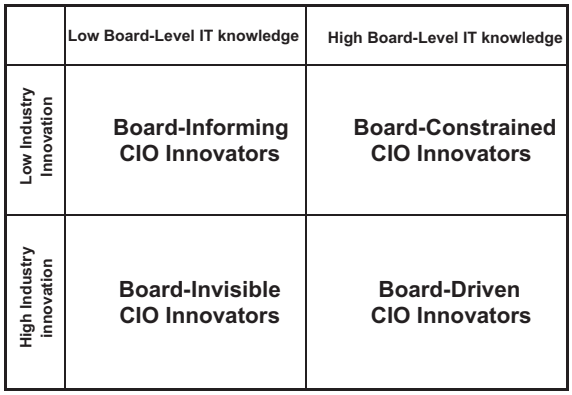

Fig. 3. Types of hospital CIO innovators.

selves rely heavily on vendors to keep up with industry innovations. Board-informing local innovators, not surprisingly, are well-positioned to seek more "off the shelf" products. While the Board may be aware of what other hospitals are doing, this awareness infrequently translates into industry innovation. Innovations occur, but only in the sense that it is an innovation for the particular hospital. One CIO gave the example of a clinical system, describing the "most innovative part" of the decision as "the massive standardization of business and clinical practices across the hospital."

A significant challenge for the CIOs in these hospitals is that, because the Board is not IT-savvy, the IT implications of major strategic decisions are ignored. Said one CIO, "because we always found out about initiatives that were going on within the organization well after they started to unfold, the IT implications of those things always became an afterthought. For example, one hospital system [in our network] built a 600 and 75 million dollar hospital and did not come to us for any of the IT components that would be required for it until well after the budget for the hospital had been approved. There were literally tens of millions of dollars of IT costs of tagged onto the project as an afterthought." Such a pattern can lead to a perspective that IT is an enormous cost-burden that gets in the way of strategic initiatives, rather than making them possible.

In short, the Board-informing CIO innovators seek to take existing innovations within the healthcare sector and apply them locally at as low a cost as possible, partnering with vendors to take advantage of vanilla solutions. The CIO must keep the board apprised of important innovations occurring elsewhere, and hence must themselves maintain a strong network of contacts with other hospitals as well as with vendors, and also work to keep the board educated on the potential of IT to improve hospital operations. Fortunately, the Board in these hospitals appears receptive to listening to and learning from the CIO. The CIOs in such hospitals play a role similar to IT consultants wherein the knowledge differential between them and the Board provides them with power to influence perceptions on what is, and is not, technically possible as well as what is even a technical versus a social system (Bloomfield and Ardha Best, 1992). Elkjaer et al. (1991) warn about the potential negative consequences of such a knowledge differential, surfacing how consultants, in attempting to maintain their image as experts, are inclined to ignore questions from users or management that seem to contradict their technical advice. Thus, provided that the CIOs do not use their power differential to ignore concerns and opposition, the Board-informing CIO can enjoy a strong relationship with the Board and oversee successful IT innovations.

4.6. The Board-constrained CIO innovators

The Board-constrained CIO innovators, among which there were 2, refer to CIOs who find themselves in hospitals with a relatively IT-savvy Board and yet are confined to local innovation. Because the Board is confident in its appraisal of IT, the CIO is less a leader and visionary or an informer than a follower of Board discretion. While these CIOs also work to

"educate them (the Board and TMT) to the technology and benefits", they see themselves more as "facilitators" than "visionaries" and focus on obtaining the "right resources" to meet the hospital's needs. We had two CIOs in this category and both had backgrounds in accounting/finance although both had been in the hospital industry for an extensive period of time (18 and 22 years). While both were conferred the title "CIO", one was not a formal member of the C-Suite. The innovations described by both of these CIOs were largely local, such as the implementation of Vista Systems, which while innovative for the hospital, is something that the CIO described as having "been implemented in the Veterans Administration for 20 years and also recognized by the Institute of Medicine and many publications." The other CIO, while active in assessing "how we can take our IT and make it stand out compared to our competitors out there," is still wrestling with electronic records and is also making small local innovations, such as providing wireless access for patients and visitors in certain areas of the hospital.

Board-constrained CIOs report an unwillingness to pursue any project unless the numbers are clearly favorable: "I can't feel comfortable about making a decision on anything- unless I provide numbers." In the case of Board-informing CIOs, if the numbers are favorable, the Board tends to follow the CIO recommendation. With Board-constrained CIOs, even if the numbers suggest a project might be valuable, these CIOs do not always get the support from the Board. One CIO reported "sometimes, there is a project I think we need to do and but am told 'not right now'. Sometimes, I am given the answer as to why we can not do it right now, and then I do have a better understanding if something is out of my control or knowledge base, and I can't know that, because of the nature of what's preventing me from moving forward." Similar to Board-informing CIOs, the Board-constrained CIOs are sometimes out of the loop on major initiatives – "sometimes there are things that I'm not totally privy to". However, unlike the Board-informing CIOs, this appears to be more because the Board trusts its own assessment of IT rather than because the Board simply fails to realize there are IT consequences of their strategic decisions. Because the Board relies on its own assessment of IT more than it relies upon the CIO to inform them of important IT developments, these Board-constrained CIOs are limited in their ability to innovate as well as in their ability to provide strategic leadership.

4.7. The Board-invisible CIO innovators

The Board-invisible CIO innovators, among which there were 3, refer to CIOs who personally strive for industry innovation while working in hospitals with Boards who are not particularly IT-savvy. These CIOs express strong personal commitment to innovation and to finding ways to innovate in spite of a Board that does not understand the capacity of IT to innovate. To compensate, these CIOs innovate surreptitiously, innovating behind the scenes, or "outside the realm of the standard procedures" in the words of a CIO, until the innovation itself can speak for itself. One of our invisible innovator CIOs described TMT and the Board as "being pretty supportive" yet also "not necessarily knowing everything that we're doing on the innovation side". The CIO went onto explain that he will generally wait until he has an agreement with a vendor to inform the TMT and Board because he "won't allow them the opportunity to squash the innovation".

The innovation in these hospitals is largely driven by the CIO rather than the TMT or Board. One CIO described his predecessor as having established a culture of innovation: "Innovation is hard and will fail a lot. When (the predecessor) came, he pushed us to do a couple of things that were really innovative and spun people's heads around a little bit. From a technical standpoint, we failed a couple of times, and we were sweating it, because they were saying, 'Oh, no, what's our new leader going to do, because technically, it didn't work right', but he was cool with it." Now CIO himself, our informant has a process in place to facilitate innovation: driven "from the bottom-up, we seek out what we call 'the knowledge needs of our users', and we deliberately manage that activity. So, we have a group of people who go out every month to every entity and encourage them to think about those things." The innovations in these hospitals often start small and grow. One of the two invisible innovator CIOs described a system he is currently working on where "we as technologists had some vision and reached out to Microsoft to develop an application that will enable a higher quality of care for our patients. We'll be debuting our first application in a month. Now, this application is not going to change the world; it's kind of our first foray as a youth case, but should that work well and be successful, and we suspect it will be, and then we'll actually do something with some of our neurologists that will really change and impact the way that we deliver care." The other Invisible Innovator CIO described "never knowing where the benefit is going to come from. The XYZ Project (an award-winning project) wasn't what we started off to do. It mutated into that. What we wanted to do actually was a cool project that we never got around to."

A characteristic of invisible innovator CIOs is that they have strong technical backgrounds yet also have some experience on the clinical side, if even just having earned a pre-med college degree (one of the CIOs) or having worked in physician relations (another of the CIOs) and, as such, having acquired an appreciation for the complexity of the environment. The complexity of the environment was emphasized by both of our invisible innovator CIOs. Said one, "I don't need to remember every interaction you've had with the bank, and I don't care how many other banks you interact with. It's irrelevant to me, but I do in healthcare need to know how often you come to visit, what the nature of your visit is and then I have to know how many other participants in the healthcare system you've been to visit in order to be able to make a real decision. When people try to oversimplify healthcare, I think they make a mistake."

Lastly, the invisible innovator CIOs attribute a large part of their current ability to innovate with past successes such that the Board and TMT, while not-IT savvy, "have a level of confidence that they didn't have maybe 10 years ago" and are willing to let the CIO serve in a visionary capacity. Thus, unlike the Board-constrained CIO innovators, the Board-invisible CIO inno-

vators operate in a relatively favorable environment because the Board appears to trust the CIO even if it does not fully understand IT.

4.8. The Board-driven CIO innovators

The Board-driven CIO innovators, among which there were 2, refer to CIOs in hospitals with IT-savvy Boards that pursue industry innovation. In these hospitals, the Board is influential and involved with a keen interest in clinical applications. Also, in these hospitals, clinical applications are considered more strategic than operational or financial ones. The CIO needs a clinical background to relate well to, and be trusted by, the board. Both of the CIOs we interviewed who are Board-driven innovators have clinical backgrounds, one having earned an MD and one with a PhD having extensive experience conducting cancer research. Board-driven CIO innovators have not only the backing of the Board to innovate with IT, but often are given mandates by the Board to innovate. With the Board comprised of many influential MDs, the CIOs are able to effectively implement IT without the degree of resistance that one expects of IT innovation in general (Markus and Benjamin, 1996) and hospitals in particular (Connell, 2004). One of the hospital's Boards set a goal of "being a leader with IT" and gave the CIO the mandate to drive strategic planning. This CIO reported that if he "were to do everything they wanted, we wouldn't be able to pay for it all." Although the Board drives IT innovation in these hospitals, the CIOs must sometimes reign in an overzealous Board that is pushing for innovation that the CIO believes is premature, either technologically or organizationally. One CIO recounted not wanting to move forward with a major innovation because he saw "all types of problems" with it and telling the Board that "it's going to be a catastrophe" to no avail: the Board insisted on moving forward and, as the CIO predicted, "it took us two years to get out of it financially. We took a huge hit." Similarly, another CIO reported on an innovation that was approved by the Board and the Finance Committee, but not approved by the Internal Network Strategy Group. Again, it was the IT department having to pull in the reins on what was perceived as an over IT-zealous Board. In addition to sometimes having to bring realism to Board ambitions for IT, the Board-driven CIO innovators also face challenges finding appropriate vendors because often, the technology desired is ahead of the market. In this case, partnering with technology firms to develop the innovations is undertaken. One CIO said that "the technology was not available, so we went out and found a partner that we have worked with," to jointly develop a new solution.

In spite of the challenges, hospitals with Board-driven CIO innovators experience high degrees of industry innovations. Examples of major innovations included being the first in industry to adopt a common medical record number such that any patient to any of the 12 clinics or hospitals in the system has a single ID in the system, facilitating the sharing of information across clinicians and sub-specialties, as well as facilitating billing. In another hospital, they were among the first to establish a virtual patient record system that "breaks down information into hospitalizations, imaging and exams." Physicians are able to access the virtual patient record from anywhere and do not have to log into multiple systems to get the information they need. Another industry innovation dealt with monitoring patients at home so they would not have to be visited each day and equipping nursing staff with notebooks such that when they visited home patients, they could electronically transmit data back and forth with the hospital.

5. Discussion of results

We found that CIO strategic leadership and the TMT's attitude toward IT both influence the hospital's level of IT innovation. First, we observed that the strategic leadership of the CIO was a key determinant in the hospital's level of IT innovation. In fact, the results indicate that CIO strategic leadership was the most important factor that determines organizational IT innovation. This finding provides additional empirical support for the prior IS leadership research that the CIO is a key figure that can impact strategic choices within the organization (Preston and Karahanna, 2009). This finding is consistent with Elenkov et al. (2005) who found that executives should not rely on their hierarchical position alone and that executives who possess relevant strategic leadership skills can have the capacity to influence innovation strategy and its outcomes. In addition to the importance of the CIO's strategic leadership, we found that the TMT's attitude toward IT was also a key factor in the hospital's level of IT innovation. This finding is also consistent with the upper echelons perspective, which argues that the attitudes of the organization's TMT are directly reflected in strategic choices, and with prior IS leadership research that has argued that top executives are key decision-makers who determine the role of IS within the organization (Preston and Karahanna, 2009). Collectively, we observe that the TMT's attitude and CIO strategic leadership explain 31.8% of the variance in the level of organizational IT innovation in hospitals.

While our survey findings confirm the literature on the importance of TMT attitude toward IT, where TMT is largely considered to be the C-level officers, our interviews yielded insights into the importance of the Board of the hospitals in fostering an environment conducive to IT innovation as well as the relationships between CIO strategic leadership and Board influence on IT innovation. Although our CIOs generally felt strong support from their TMT, their views of the Board support were more varied. Our interviewees felt that the Board exerted strong influence on the degree to which they were allowed or encouraged to innovate. The Board may be particularly important in influencing IT decisions in the healthcare industry because many Hospital Boards are largely, or sometimes fully, comprised of MDs – representatives of the major, powerful user group

that often hinders IT implementations (Lapointe and Rivard, 2007). Support from the Board for IT projects could go a long way in helping win support among the physician staff.

Contrary to expectations, the hospital's decision-making climate was not a factor that directly influenced the hospital's level of IT innovation. We note that the average value of organizational climate was 3.96 out of 5.00 (with a standard deviation of 0.70), which indicates that the hospitals in our sample had an organizational climate that generally encouraged its executives to be assertive. IT innovation therefore appears to be independent of the general level of encouragement for innovation within a given hospital. It appears that hospital executives operating in a climate of support for taking initiative do not appear to transfer this support into IT initiatives. Perhaps these hospital executives are more likely to champion major operational or medical innovations than IT ones. This idea was supported by the CIOs who were interviewed for this study. On the other hand, the results also indicate that one does not need to have a general climate that supports innovation in order to innovate with IT. This may potentially be good news for CIOs in hospitals with conservative, risk-averse climates.

Whereas the hospital decision-making climate did not appear to influence hospital IT innovation, our interviews suggest that the Board plays a major role in determining hospital IT innovation. Recent research that examined the relationship of the Board with regard to IT has focused on Board-level IT governance (Boritz and Lim, 2008) and Board-level IT "attention deficit" (Huff et al., 2005). Our work suggests that not all hospital boards suffer from the type of attention deficit as found in the firms studied by Huff et al. (2005) but rather, some boards are active supporters and drivers of IT innovation in hospitals, keen to achieve clinical improvements while cognizant of the financial risks inherent in innovations. In addition, while Boritz and Lim (2008) found that CIO involvement at the board level may not always be required to have IT represented at the boardroom table, our interviews suggest that for hospitals, it certainly helps to have the Board either be receptive to the CIO's vision or be actively involved in setting the IT vision. In addition, whereas Earl (1989) suggests that a CIO needs a combination of technical and business knowledge to successfully innovate, our interviews suggest that in hospitals, CIOs benefit not only from technical and business experience, but clinical experience as well: CIOs with clinical backgrounds appear to enjoy advantageous support at the Board level compared with CIOs without experience.

Our study, because it aimed to understand the role of the CIO in hospital innovation, considered a small set of possible predictors of hospital IT innovation. Future research may extend and expand the nomological framework presented in this study to further examine the antecedents of hospital IT innovation. In a review of IT innovation research, Jeyaraj et al. (2006) identify 112 independent variables examined across the literature on organizational IT innovation. These independent variables were classified into three major groups: innovations characteristics (13 variables), organizational characteristics (83 variables), and environmental characteristics (16 variables). Clearly, no single research project can capture all 112 predictors. However, future research could examine some subset of these in one of the major groups to further understand the phenomenon of hospital IT innovation.

Finally, the findings of this study indicate that hospitals that are more innovative in their approach and use of IT show greater IT impact that contributes to hospital performance. We observed that firms that are innovative in their use of IT are better able to create IT capabilities that impact the contribution of IT to the performance of the hospital. In our model, we found that IT innovation explained 39.3% of the variance in IT impact, which consequently explained 10.6% of the hospital's level of financial performance (while controlling for prior financial performance). It is important to note that we did not gather data on the cost of hospital IT innovation. The possibility exists that hospitals were investing enormous amounts of resources into these systems and yielding only modest financial returns. Such a situation would create a productivity paradox in which increasing investments in healthcare IT promising to bring efficiencies as well as improve quality do little more than increase the cost of providing the services. Future research should take a macro-perspective to understand whether the investments in healthcare IT as a whole bring both quality of care benefits to patients and financial benefits to the industry.

6. Limitations and conclusion

As with all research, this study had several limitations. Our study has only considered the positive impacts of hospital IT innovation. In fact, IT innovation in hospitals as noted in previous work often benefits the patient (higher quality of care), pharmacies (reduced mis-fills), and insurance companies (fewer unnecessary tests) without actually benefitting the hospitals who are paying for the systems or the users – doctors and nurses – who must spend time updating records or ordering online. Moreover, modern healthcare technologies also come with their share of risks: hospitals often purchase new technology but fail to provide financial support for safely operation the equipment, manufacturers sometimes sell machines before the software bugs have been detected and removed, and errors that do occur in using medical technology are rarely admitted or reported (Bogdanich, 2010; Goldstein, 2010). The outcomes for patients can be grim: one study identified more than 300 patients across four hospitals that had been overradiated by powerful CT scans, including 260 patients receiving eight times the recommended radiation treatment. And the errors were not discovered until well over a year after the administration of the treatment. Upon visiting a medical facility in Florida in 2005, inspectors from a radiology physics center funded by the US government discovered that a miscalibrated radiation machine had overradiated 77 brain cancer patients by 50%. For the most part, errors in the programming of complex medical technology remain undetected and unreported. There is a great need for studies to investigate the downsides of IT innovation in hospitals. Also, our study

did not consider external factors, such as the payment scheme (capitation versus fee-for-service), that might influence the impact that IT innovations have on hospital performance. Also, we considered only planned innovations using a decidedly top-down model. Often, innovation is a by-product of tinkering and bottom-up exploration of emerging technologies (Ciborra, 1992). Other work is necessary to understand the nature of unplanned hospital IT innovation. In addition, our study only considered financial impacts of IT innovations in hospitals. Other performance impacts, such as clinical benefits or process improvements, were not considered and might explain a greater portion of the variance in the relationship between IT innovation and hospital performance. Moreover, of IT innovation explained only 10% of the variance in financial impact. Clearly, there are other very important variables affecting hospital financial performance that must be considered in future work.

This study was driven by an interest in understanding the primary factors that influence hospital IT innovation as well as the relationship of hospital IT innovation with hospital performance. To this end, we developed and empirically tested a theoretical model of the antecedents and consequents of organizational IT innovation. We also conducted interviews to gain richer insights into the nature of the CIOs involvement in hospital IT innovation. We found that there are different approaches to CIO strategic leadership for innovation – from informers, to invisible innovators, to the more traditional CIO leader developing strategies in conjunction with the TMT and Board. TMT support, while predictive of innovation, may be more a reflection of board-level attitudes with the board playing a major role in establishing the type of innovation likely to occur (local versus industry) as well as the means through which the innovation occurs (invisibly or by mandate). We also found that the CIO's leadership along with TMT support of IT predicted a large degree of the variation in hospital IT innovation. Finally, our study provides evidence that hospital IT innovation can contribute to hospital performance outcomes. We hope that this study provides a basis from which future research can examine how hospital IT innovation can be developed and how hospital IT innovation can be managed in order to achieve performance outcomes.

Appendix A

Construct operational definitions and scales.

CIO strategic leadership: The degree to which the CIO is effective strategic leader within the organization
Source: (Smaltz et al., 2006; CIO interviews)
CIOlead1: Our CIO is an effective strategic leader within the organization
CIOlead2: Our CIO is effective as a strategic business planner
CIOlead3: Our CIO is an effective visionary within the organization
TMT's attitude toward IT[a]: The TMT's attitude that IT is an essential component of the organization. Source: (CIO interviews)
TMTatt1: Our TMT has a favorable attitude toward IT
TMTatt2: Our TMT is reluctant to believe that IT initiatives can positively impact organizational outcomes (reverse coded)
TMTatt3: Our TMT supports the view that IT is critical to the success of the organization
Hospital climate[a]: The degree that the hospital's organizational climate encourages its executives to be assertive
Source: (Morrison and Phelps, 1999; Neal et al., 2005; Parker et al., 2006; Patterson et al., 2005; CIO interviews)
HospClim1: The organization wants its executives to have a "take charge" attitude
HospClim2: The organization appreciates it when its executives develop their own solutions to pressing organizational problems
HospClim3: The organization rewards those executives who independently introduce new structures, technologies, or approaches to improve efficiency
HospClim4: The organization wants its executives to take the initiative to institute new effective work methods
IT innovation[a]: The degree that the hospital's IT strategy is to be industry innovator
Source: (Conant et al., 1990; Li et al., 2006; Segev, 1987; CIO interviews)
Innovate1: Our organization is a leading IT innovator in our industry
Innovate2: Our organization believes in being first in the industry in developing new IT initiatives even if not all of these efforts prove to be highly profitable
Innovate3: Our organization responds rapidly to early signals concerning areas of opportunity for IT
Innovate4: Our organization's IT initiatives are often emulated by competitors in our industry
IT Impact[b]: The extent that IT has contributed to organizational outcomes
Source: (Premkumar and King, 1992; Saunders and Jones, 1992). Please assess the extent that IT has contributed to each of the following in your organization:
Impact1: Return on investment
Impact2: Market share
Impact3: Process IMPROVEMENT

[a] 5-Point scale ranging from "strongly disagree" (1) to "strongly agree" (5).
[b] 5-Point scale ranging from "no extent" (1) to "very great extent" (5).

Appendix B

CIO, hospital executive and firm characteristics.

Executive characteristics	CIO – N (%)	Hospital executive – N (%)
TMT membership	70 CIOs 59 (84.3%)	107 Executives across 70 Hospitals 94 (87.8%)
Reporting level to CEO CEO respondent 0 (direct report)/1/2	70 CIOs N/A 34 (48.6%)/35 (50.0%)/1 (1.4%)	107 Executives across 70 Hospitals 14 (13.1%) 60 (56.1%) / 33 (30.8%) / 0 (0%)
Executive title	70 CIOs CIO: 68 (97.1%) IT director/manager: 2 (2.9%)	107 Executives across 70 hospitals CEO: 14 (13.1%) COO: 11 (10.3%) CFO: 8 (7.5%) CMO/CNO/VP/other: 74 (69.1%)

Appendix C

Summary statistics.

Variable	Respondent	*N*	Mean	Std. dev.	Min.	Max.
Constructs						
CIO strategic leadership[a] (three questions)	Hospital exec	70	3.81	0.96	1.00	5.00
TMT attitude toward IT[a] (3 questions)	CIO	70	4.04	0.79	1.67	5.00
Hospital climate[a] (four questions)	Hospital exec	70	3.96	0.70	2.00	5.00
Hospital IT innovation[a] (four questions)	Average CIO/hospital exec	70	2.85	0.77	1.25	4.15
IT Impact[b] (three questions)	Hospital exec	70	3.01	0.79	1.33	5.00
Executive characteristics						
CIO age[c]	CIO	70	51.67	7.71	28	69
CIO organizational tenure[c]	CIO	70	10.23	8.12	1	33
CIO positional tenure[c]	CIO	70	6.30	5.50	1	30
Hospital executive organizational tenure[c]	Hospital exec	107	11.25	7.90	1	37
Hospital executive positional tenure[c]	Hospital exec	107	6.52	4.32	1	21
Organizational characteristics						
Corporate annual sales (million $)	AHD database	70	$500	$395	$0.65	$186,464
Number of employees	AHD database	70	1676	1836	84	9500

[a] 5-Point scale ranging from "strongly disagree" (1) to "strongly agree" (5).
[b] 5-Point scale ranging from "no extent" (1) to "very great extent" (5).
[c] Measured in years.

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