THE IMPACT OF INFORMATION TECHNOLOGY ON SMALL, MEDIUM, AND LARGE HOSPITALS: QUALITY, SAFETY, AND FINANCIAL METRICS

by

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"I can do all things through Christ, who strengthens me" ~ Philippians 4:13

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ABSTRACT

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This study focuses on the role of information technologies in healthcare, and investigates the relationship of IT sophistication to patient safety, healthcare quality, and financial performance in Texas acute care hospitals. A value/supply chain perspective guides the development of a general model that integrates hospitals' IT sophistication with their patient and financial outcomes. From the model emerge hypotheses that are tested using the structural equation modeling approach, taking into account differences in outcomes across small, medium, and large hospitals. Our testing and comparisons give insight into the dynamics of health information technology and provide specific direction for practitioners and future research.

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CHAPTER I

INTRODUCTION

1.1 Healthcare Information Technology

By several measures, healthcare and healthcare information technology spending continues to rise at the fastest rate in our history. In 2005, total national health expenditures rose 6.9 percent -- two times the rate of inflation. Total spending was $2 trillion in 2005, or $6,700 per person (2006). Total health care spending represented 16 percent of the gross domestic product (GDP), and U.S. health care spending is expected to increase at similar levels for the next decade reaching $4 trillion in 2015, or 20 percent of GDP (Borger et al. 2006).

Concurrently, the expenditure on Information Technology in healthcare continues to grow. According to new research by Datamonitor, Healthcare providers will spend as much as $39.5 billion on information technology by 2008 (Datamonitor 2006; Monegain 2006). Fueled by the desire to reduce medical errors and improve clinical work processes, the Health Information Technology (H.I.T.) market is flourishing. The H.I.T. market growth is led by picture archiving computer systems (PACS) and computerized physician order entry (CPOE) buying and followed by the purchase of other clinical information systems such as computerized patient record, pharmacy, surgery, emergency department, radiology, and document management systems, to name a few (Dorenfest 2004). With such rapid growth in H.I.T. and the vast and diverse array of alternative technologies, there has become a pressing need to better understand how to most effectively utilize these resources.

Current research literature looks at disparate aspects of healthcare. The majority of literature takes a management perspective and concentrates mainly on the adoption, implementation, and acceptance of technologies (Adams et al. 1992; Hu et al. 1999; Paul et al. 1999; Brynjofsson and Hitt 2000; Ball 2003). However, research that examines the actual impact that IT is having in the healthcare system is sparse. Additionally, the most common examples of empirical analysis are case studies that examine the costs and benefits of *specific* IT applications (i.e. telemedicine, CPOE, etc.) (Memel et al. 2001; Ammenwerth et al. 2002; Bello et al. 2004; Al-Qirim 2007; Rahimi and Virmarlund 2007). While these investigations provide a much needed evaluation and contribute to the growing body of HIT literature, this type of research lacks perspective on how the actual HIT systems tie together and how they perform in a healthcare environment. Therefore, it is proposed that by looking at HIT through an operations management perspective the infrastructure of the HIT systems can be evaluated and its impact ascertained.

1.2 Research Goal

It is the goal of this research to use applied statistical techniques to better understand the dyadic relationship between information technology and operational outcomes in an acute care hospital environment. By looking at both financial and patient based outcomes, identification of which HITs support these operational aspects can be recognized. Thus, providing guidance to different types of hospitals on how best to expend their HIT dollars.

This study is an extension of previous exploratory research performed by Hart (2006) that examined the overall relationship between IT Sophistication (availability of information technology applications) and patient safety outcomes of acute care hospitals. Conversely, this research takes a confirmatory approach at analyses and adds to the previous research by incorporating new constructs and measurements derived from existing HIT literature.

1.3 HIT Theory

1.3.1 Technology Acceptance and Adoption

Acceptance of emergent information technologies (IT) has occupied a central role in information systems (IS) research since the inception of the field. There have been many studies that investigate IT acceptance in different settings at both individual and organizational levels of analysis and different theoretical models have been used (Davis et al. 1989; Niederman et al. 1991; Alavi and Carlson 1992; Hartwick and Barki 1994; Markus and Keil 1994; Brancheau et al. 1996; Agarwal 2000; Venkatesh et al. 2003; Alavi Carlson, P.). Of the models that have been proposed and examined, Davis'(1986) Technology Acceptance Model (TAM) appears to be the most recognized and utilized. TAM is an intention-based model developed specifically for explaining and/or predicting user acceptance of technology. TAM has been used as the theoretical basis for many empirical studies of user technology acceptance and adoption (Davis 1989; Davis et al. 1989; Mathieson 1991; Adams et al. 1992; Taylor and Todd 1995;

Chau 1996; Chau 1996; Szajna 1996; Paul et al. 1999; Agarwal 2000; Venkatesh 2000; Chau and Hu 2001; Lee et al. 2003; Cheung and Sachs 2006; Schepers and Wetzels 2007) and has accumulated abundant empirical support (Hu et al. 1999). However, with few exceptions (Kim and Michelman 1990; Chau and Hu 2001; Devaraj and Kohli 2003; Kohli and Kettinger 2004), IS research is scarce regarding IT acceptance in a healthcare environment. In investigating the impact of IT on financial and clinical outcomes, it would stand to follow that testing the effect of IT acceptance would be paramount and that TAM would be a promising model of choice. The following explains why this is not true.

Little is known about the adoption and use of healthcare IS among healthcare professionals. Therefore, several studies investigated physicians' perceptions of IT in different settings. For example, Chau & Hu (2001) used a model comparison approach (comparing TAM, theory of planned behavior and the decomposed theory of planned behavior) to investigate the adoption of telemedicine by healthcare professionals. They found that attitudes, together with system usefulness are major determinants of physicians' acceptance of telemedicine. However, perceived ease of use, a major construct in the IS literature was not found to be significant. The same study also pointed out compatibility of a system with a physicians' practice routine as a significant predictor of technology acceptance. Furthermore, results from the same study showed that physician' groups "may differ from subjects commonly investigated in previous IS studies (such as clerical, administrative, knowledge workers, system developers) in areas such as adaptability to new technologies, mental and cognitive capacity and work arrangement" (Chau &Hu, 2001).

Several other authors found similar results (Hu et al. 1999; Chismar and Wiley-Patton 2003) in investigating physicians' acceptance of telemedicine or Internet-based applications. These results suggest TAM is not entirely applicable in a healthcare setting when investigating physicians' technology acceptance. These results also suggest that healthcare is a unique industry and thus the evaluation of technology by healthcare professionals may differ from those of other subjects previously examined in IS research. It is also worth noting that most of these studies have used specifically telemedicine as the technology of interest. Therefore, a need exists for research that encompasses a wider breadth of technologies, focuses on the impact of IT in the healthcare environment, and analyzes the effects that IT is having on healthcare related outcomes.

1.3.2 The HIT Model

Tan (1999) discusses what he denotes as the ideal healthcare information technology (HCIT) model and addresses the organization's basic goals of staying competitive and meeting the expectations of the business and healthcare environment (Tan and Modrow 1999). He provides an accountability expectations framework that enables the assessment of fit to desired HCIT within the organizational environment. Tan denotes that for HCIT to be pertinent strategically, the system should be able to link the end-users to organizational performance. When an organization commits to industry performance standards and actively benchmarks against performance goals, accountability becomes apparent. Tan further explains that management decision making is then clearly linked to the performance measures, and therefore the results of the operating decisions can be evaluated.

1.3.3 A Value Chain Perspective

While healthcare differs in many ways from other organizations, the healthcare environment does mirror other industries, such as manufacturing and distribution, when looked at from a value/supply chain perspective (Hughes et al. 1998; Waller 1999). Porter (1985) proposed the value chain as a means by which business activities that transform inputs could be identified and analyzed. He purports that stages in the value chain can be explored for interrelationships and common characteristics which could lead to opportunities for cost reduction and differentiation. Therefore, in order to achieve a sustainable competitive advantage, it is not possible for a firm to look at activities as a whole. Instead, it is necessary to break down a business unit into strategically relevant stages to take into full account all of the tasks that are conducted to add value. These tasks include product development and design, production, distribution, marketing, sales, services and the many forms of support required for the smooth operation of a business (Hax and Majluf 1991).

The concept of the value chain reverses supply chain thinking by identifying the customer's needs and working backwards through the process infrastructure. Additionally, the value chain asks: is there a better way of delivering value to customers? Can the "value" delivered be enhanced? Can costs be reduced? Healthcare is in no way different. Patients, payors, and suppliers are the customers.

They have value needs which are met by specific resources and services. Healthcare has "marketing channels" and has specialist infrastructures that deliver value (Walters 2001). It follows that in a healthcare environment the need to identify and disaggregate processes that deliver value to the customer exists. For purposes of this research, the patient as customer is focused on due to their direct connection with clinical outcomes.

Walther and Jones (2001) map the organizational structure of the value chain (see Figure 1), and identify the processes required to translate customer and value chain member expectations into delivered value.

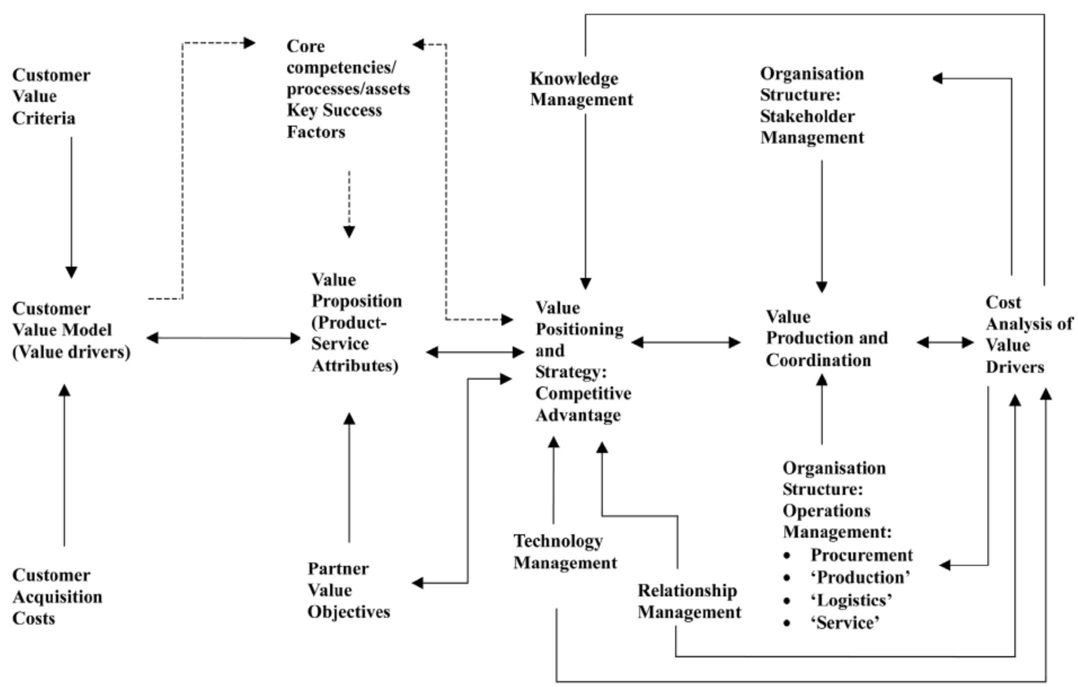

Figure 1 Organizational Value Chain Structure

Value chain management tells us that each separate aspect of the healthcare system impacts others. This is the same as in supply chain management literature; both theories argue that a chain is only as strong as its weakest link. Therefore, the overall goal within the healthcare value chain is to achieve performance improvements in terms of costs and time responsiveness, while at the same time adding value by providing high-quality patient care service levels (Kitsiou et al. 2007). Thus, if we look at the patient's value added as being efficient, effective service, the process of delivering that service must be analyzed and an area for improvement identified.

As seen in figure 1, technology management is one of the key processes required within an organizations value chain structure to facilitate value positioning, strategy, and competitive advantage. Many authors in the literature have described the importance of information systems, information management, and system integration as a vital element in this drive towards improvements in efficiency and effectiveness (Spekman and Myhr 1998; Bartezzaghi 1999; Thoneman 2002). Dongsoo (2005) and McCann (2003) suggest that one of the most important critical success factors towards added value is the facilitation of efficient and effective information sharing in order to establish integrated process methods that improve decision making and balance demands and costs.

Therefore, HITs have the ability and potential to individually address internal functional areas and segments of the value chain that optimize effectively certain processes and specific needs within departmental units (Xu et al. 2000; Kitsiou et al. 2005). The previous discussions identify a gap in the literature and a much needed area of research. The investigation of healthcare information technologies in a hospital setting would provide some insight into the capabilities and shortcomings of HIT.

1.3.4 The SCOR Model

. Through research a better understanding of the relationship HITs have with the efficiency and effectiveness of healthcare delivered can be achieved. Because value chain analyses prescribes the “breaking down” of processes into smaller tasks, we borrow from the supply chain literature a perspective on how to analyze this relationship.

The Supply Chain Operations Reference-model (SCOR) was developed by the Supply Chain Council (SCC) as the cross-industry standard for supply-chain management. The model prescribes a set of process templates and their decomposition into more detailed sets of tasks. SCOR is one of the best-known guidelines used by companies to examine the configuration of their supply chains, identify and measure metrics in the chain, determine weak links, and achieve best practices (Council 2002). The framework of the SCOR model is based on process description. As shown in Figure 2, SCOR uses a building block approach based on five management processes to describe supply chains. This approach allows a description to be assembled across organizations, internal and external, across industry segments, and across geographies (Wondergem 2002).

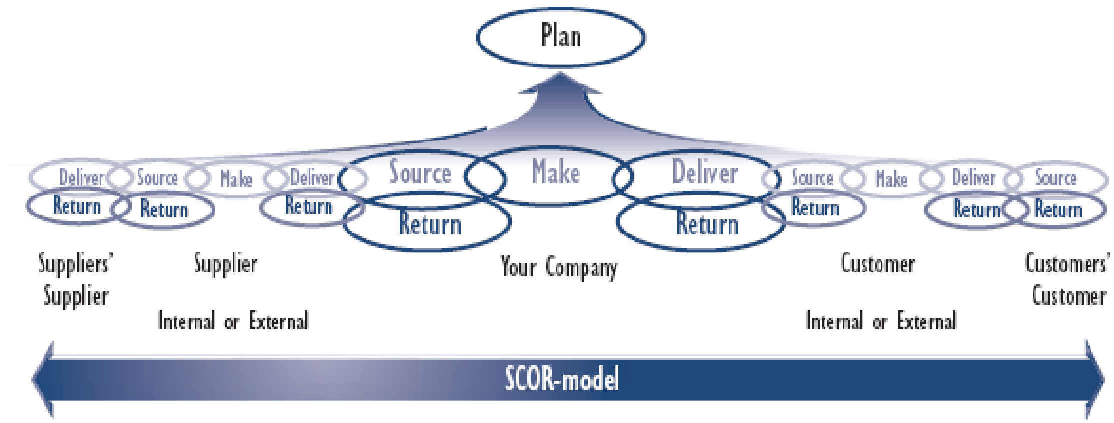

Figure 2 Score building block model

Each organizational element within the chain has five distinct management processes: plan, source, make, deliver, and return. Plan activities balance resources, and provide integration between activities and organizations. Source activities are associated with acquiring raw materials and connecting organizations with their suppliers. Make activities transform the product to a finished state to meet planned or actual demand. Deliver activities are associated with the management of orders and the delivery of finished goods, connecting an organization with its customers. Finally, return activities are associated with returning or receiving returned products for any reason (Wikipedia; Poluha 2006). With regard to the healthcare environment, this mirrors the nursing process where assessment is equated to plan, planning and implementation compares to the make and deliver processes, and evaluation/reassessment emulates return. Therefore, the process of providing care to the customer (patient) falls into the make and deliver activities.

SCOR proceeds in taking these five processes and breaking them down further into three levels of detail. On the first level of detail, processes within the value/supply chain are classified into Plan, Source, Make, Deliver, and Return. At this level performance can be directly tied to the business objectives of the organization. Levels two and three process elements are used to describe more and more detailed activities to provide greater insight into the operation of the value/supply chain. The second level gives a list of configurable process templates that can be chosen when modeling a specific supply chain instance. Level three processes specify task inputs and outputs, business metrics that can be collected for a given task as well as best practices for task implementation that should result in the improvement of business performance indicators. Because this is a cross-industry model and each organization's operations are unique, the model must be extended by the implementing organization to level four (Wondergem 2002; Poluha 2006).

In order to best examine and identify the relationship HITs have with performance outcomes in hospitals, investigation must occur at the direct measurement level; level three. This approach allows the identification of which specific technology applications/categories directly impact the relationships of interest and provides a better view of the technologies impacting the performance outcomes.

CHAPTER II

LITERATURE REVIEW

2.1 Theoretical Development

2.1.1 Role of IT in Healthcare

The role of information technology (IT) in the services sector is currently the subject of considerable scholarly reflection. Empirical results of studies of the link between IT investment and performance have generally been mixed, though recent evidence shows some support for a positive relationship. Several studies have recognized the tremendous room for growth in the use of health information technology (HIT) to enhance patient care quality and safety (Ammenwerth et al. 2002; Bates 2002; Brooks et al. 2005; Plebani 2007). The healthcare industry has suffered compared to other industry sectors such as banking and finance from sluggish IT investment and acquisition. Thus, the healthcare industry has less developed IT applications. In recent years, however, there has been a 9% annual increase in national expenditures on HIT (Dorenfest 2004). Yet it must be noted that the level of IT capacities remains variable across health care settings (Cushman 1997; Voss 2003; Wickramasinghe and Silvers 2003; Jaana et al. 2005; Burca et al. 2006).

Two different reports by the Institute of Medicine (IOM) and the Government Accounting Office (GAO) reached similar conclusions on the importance of technology in reducing costly medical errors. The 2001 GAO report indicates that medication-related injuries result in 1.4 and 2 million annual hospitalizations and visits to physician offices, respectively (Case et al. 2002). The 2000 IOM study, *To Err Is Human*, reports that approximately one hundred thousand patients die each year in U.S. hospitals from medical errors (Kohn et al. 2000). This report dramatically changed healthcare providers', policy makers', and the publics' perception of patient safety in US hospitals. The increased focus on improving patient safety and the lack of consistent hospital patient safety data led the Agency for Healthcare Research and Quality (AHRQ) to develop a set of Patient Safety Indicators (PSIs), to be added to already existing Inpatient Quality Indicators (IQIs), designed to identify potential hospitalization-related adverse events from administrative discharge databases (Remus and Fraser 2004; Quality 2005).

A subsequent IOM report, "Crossing the Quality Chasm," underscored the importance of patient safety as a key dimension of quality and identified information technology as a critical means of achieving this goal. Additionally, the availability of information technology (IT) applications in hospitals has been identified as a means of improving patient safety and reducing the number of adverse events (Birkmeyer et al. 2000; Gaba 2000; Medicine 2001; Remus and Fraser 2004). The medical Errors Reduction Act of 2001 supports the use of information technology innovations such as computer-based physician order entry systems and the Barcode-enabled Point-of-Care systems, and the proper utilization of technology and knowledgeable information technology (IT) support staff could reduce medical errors about 70 percent annually, alleviating $7 billion in costs and the immeasurable loss resulting from death (Goolsby, 2002; Armstrong 2003).

Technology has also played a vital role in improving efficiency in hospitals because networking information systems remain the biggest barrier to institutional consolidation and organizational operations functioning as a single unit (Kienle 1997; Skyrme 2002). A good example of this is how the computerization of medical records and electronic data interfacing of laboratory results and other clinical procedures greatly enhance the ability to document and exchange medical information in a timely manner. Further, the use of certain information technologies, such as Computerized Physician Order Entry (CPOE), documentation related nursing applications, and integrated systems, streamline processes and workflow. Studies show that this leads to reduced physician time, reduced length of stay, patients leaving without being seen, and wait times (Peirpont and Thilgen 1995; Wong et al. 2003; Pizziferri et al. 2005).

Therefore it is undeniable that IT in healthcare has the potential to improve efficiency and quality by improving productivity, saving time, decreasing medical mistakes, and enhancing communication. Following this rational, figure 4 shows the proposed research model that explores the relationships between IT Sophistication (discussed further in chapter 3) and the financial performance, safety, and mortality rates of hospitals. A subsequent discussion of the literature and theory support are discussed in the following theoretical development of hypotheses.

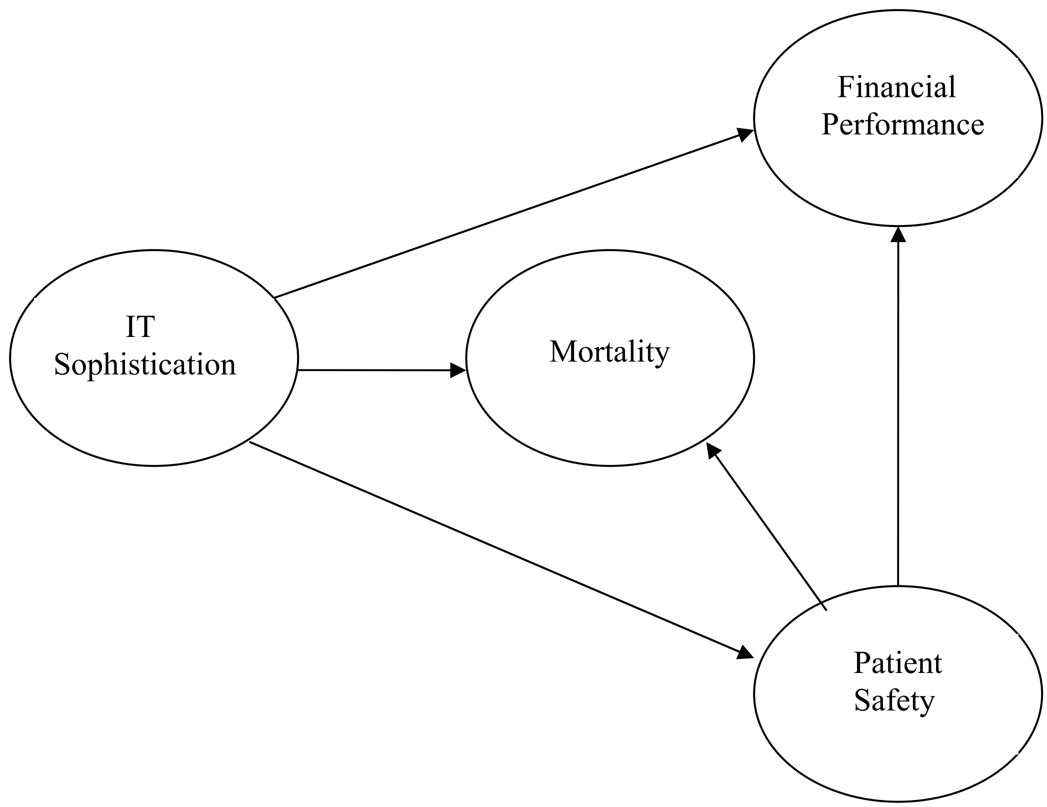

Figure 3 Proposed Research Model

2.1.2 Quality and Patient Safety

Excellent IT and high-quality healthcare are closely linked. In recent years attention has increasingly turned to the role of information and communication technology as a means to improve clinical decision-making, patient safety, and overall quality of care. LDS Hospital and Intermountain Health Care in Salt Lake City, Wishard Memorial Hospital and its affiliated clinics in Indianapolis, and Brigham and Women's Hospital and Partners healthcare System in Boston, MS are perceived as having the best information systems (Evans 1991; Tierney et al. 1993; Teich et al. 1996). In conjunction, the three healthcare organizations listed above are highly recognized as quality leaders due to excellent clinical outcomes, which have been achieved in part because of their information systems (Bates 2002). Health Information Technology (HIT) is a key element for meeting the challenges of steeply increasing health costs and shortfalls in health care quality. Within the last few years, the federal government has made progress in setting the stage for transforming health care through improved HIT (The Lewin Group 2005). During the Presidential debate in October 2004, President Bush cited electronic health records as an essential means "to cut down on error as well as to reduce costs." In his State of the Union Address on February 2, 2005, President Bush called for "improved information technology to prevent medical error and needless costs."

Thousands of Americans die each year as a result of medical errors caused primarily by systematic problems, and many more experience other unnecessary harms. The Institute of Medicine estimates between 44,000 and 98,000 people die from medical errors each year (Kohn et al. 2000). Between 6% and 10% of all hospitalized patients will experience and adverse drug event (ADE) and the number of serious medication errors resulting in death more than doubled from 1983 to 1993. The Center for Information Technology Leadership estimates that, of the 900 million outpatient visits in the U.S., 8.8 million are attributed to ADEs, 3 million of which are preventable (Walker et al. 2004).

Over the past 30 years, research has demonstrated that HIT can improve patient safety and quality of care, and the improvement related to these HITs can be seen across different areas. Several studies have examined the case for IT and quality and the major effect of health information technology on the quality of care has been seen in increasing adherence to guideline or protocol-based care (Chaudhry et al. 2006). However, a small body of literature supports the claim that HIT use is beneficial in the areas of medication safety, adherence to immunization and disease-based guidelines, patient decision-support in diabetes management, clinical documentation, patient appointments, and in hospital order processing (Shekell et al. 2006). Following is a brief look at the literature supporting the use of HIT within the healthcare environment.

2.1.2.1 Adherence

Studies conducted on adherence examined the effects of health information technology on enhancing preventative health care delivery found that rates of influenza vaccination improved 12-18% and pneumococcal vaccinations improved 20-33% (Tierney et al. 1986; Litzelman et al. 1993; Dexter et al. 2004). Research that examined the effect of health information technology on secondary preventative care for complications related to hospitalization found a decrease (from 8.2% to 4.9%) in deep venous thrombosis and pulmonary embolism (Kucher et al. 2005), a 5% decrease in pressure ulcers in hospitalized patients (Wilson et al. 1995), and another showed a 0.4 percent decrease in postoperative infections (Larsen et al. 1989; Wilson et al. 1995; Kucher et al. 2005). Finally, two studies that examined the role of HIT in identifying infectious disease outbreaks revealed a 14% increase in identification of hospital-acquired infections and a 65% relative decrease in identification time (Evans et al. 1986; Overhage et al. 2001).

2.1.2.2 Medication Use

At LDS Hospital in Salt Lake City, a computerized physician order entry (CPOE) system with decision support reduced the incidence of adverse drug events related to antibiotic administration by 75% (Classen et al. 1997). It also significantly reduced orders for drugs for which patients' records reported allergies and adverse effects that were caused by antibiotics. At the Regenstrief Institute for Health Care in Indianapolis, researchers demonstrated that automated computerized reminders increased orders for recommended interventions from 22% to 46% (Ortiz et al. 2002). At the Brigham and Women's Hospital in Boston, use of a CPOE system with decision support led to increased use of appropriate medications for high-risk clinical situations, such as an increase in the use of subcutaneous heparin to prevent venous thromboembolism, from 24% to 47%. Further, research on clinical monitoring and aggregation of data showed adverse drug event identification increase from 0.04% to 2.4% and a decrease in adverse drug event rates from 7.6% to 2.2% (Evans et al. 1992).

2.1.2.3 Medication Errors

Another area that has seen substantial benefit from HIT is the reduction in medication errors. Bates et. al (1998) found that implementation of computerized physician order entry resulted in a 55% decrease in serious medication error rate. A second follow up study by the same authors found an 86% relative decrease in nonintercepted serious medication errors (Bates et al. 1999). HIT also aids in preventing medication errors by improving medication dosing. Several studies have shown a 12% to 21% improvement in dosing (Evans et al. 1999; Mullett et al. 2001; Chertow et al. 2001)

2.1.2.4 Clinical Decision-making

Southern California Evidence-based Practice Center reported that clinical HIT systems may make a substantial impact on medical quality and safety by integrating relevant automated decision-making and knowledge acquisition tools into the practices of medical providers, thereby reducing errors of omission that result from gaps in provider knowledge or the failure to synthesize and apply that knowledge in clinical practice (Shekell et al. 2006). A 1998 systematic review of the literature that assessed the effects of 68 computer-based clinical decision support systems demonstrated a beneficial, though variable impact on physician performance in 43/65 studies (66%) and a beneficial effect on patient outcomes in 6/14 studies (43%) (Hunt et al. 1998). A study by Christakis et al. (2001) measure the impact of HIT on the antibiotic prescribing behavior of pediatric providers in an academic pediatric residency training clinic and compared cohorts during the pre-intervention and post-intervention phases. The results demonstrated that the prescribing practices of physicians for treatment of a common pediatric illness can be affected by a computerized reminder system. In a similar study, a system that provided recommendations for disease management and correct use of antibiotics was utilized and results demonstrated a decreased use of antibiotics for two types of illnesses (Margolis et al. 1992). Further, Mullet et al.(2001) measured the impact of an anti-infective computerized decision-support system and reported a 59% decrease in pharmacist interventions and a decreased number of patient days.

2.1.2.5 Mortality

Finally, a study done by Pricewaterhouse Coopers (PWC) (2007) created an economic model to analyze cost efficiency in healthcare organizations. The model used to examine business performance metrics also was applied to quality metrics by focusing on a single outcome: hospital mortality rates adjusted for risk, case mix, and state averages. The analysis revealed a statistically relevant correlation between hospital IT investment and mortality rates. Significant differences were found between hospitals at the low end versus the high end of PWC's IT Capital Index, and suggest that hospitals investing in IT can reduce mortality rates without a corresponding increase in overall operating costs.

Therefore, evidence suggests that a linear relationship should be present between the existence of IT in a healthcare setting and the quality and safety of the healthcare. Further, the improvement in safety should result in fewer cases of mortality and costly adverse drug events, medical errors. In more formal terms:

H1a: There is a negative relationship between IT Sophistication and Mortality. As IT sophistication increases mortality should decrease.

H1b: There is a negative relationship between IT Sophistication and Mortality related to Procedures. As IT sophistication increases mortality rates related to procedures should decrease.

H1c: There is a negative relationship between IT Sophistication and Mortality related to Conditions. As IT sophistication increases mortality rates related to conditions should decrease

H2: There is a negative relationship between IT Sophistication and Patient Safety. As IT sophistication increases we should see a decrease in patient safety indicator rates.

H3: There is a positive relationship between Patient Safety and Mortality. As patient safety indicator rates decrease we should see a decrease in mortality.

H4: There is a negative relationship between Patient Safety and Financial Performance. As patient safety indicator rates decrease we should see an increase in financial performance.

2.1.3 Financial Performance

"An organization's ability to apply technology to optimize care delivery, operational, and administrative processes will directly affect revenue growth and profitability due to dramatic improvements in quality of care, reductions in costs, market share growth, and physician and consumer preference" (King et al. 2003). This suggests that the type of technology implemented, which must vary based on the area of implementation, should directly impact the financial performance of the organization. Thus, the identification of the right technology for a specific area, based on empirical evidence of direct affects on performance indicators, is crucial knowledge in the decision making process. Several studies in healthcare information technology (HIT) and financial performance have been published. Of these studies, few are empirically based and directly measure HIT and financial performance.

The Health Forum American Hospital Association proposes that organizations who invest more in IT are more efficient and have higher quality. They state that hospitals with more IT systems in place have lower median expenses per discharge and greater productivity, as measured by full-time equivalent staff (FTE) per adjusted occupied bed, paid hours per adjusted discharge, and net patient revenue per FTE (AHA 2001). Menachemi et al. (2006) observed 82 Florida hospitals and their relationship between IT and financial performance. Two major categories of financial performance were used for analyses; one relating to the overall financial performance of the hospital, and the other reflecting the operational performance of the organization. Overall financial performance measured hospital wide indicators and included return on investment (ROA), cash flow ratio, operating margin (OM), and total margin. Operational performance was measured using net inpatient revenue, net patient revenue, operating income, total income, hospital expenses and total expenses. The availability of IT applications was measured; however, the actual use of the applications was not considered due to lack of data source. The IT applications were grouped into three categories (administrative, clinical, and strategic) with a subset of patient safety applications. Actual results revealed positive relationships between all The IT application groups and operation performance, as well as, overall financial measures except for the patient safety group.

Devaraj and Kohli (2000) encompassed a 3-year longitudinal study of eight hospitals. They examined monthly data to determine the relationship of IT investment to performance, and the combined effect of technology and business process reengineering (BPR) on performance. The hospitals included in the study had recently implemented a decision support system (DSS) to help evaluate contracts. They utilized the variables net revenue per day and net patient revenue per admission to measure revenues and profitability. Technology investment was measured by IT labor, capital and support for every hospital. The findings revealed a significant relationship between investing in IT and organizational profitability. They found that profitability impact can be seen in three months or more after implementation of IT. The study also reports positive combined effects of business process reengineering and IT investment on profitability.

Smith et. al (2000) examined the relationship between IT investment and medical group practice performance. Financial performance was measured by gross charges per physician, net revenue per physician, operating costs per physician, and operating margin. The investments in IT included hardware and software, computer repair and maintenance, data processing services, telecommunication equipment and operating costs, depreciation cost for equipment, and answering services. The results showed that for net revenue all three independent variables make statistically significant predictors. For the financial measures all were statistically significant, whether multi-specialty or single-specialty group

Finally, several studies looked at estimating the actual quantifiable benefits of HIT implementation. First, Partners HealthCare ambulatory health electronic record (HER) was the HIT of interest in a study by Wang et. al. (2003). The system analyzed included health information and data storage capability, results management, order entry management, point-of-care decision support, and administrative information management functionalities. The five year total benefits of a HER implementation showed present value of annual benefits to be $129,300 per provider, and a net benefit of $86,400 per provider. The largest proportion of the benefit amount was due to savings in drug expenditures (33% of total benefits), while decreased radiology accounted for 17%, decreased billing errors for 15%, and improvements in charge capture 15%. Another study that focused on the ambulatory HER system in a health maintenance organization (HMO) calculated the averted costs associated with improved efficiency. This study estimated an annual savings of $3,700,000 (in 1996 dollars) from reduced medical record room and support staff, elimination of clinical forms, and automatic collection of billing data (Khoury 1997; Khoury 1998). Finally, a cancer center study projected the benefits of an HER over a ten year period. The authors divided the benefits into capture and access, decision support, optimization of clinical practice, business management, and streamlining of patient flow. The estimated total quantified benefits were $129.69 million over ten years. Adjusted by the total implementation and system costs, the authors' assigned confidence factor, and a 9.5-percent discount rate, the net value was predicted to be $24.9 million (in 1994 dollars)(Kian et al. 1995).

All five cost-benefit analyses predicted substantial savings from HER, health care information exchange, and interoperability implementation. In addition, all five studies posit that the quantifiable benefits of HIT implementation outweigh the investment's costs. Therefore, it follows that we should see a direct positive relationship between the amount of HIT applications utilized (IT sophistication) and the fiscal performance of hospitals. Further, we posit that this relationship will hold with overall financial performance, profitability, and in operational performance.

H5a: IT sophistication is positively related to a hospital's overall financial performance. As IT sophistication increases we should see an increase in overall financial performance.

H5b: IT sophistication is positively related to a hospital's profitability. As IT sophistication increases we should see an increase in profitability.

H5c: IT sophistication is positively related to a hospital's operational performance. As IT sophistication increases we should see an increase in operational performance.

CHAPTER III

CONSTRUCT DEVELOPMENT

3.1 IT Sophistication

3.1.1 Definition

IT Sophistication includes a wide foundation and has important implications for the management of organizations. In order to define IT sophistication it is best to first look at the broader scope of technological sophistication. Khandwall (1976) argues that a technologically sophisticated firm; "…implies that the products and processes produced or utilized involved the use of very sophisticated and complex operations technologies with a lot of research and development involved, while a relatively technologically unsophisticated environment implies the opposite."

Technological sophistication fundamentally reflects the diversity of the hardware devices utilized. In health care institution this refers to various domains such as medical imaging, bar coding devices, data warehousing, wireless networks, and PACS (picture archiving and communication system) equipment (Pare and Sicotte 2001).

IT, on the other hand, is the acquisition, processing, storage and dissemination of vocal, pictorial, textual and numeric information by a microelectronics-based combination of computing and telecommunication. It includes all hardware, software, communications, telephone and facsimile facilities (Fletcher 1991; Weill 1992). Such a broad definition calls attention to the fact that IT is used extensively throughout organizations in some form. The application of IT in services management, specifically in healthcare management, ranges from productivity tools (spreadsheets, word processing and simple patient databases) to more sophisticated decision support systems and computerized patient records (Fletcher 1991). IT sophistication, as defined by Raymond and Pare (1992), is a multi-dimensional construct, which includes aspects related to technological support, information content, functional support, and IT management.

3.1.2 Conceptual Framework

One of the first attempts at characterizing information technology was made by Nolan (1973, 1979) with his stages of electronic data processing (EDP) growth model. In the context of IT adoption by organizations, the evolution concept is used in identifying and planning the different stages of systems growth. One of Nolan's objectives was to explain the relationship between a stage and the preceding or following stage. While the empirical validity of this model has been contested (Benbasat et al., 1984; King and Kraemer, 1984), and while it pertains to the evolution of organizational information systems, a fundamental concept was introduced in regard to the characterization of IS, i.e., the concept of the organization's "IS maturity." In Nolan's model, the notion of IS maturity is closely related to IS evolution, maturity being defined as the ultimate stage of computing growth in organizations. IS maturity thus refers to a state where information resources are fully developed and computer-based systems are fully integrated.

Following this, researchers became interested in characterizing organizational information systems, and particularly in identifying different criteria of systems "maturity" or "sophistication" (Cheney and Dickson 1982; Saunders and Keller 1983; Gremillion 1984; Mahmood and Becker 1985; Raymond and Pare 1992). Much of these studies have used Nolan's model as a theoretical foundation. Among others, Cheney and Dickson (1982) investigated the relationship between what they defined as "technological sophistication" (hardware and software system, nature of application systems), "organizational sophistication" (information resources management activities) and system performance. One of their most important results was that user performance appeared to be very much influenced by organizational sophistication, but very little by technological sophistication. Also, within the IS usage perspective, Saunders and Keller (1983) referred to IS maturity as the "sophistication of the mix of applications provided by the IS function," focusing more on the nature, content and structure of the information provided.

Pare and Sicotte (2001) then initialized a study performing an in-depth review of the different models and variables proposed in the information systems, health management and medical informatics literatures that characterized explicitly or implicitly the concept of IT sophistication (Sneider 1987; Austin 1992; Singh 1997; Hatcher 1998). From this review they defined IT sophistication as a construct which refers to the diversity of technological devices and software applications used to support patient management and patient care, clinical support, and administrative activities. Their conceptualization also considers the dimension of systems integration. System integration considers the extent to which computer-based applications are integrated (electronic and automatic transfer of information). Their general framework for classification of IT sophistication is presented in Figure 5 and includes three core domains; patient management and care, clinical support, and administrative activities. This framework forms the basis for the inclusion of functional, technical, and information integration sophistication as the three sets of items that assess the different dimensions of clinical information technology sophistication in this study and are measured across the two clinical domains patient management and care and clinical support. This study does not include consideration of the administrative domain, however, because there is no theoretical background supporting the idea that administrative activities affect a hospital's clinical performance.

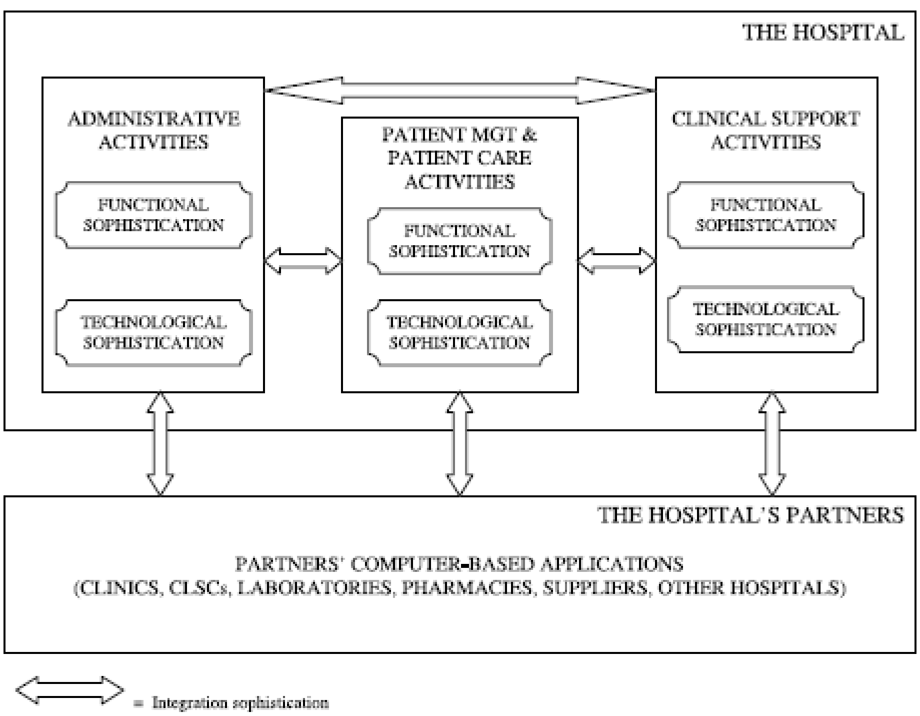

Figure 4 IT Sophistication framework in hospitals by Pare and Sicotte

3.1.3 IT Sophistication Construct

Information Technology Sophistication is operationalized in this study through the classification of each individual hospital's information technology applications into three categories: technical sophistication, functional sophistication, and integration sophistication. The logic and guidelines used in mapping these applications into one of the three categories follows that put into place by Pare and Sicotte (2001). All hospital applications were screened for inclusion and only those applications that were denoted as automated or to be replaced were included in the study. Those technologies that were denoted as contracted/not yet installed or not automated were rejected for inclusion. A complete list of incorporated applications/technologies and their classification can be seen in tables 1-3. It should be noted that all applications utilized in this study were mapped to their appropriate domain in accordance with Pare and Sicotte's (2001) mapping technique.

3.1.3.1 Technical Sophistication

Technological Sophistication reflects the diversity of hardware devices used by health care institutions and refers to various domains including medical imaging, bar coding devices, data warehousing, wireless networks and PACS equipment. These information technologies and devices are grouped into five categories: office automation systems, human-computer interaction devices, storage and compression devices, data distillation systems, and connectivity devices. Technologies mapped to this dimension are shown in Table 1

3.1.3.2 Functional Sophistication

Functional sophistication represents the proportion and diversity of processes or activities being supported by computer-based applications. These management processes include inpatient pre-admission and admission, outpatient admission, waiting list management, bed availability estimation, and inpatient discharge and transfer. Patient care activities include order entry/results reporting, physician order transcription, historical record keeping, care planning, and vital sign recording, to name a few. Some clinical support processes include test management, specimen pick-up scheduling, and blood bank management; label and results capturing (radiology); and medication management, intravenous admixtures management, and drug interaction checking (pharmacy). The technologies mapped to this dimension are presented in Table 2.

3.1.3.3 Integration Sophistication

Lastly, information sophistication refers to the degree to which computer-based applications are integrated both internally within the department/clinical area via a common database and externally integrated with systems in other parts of or outside the hospital via electronic communication links (Pare and Sicotte 2001). The technologies mapped to this dimension can be seen in Table 3.

Table 1 Functional Sophistication Applications

Sophistication Dimension	Domain Activity	Application / Hardware
Functional	Patient Mgmt	Patient scheduling, Operating Room Scheduling, Registration
	Patient Care	Order entry, Physician documentation, Nursing documentation, Computerized Physician Order Entry, Outcomes & Quality Management, Staff scheduling, Nurse Acuity, Nurse Staffing, Operating Room pre-op, Emergency Department information system, Obstetrical Systems
	Clinical Support	Pharmacy Management System, Laboratory Information System, Radiology Information System, Cardiology Information Systems, Blood Bank, Anatomical Pathology, Microbiology, Respiratory Care Information Systems
Total Number of applications/hardware (denominator) = 22		

Table 2 Technological Sophistication Applications

Sophistication Dimension	Domain Activity	Application / Hardware
Technological	Patient Mgmt	RFID-Patient Tracking, Bar-coding
	Patient Care	MD: clinical decision support, dictation, dictation with speech recognition, handhelds, transcription, OR peri-op, OR post-op RN: ICU, Intensive care/medical surgical, handhelds, NICU
	Clinical Support	Radiology: Angiography, CR, CT, DF, DM, DR, MRI, NM, US (PACs), Telemedicine-Radiology, Telemedicine-Pathology, handhelds, Cardiology: Cath Lab, CT, Echo, Intra Ultra, Nuclear Cardiology
Total Number of applications/hardware (denominator) = 30		

Table 3 Integration Sophistication Applications

Sophistication Dimension	Domain Activity	Application / Hardware
Integration	Across All Domains	Electronic Medication Administration Record , Clinical Data Repository, Enterprise Electronic Medical Record, Enterprise Master patient Index, Intranet, Internet, Enterprise Resource Planning, Interface engine (Integration Engine)
Total Number of applications/hardware (denominator) = 8		

3.2 Agency for Healthcare Research and Quality

The Agency for Healthcare Research and Quality (AHRQ) was formed in 1999 to conduct and support research and to build public-private partnerships that would: identify the causes of preventable health care errors and patient injury in healthcare delivery; develop, demonstrate, and evaluate strategies for reducing errors and improving patient safety; and disseminate effective strategies throughout the healthcare industry (Ortiz et al. 2002). As a result, the AHRQ developed Inpatient Quality Indicators (IQIs), in response to a need for nationally defined, multidimensional, accessible quality indicators. The AHRQ IQIs are a group of measures that can be used with hospital inpatient administrative billing data to identify detectable variations in the quality of inpatient care. The AHRQ's Evidence-Based Practice Center at the University of California San Francisco and Stanford University adapted, expanded and refined the indicators based on the original Healthcare Cost and Utilization Project Quality Indicators developed in the early 1990s. These indicators serve as a starting point to assist hospitals in assessing the quality of care provided to patients. The indicators are expected to be used together with other hospital performance improvement activities and to supplement continuous quality improvement efforts.(AHRQ 2003).

3.2.1 Standardized Definitions

In the literature, the distinctions between medical error, adverse events, complications of care, and other terms pertinent to patient safety are not well established and are often used interchangeably. The AHRQ defines the terms medical error, adverse events or complications, and similar concepts as follows:

Complication or adverse event. “An injury caused by medical management rather than by the underlying disease or condition of the patient” (Brennan et al. 1991). In general, adverse events prolong the hospitalization, produce a disability at the time of discharge, or both (AHRQ 2007).

Medical error. “The failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning).” The definition includes errors committed by any individual, or set of individuals, working in a health care organization (IOM 2000).

Patient safety. “Freedom from accidental injury,” or “avoiding injuries or harm to patients from care that is intended to help them.” Ensuring patient safety “involves the establishment of operational systems and processes that minimize the likelihood of errors and maximizes the likelihood of intercepting them when they occur” (IOM 2001).

Patient safety indicators (PSI). Specific quality indicators which also reflect the quality of care inside hospitals, but focus on aspects of patient safety. Specifically, PSIs screen for problems that patients experience as a result of exposure to the healthcare system, and that are likely amenable to prevention by changes at the system or provider level (AHRQ 2007).

Preventable adverse event. An adverse event attributable to error is a "preventable adverse event." A condition for which reasonable steps may reduce (but not necessarily eliminate) the risk of that complication occurring (AHRQ 2007).

Quality. "Quality of care is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (AHRQ 2007).

Quality Indicators (IQI). Screening tools for the purpose of identifying areas of concern regarding the quality of clinical care. Quality indicators may assess any of the four system components of health care quality , including patient safety, effectiveness, patient centeredness, and timeliness (AHRQ 1999).

Rate based indicators. Indicators for which the primary purpose is to identify the rate of a complication rather than to identify specific cases (AHRQ 2007)

3.2.2 Indicator Reliability and Validation

AHRQ's quality indicator development process included a literature review to identify quantity concepts, potential indicators, and previous work on indicator validity; a review of ICD-9-CM coding to ensure correspondence between clinical concept and coding practice; clinical review panels to refine indicator definitions and risk groupings and to establish face validity when minimal in literature; and empirical analysis to explore alternative definitions, to assess nationwide rates, hospital variation, relationships among indicators and to develop methods to account for differences in risk (AHRQ 2007).

To evaluate the soundness of each indicator, the project team applied six questions regarding the following areas of evidence:

Face validity**.** Does the indicator capture an aspect of quality that is widely regarded as important and subject to provider or public health system control? Consensual validity expands face validity beyond one person to the opinion of a panel of experts.

Precision**.** Is there a substantial amount of provider- or community-level variation that is not attributable to random variation?

Minimum bias**.** Is there either little effect on the indicator of variations in patient disease severity and comorbidities, or is it possible to apply risk adjustment and statistical methods to remove most or all bias?

Construct validity**.** Does the indicator perform well in identifying true (or actual) quality of care problems?

Fosters real quality improvement**.** Is the indicator insulated from perverse incentives for providers to improve their reported performance by avoiding difficult or complex cases, or by other responses that do not improve quality of care?

Application. Has the measure been used effectively in practice? Does it have potential for working well with other indicators? (Davies et al. 2001)

Face validity or consensual validity was evaluated using a structured panel review, minimum bias was explored empirically and briefly during the panel review, and construct validity was evaluated using the limited literature available. A full discussion of the framework and statistical analyses can be viewed in the Stanford Technical report (McDonald et al. 2002).

3.3 Mortality

For purposes of this research AHRQ IQIs were adopted to operationalize the construct Mortality and capture characteristics of the quality of patient care that reflect internal hospital activities. The AHRQ IQIs are organized into three modules: Prevention Quality Indicators (PQIs), Inpatient Quality Indicators (IQIs) and Patient Safety Indicators (PSIs). Each of the modules includes area-level indicators that report performance throughout a geographic area, such as a county or metropolitan statistical area (AHRQ 2003; Services 2007). The area-level indicators are not included in this study because the focus of this project is to report information relevant to hospital inpatient quality of care. The IQIs and PSIs also include provider-level indicators that reflect care provided within the hospital setting and these indicators are utilized in this research.

The IQIs focus on the health care provided within an inpatient hospital setting and are a proxy measure of quality. Scientific evidence for these indicators is based on reports in peer reviewed literature. Structured literature review and empirical analyses were used to establish validity of the indicators and details regarding the development process are presented in the publication “Refinement of the HCUP Quality Indicators” available at www.qualityindicators.ahrq.gov (AHRQ 2003). The IQIs are comprised of three subsets of measures that include volume, mortality and utilization indicators.

3.3.1 Volume Indicators

The volume indicators are in areas for which a link has been demonstrated between the number of procedures performed and outcomes. They are based on evidence suggesting that hospitals performing more of a certain intensive, high-technology, or highly complex procedures may have better outcomes for those procedures. The volume indicators are not reported as part of this research project in order to control the breadth and complexity of the model.

3.3.2 Utilization Indicators

The utilization measures examine procedures whose use varies significantly across hospitals and for which questions have been raised about overuse, underuse and misuse. These indicators are not utilized in this research due to control of breadth and complexity of the model.

3.3.3 Mortality Indicators

Ten mortality measures are utilized to examine outcomes following procedures and for common medical conditions. The mortality indicators are divided into two subsets of measures: procedures and conditions. The inpatient procedures IQIs include procedures for which mortality has been shown to vary across institutions and for which there is evidence that high mortality may be associated with poorer quality of care. The inpatient conditions IQIs include conditions for which mortality has been shown to vary substantially across institutions and for which evidence suggests that high mortality may be associated with deficiencies in the quality of care (AHRQ 2007). The mortality measures are reported as part of this research, with the exception of pancreatic resection mortality, carotid endarterectomy mortality, and hip replacement mortality because of the low volume of such procedures performed in the state of Texas, which limits adequate analysis.

3.3.4 AHRQ IQIs Measured

The mortality construct in this study is operationalized through the measurement of several AHRQ IQIs. In the general model designed for this study, mortality is a second order construct comprised of the mortality rates from two first order constructs; procedures and conditions. Analyses is performed on both the second order construct mortality and then on the individual first order constructs. The AHRQ IQIs utilized in each construct can be seen in tables 4 and 5. All employed IQI measures in this study are risk-adjusted rates that reflect the age, sex, modified diagnostic related groups (DRGs), and comorbidity distribution of data in the baseline file, rather than the distribution for each hospital. The use of risk-adjusted rates facilitates the ability to generalize the data and puts each hospital "on an even playing field." Thereby alleviating some of the differences seen across hospitals due to types of patients seen, primary specialty performed, and case mix. Risk-adjusted allow the measures to reflect provider performance as if each provider had the average case mix in the sample (Services 2007).

Table 4 AHRQ IQIs measured to operationalize the Procedures construct (Services 2007)

Procedures:	
IQI Name	**Definition**
Abdominal Aortic Aneurysm Repair Mortality Rate (IQI 11)	A relatively rare procedure that requires proficiency with the use of complex equipment; and technical errors may lead to clinically significant complications, such as arrhythmias, acute myocardial infarction, colonic ischemia, and death.
Esophageal Resection Mortality Rate (IQI 8)	A rare procedure that requires technical proficiency; and errors in surgical technique or management may lead to clinically significant complications, such as sepsis, pneumonia, anastomotic breakdown, and death.
Coronary Artery Bypass Graft Mortality Rate (IQI 12)	A relatively common procedure that requires proficiency with the use of complex equipment; and technical errors may lead to clinically significant complications such as myocardial infarction, stroke, and death.
Craniotomy Mortality Rate (IQI 13)	Craniotomy for the treatment of subarachnoid hemorrhage or cerebral aneurysm entails substantially high post-operative mortality rates.
Percutaneous Transluminal Coronary Angioplasty Volume (IQI 6)	A relatively common procedure that requires proficiency with the use of complex equipment, and technical errors may lead to clinically significant complications and death.

Table 5 AHRQ IQIs measured to operationalize the Conditions construct (Services 2007)

Conditions:	
IQI Name	**Definition**
Acute Myocardial Infarction Mortality Rate (IQI 15) & Acute Myocardial Infarction Mortality Rate, Without Transfer Cases (IQI 32)	Timely and effective treatments for acute myocardial infarction (AMI), which are essential for patient survival, include appropriate use of thrombolytic therapy and revascularization.
Congestive Heart Failure Mortality Rate (IQI 16)	Congestive heart failure (CHF) is a progressive, chronic disease with substantial short-term mortality, which varies from provider to provider.
Acute Stroke Mortality Rate (IQI 17)	Quality treatment for acute stroke must be timely and efficient to prevent potentially fatal brain tissue death, and patients may not present until after the fragile window of time has passed.
Gastrointestinal Hemorrhage Mortality Rate (IQI 18)	Gastrointestinal (GI) hemorrhage may lead to death when uncontrolled, and the ability to manage severely ill patients with comorbidities may influence the mortality rate.
Pneumonia Mortality Rate (IQI 20)	Treatment with appropriate antibiotics may reduce mortality from pneumonia, which is a leading cause of death in the United States.

3.4 Patient Safety

3.4.1 AHRQ Patient Safety Indicators

For purposes of this research AHRQ PSIs were adopted to operationalize the construct Safety and capture characteristics of the quality of patient care that reflect internal hospital activities. The PSIs are a set of measures that can be used to screen for adverse events and complications that patients may experience as a result of exposure to the health care system. The PSIs provide a measure of the potentially preventable complication for patients who received their initial care and the complication of care within the same hospitalization. PSIs are divided into to levels; area and provider. Provider-level indicators are included in this study and report only those cases where a secondary diagnosis code flags a potentially preventable complication (AHRQ 2007).

3.4.2 AHRQ PSIs Measured

PSIs were chosen for inclusion in this study based on availability and validity measures as specified by the Agency for Health Research and Quality (AHRQ 2007). In the general model designed for this study, safety is a second order construct comprised of the safety indicator rates from two first order constructs; post operative and general safety. Analyses is performed on both the second order construct safety and then on the individual first order constructs. Indicators that were coded as rare, under-reported, unscreened, or obstetrical were excluded from the model as recommended by AHRQ due to possible skewing of the data. Table 6 displays the comprised indicators. All employed PSI measures in this study, excluding Death in Low Mortality DRGs, are risk-adjusted rates that reflect the age, sex, modified diagnostic related groups (DRGs), and comorbidity distribution of data in the baseline file, rather than the distribution for each hospital. The observed rate for Death in Low Mortality DRGs is measured due to the risk-adjustment transforming all hospital rates to zero.

Table 6 Patient Safety Indicators included in study

Patient Safety Measures	
PSI Name	**Definition**
Death in Low Mortality DRGs (PSI 2)	In-hospital deaths per 1,000 patients in DRGs with less than 0.5% mortality. Excludes trauma, immuno-compromised, and cancer patients.
Failure to Rescue (PSI 4)	Deaths per 1,000 patients having developed specified complications of care during hospitalization. Excludes patients age 75 and older, neonates in MDC 15, patients admitted from long-term care facility and patients transferred to or from other acute care facility.
Selected Infections Due to Medical Care (PSI 7)	Cases of secondary ICD-9-CM codes 9993 or 00662 per 1,000 discharges. Excludes patients with immuno-compromised state or cancer.
Postoperative Hip Fracture (PSI 8)	Cases of in-hospital hip fracture per 1,000 surgical discharges. Excludes patients in MDC 8, with conditions suggesting fracture present on admission and MDC 14.
Postoperative Hemorrhage or Hematoma (PSI 9)	Cases of hematoma or hemorrhage requiring a procedure per 1,000 surgical discharges. Excludes MDC 14.
Postoperative Respiratory Failure (PSI 11)	Cases of acute respiratory failure per 1,000 elective surgical discharges. Excludes MDC 4 and 5 and obstetric admissions.
Postoperative PE or DVT (PSI 12)	Cases of deep vein thrombosis or pulmonary embolism per 1,000 surgical discharges. Excludes obstetric patients.

3.5 Financial Performance

Numerous measures and approaches could characterize organizational performance. Therefore, determining which commonly used financial ratio is an appropriate measure to account for IT-related financial performance becomes a challenge. Within the literature there are several studies that have measured the financial performance of hospitals (Snyder-Halpern and Wagner 2000; Sobol 2000; Tennyson and Fottler 2000; Kim et al. 2002; McCue and Draper 2004; Rosko 2004; Hayden 2005), but there are relatively few studies that have directly measured HIT and financial performance, and all utilize disparate measures (Devaraj and Kohli 2000; Smith et al. 2000; Menachemi et al. 2006). Thus, a review of the existing literature on financial performance measures becomes necessary to conclude an appropriate proxy measure.

3.5.1 Financial Ratios

Techniques to measure financial performance of a business enterprise usually rely on financial ratios – the mathematical relationship between two or more financial measures. Empirical studies have demonstrated the usefulness of financial ratios in predicting performance of businesses including bankruptcy (Chen and Shimerda 1981). Ratio analysis, "…enables rapid and comprehensive digestion of routine financial statements in a minimum amount of time with a maximum acquisition of useful information (Choate 1974). Further, financial ratios often are used to benchmark performance with peer groups or to evaluate and/or predict performance. Benchmarking allows managers to determine how their firm compares with similar firms and evaluation/prediction allows researchers and managers to estimate how past performance may be a predictor of future performance.

In healthcare, financial ratios have been used for many years. In the mid-1970s, working together, the Healthcare Financial Management Association (HFMA) and William O. Cleverley created the Financial Analysis Service which evolved into a robust database of 29 financial ratios measuring most aspects of financial performance in hospitals (Cleverley and Rohleder 1985). This service provided hospital managers and others with evaluative tools to compare and predict. While these ratios provided a basis for improved decision making they still presented a bewildering array of data to digest (Cleverley 1984; Barnes 1987; Glandon et al. 1987).

3.5.2 Reduction of Choices

Cleverly and Rohleder (1985) used the HFMA Financial Analysis Service (FAS) as the basis for a study into the unique dimensions of financial ratios. They confirmed a growing consensus that the 29 FAS ratios needed a context for evaluation. To develop this framework, Cleverley and Rohleder used factor analysis on FAS data for the years 1978-1980. Based on this factor analysis, 10 factors were identified and individual ratios were categorized within these factors and ranked in terms of their factor loading. The 10 factors of financial performance were profitability, short-term cash position, capital structure, liquidity, age of plant, debt coverage, payment mix, leverage, current asset efficiency, and fixed asset efficiency. By using this approach, they found that 10 ratios best reflected the 10 factors and that theses ratios account for most of overall financial performance (Cleverley and Rohleder 1985).

Following Cleverley and Rohleder's earlier work, Zeller, Stanko and Cleverly (1996) analyzed data from different types of non-profit hospitals and performed a more comprehensive research methodology. In this study, the researchers used 1989-1992 FAS data that identified seven financial factors of hospital performance which consistently accounted for 70% to 80% of total financial performance. These factors included profitability, fixed asset efficiency, capital structure, fixed asset age, working capital efficiency, liquidity, and debt coverage. Of these factors, they reported that profitability showed the highest correlation (.95) among each category of analysis (ownership, teaching status, and location). The intra-factor correlation in their analysis indicated that the following profitability ratios had the highest correlations: Return on assets (ROA=net income divided by total assets), Total Margin (TM=net income divided by operating revenue), Return on Investment, price level adjusted (ROI=net income plus interest and depreciation divided by total assets, price level adjusted by the Consumer Price Index), and Operating Margin (OM=operating income divided by operating revenue) (Zeller et al. 1996).

Other cross-sectional and intra-factor analyses performed by the authors identified ratios that were highly correlated with each category and within each factor. The authors concluded that the hospital's ownership, teaching status, and location did not alter the framework for financial ratio analysis. They also reported that the importance of profitability to not-for-profit hospital was noteworthy. Given that most hospital resources are derived from revenue collected from services rendered, this aspect of funds flow is more important to hospitals than many other types of not-for-profit enterprises (Zeller et al. 1996).

3.5.3 A Unidimensional Indicator

Continuing research has been done to develop a single measure able to both compare and predict. Caruana (1978) described a viability index that combined several financial ratios from conceptually different dimensions. This ratio joined the concepts of capital structure, profitability, and an inverse liquidity ratio. These ratios were weighted and calculated such that larger scores indicated greater debt relative to equity, greater expenses relative to revenue, and lower current liquidity; thus making the hospital less viable.

Cleverley and Nilen (1980) developed a similar approach to viability by relating liabilities to assets and more heavily weighting operating expenses to operating revenue. The researchers stated that as liabilities approach assets and as expenses approach revenue the organization is less viable. Therefore, values less than one are desirable.

Cleverley (1984) focused on the Financial Accounting Standards Board definition of financial flexibility and developed the Financial Flexibility Index (FFI). The conceptual framework for this ratio was that a hospital's sources and uses of funds determined its flexibility to meet its needs, however unexpected. Cleverly used ratios that measured the source and use of funds and weighted those components thought to increase flexibility (e.g. sources such as profitability) and those components that reduce flexibility (e.g. uses such as cash flow to total debt) (Cleverley 1984).

In order to understand the true financial position of a hospital and design strategies to change performance, Cleverly (1995) stated that return on equity is a critical measure of performance. He noted that a critical factor in measuring the success of an organization is whether it is capable of generating resources needed to meet its mission. "There is no other financial objective that is more important than equity growth in any business entity for measuring long-term financial success (Cleverley 1995).

While these techniques reduced the volume of data needed for evaluation, some researchers noted that aggregate indexes of financial performance was multi-dimensional and could not be captured through broad-based indexes weighted for certain levels of financial performance. They also noted that the construct for development of theses indexes lacked significant empirical base. Finally, they noted that from a predictive standpoint, there is little agreement on what constitutes failure since bankruptcies of hospitals are relatively rare (Glandon et al. 1987).

Arthur Andersen and the American Hospital Association developed a paper entitled "Financial Viability Measure for Hospitals and Health Systems" to examine the question, "How do we know if a hospital or health system is financially sound?" The panel concluded that a variety of measures are important, but noted the use of the data determines they type of data needed (Anderson 1998).

Given this discussion, it appears that a single index probably does not respond to the unique demands of decision makers and, in fact, may mislead them. The selection of the "right" ratios, factors, or indexes, however, requires an identification of the needs of the organization. As such, the literature is clear that the use of these data is probably the most important determinate in measurement selection.

3.5.4 Key Indicators

This literature review identified several approaches to validate and narrow the number of ratios that should be examined to determine financial performance. From the research presented, it appears that profitability measures tend to have more reliability in predicting other ratios than any other factor grouping. Given the conclusions of many researchers that most hospitals are uniquely depended on operating sources of working capital, primarily revenue, this is not surprising. With regard to profitability, a hospital is like any other organization. Irrespective of ownership type or affiliation a hospital must produce profits in order to succeed and survive (Cleverley and Harvey 1992). Additionally, financial statements, from which most ratios are calculated, are designed to measure changes in financial condition (income statement) and changes in financial positions (balance sheet). These accounting statements tend to focus on the results of operations and hence focus on profitability.

It also appears, based on research presented in the literature, that profitability measures that relate operational performance to investments, assets, or equity (return on investment, return on assets, or return on equity) better measure financial performance than those that simply relate margin production related to revenue (total margin, operating margin, etc). Additionally, the effective use of assets also appear important to overall financial performance. For example, return on assets and asset turnover ratios that measure the relationship of revenue generation to assets appear to be important to understanding the effective deployment of resources (Cleverley 1995). Additionally, hospital executives' subjective perceptions of financial performance appears to correlate with the objective measures return on assets and operating margin (McCracken et al. 2001).

3.5.5 Ratios Utilized

In accordance with the literature, this study utilizes a multidimensional construct comprised of profitability and operational performance to measure financial performance. The construct profitability is measured by return on assets (ROA), Operating Margin (OM), and Return on Equity (ROE). The construct operational performance is measured by net patient revenue per day and net patient revenue per discharge (Cleverley 1995; Devaraj and Kohli 2000; Smith et al. 2000; McCracken et al. 2001; Menachemi et al. 2006). Analyses is performed on both the second order construct financial performance and then on the individual first order constructs.

CHAPTER IV

RESEARCH DESIGN AND METHODOLOGY

4.1 Data collection

Based on the literature review, little work has been done examining the direct impact of HIT on healthcare. This project follows previous exploratory research performed by Hart (2006), and was designed to add to the body of knowledge by providing a new perspective on the role of HIT in healthcare and through the identification of specific impacts HIT has on quality, safety, and financial outcomes in a hospital environment.

The primary analysis of the relationship between IT sophistication and financial performance, mortality, and safety was performed using secondary data collected and compiled from three data sources. The Dorenfest Institute for Health Information Technology Research and Education (IHDS), through the Healthcare Information and Management Systems Society (HIMSS), provided information systems data for acute care hospitals in Texas, the American Hospital Directory (AHD) provided key characteristic, utilization, and financial records, and the Dallas Fort Worth Hospital Council (DFWHC) supplied the AHRQ IQI and PSI files for the state of Texas.

4.1.1 Information Systems Data Source

Information Systems Data was provided by the Dorenfest Institute for Health Information Technology Research and Education. IHDS provides a variety of detailed historical data, reports, and white papers about information technology (IT) use in hospitals and integrated healthcare delivery networks at no charge to universities, students under university license, U.S. governments (local, state and federal), and governments of other countries that will be using the data for research purposes. The IHDS operates through the Health Information Management Systems Society foundation. Actual data used in this study was extracted from the 2005 HIMSS Analytics Database, derived from the Dorenfest Integrated Health Care Delivery System (IHDS) Database (HIMMS 2005).

4.1.2 Demographic and Financial Data

Demographic and financial data was provided by The American Hospital Directory (AHD). The AHD provides online data for over 6,000 hospitals and contains information about hospitals built from both public and private sources including Medicare claims data (MedPAR and OPPS), hospital cost reports, and other files obtained from the federal Centers for Medicare and Medicaid Services (CMS). While AHD requires subscriptions to access their database, they offer free subscriptions to colleges and universities for use in health education.

4.1.3 AHRQ IQI and PSI Data

Inpatient quality indicators and patient safety indicators for the state of Texas were obtained through the Dallas Fort Worth Hospital Council Data Initiative. DFWHC Data Initiative is a not-for-profit education and research foundation established in 1997 to answer the growing need in the health care community for high quality, standardized data which could be used to measure value, facilitate evaluation of health care quality and promote quality improvements.

4.1.4 Compilation of Datasets

First, the HIMSS Analytics database was analyzed and all information on Texas hospitals was extracted from the database. This yielded a total of 197 Texas hospitals, their demographic, IT application, and technology information. Second, financial records, demographics, IQIs, and PSIs for the Texas hospitals were extracted from their appropriate databases. The hospitals from both databases were then compared to the sample from IHDS and a new sample dataset was formed. All hospital information, including names, IDs, and addresses, were evaluated to ensure accuracy in the merging of datasets. Any hospital not appearing in all three data files or who could not be confidently identified as matches were deleted from the sample. Data was examined and outliers were removed. Upon completion of merging and cleaning of the datasets, the sample included 148 Texas acute care hospitals.

Initial partitioning of the data revealed a significant amount of variation between public/private hospitals and government owned hospitals. Since the number of government hospitals was relatively small (12), we deleted these hospitals from the sample and no analyses were performed on them. The final sample utilized in this study was comprised of 136 Texas acute care hospitals.

4.2 Descriptive Statistics

Summaries of acute care hospital characteristics are given in tables 7-9 for the hospitals analyzed in this study. The majority of the 136 hospitals were metropolitan hospitals with an equal number of non-profit and for-profit hospitals represented. As reported previously, a small number of government hospitals were deleted do to initial partitioning of the data. Data for hospital internal operations stratified by ownership status is presented in table 7. Score dispersion for the Information technology sophistication construct are seen in table 9. The possible range of scores was between 0 to 100.

Table 7 Hospital Characteristics – Frequency Data

Variable (n= 136)		Frequency	Percent
Metropolitan status			
	Urban	104	76.5
	Rural	32	23.5
Ownership			
	For Profit	68	50
	Not-For Profit	68	50

Table 8 Descriptive Statistics by Ownership. – Dollar figures reported in millions

Status	# of General Beds		Rev Per Discharge		Rev Per Patient Day	
	M	SD	M	SD	M	SD
Profit	196	23	12316.33	361.30	3038.25	112.40
Non-Profit	218	29	11648.31	411.15	2875.23	78.66

Table 9 Descriptive Statistics For Sophistication Scores

Sophistication (N=136) Scale: 0 to 100	M	SD	Range
Functional	54.74	16.96	16 - 100
Technological	31.57	11.48	0 - 67
Integration	44.85	21.60	0 - 88
Total Sophistication	45.85	12.48	10 - 73

4.4 Data Analysis

4.4.1 Technique

Analysis was performed using Partial Least Squares (PLS) modeling. PLS is a structural equation modeling (SEM) technique that assesses the psychometric properties of the scales employed to measure the theoretical constructs and estimates the hypothesized relationships among said constructs (Barclay et al. 1995; Chin et al. 2003 ; Westland 2007). While other SEM tools exist, the choice to use PLS was driven by several factors. PLS was developed to handle both formative and reflective indicators whereas other SEM techniques do not permit this. The existence of this ability enables the designation of the type of relationship that the researcher believes to exist between the manifest variables and the latent constructs. Second, Wold (1981) specifically advises that PLS is not suitable for confirmatory testing, rather should be used for prediction and the exploration of *plausible causality*. Other techniques are primarily concerned with parameter accuracy. Thirdly, PLS does not make the assumption of multivariate normality that the SEM techniques LISEREL and AMOS do, and being a nonparametric procedure, the problem of multicollinearity is not an issue (Bido 2006). Finally, PLS's requirement on sample size is lower than the other SEM techniques (Chin 1998; Chin and Newsted 1999; Westland 2007). Sample size requirements are equal to the larger of; 10 times the number of indicators on the most complex formative construct or 10 times the largest number of independent constructs leading to an endogenous construct (Chin et al. 2003 ; Bido 2006; Westland 2007). Thank you to the University of Hamburg, Germany, School of Business for providing the use of their SmartPLS software to perform this research analyses.

4.4.2 Measurement Model

Several steps were used in the assessment of the measurement model shown in table 10; exploratory factor analysis, item purification, assessment of convergent and discriminant validity, and evaluation of the measure's reliability.

4.4.3 Item Purification

In order to explore the construct dimensions, an Exploratory Factor Analysis (EFV) was run using the Principal Components extraction method with Varimax rotation. The results from the Exploratory Factor Analysis confirmed the need to remove hip fracture and hip replacement from the peri-operative factor, and pancreatic resection and carotid endarterectomy from the mortality construct. The financial profitability construct factor return on equity (ROE) proved not to fit with other profitability measures and was removed. All other items loaded as predicted onto their dimensions.

Table 10 Final Constructs and Factor Loadings

Study Scale Items	Factor Loadings
IT Sophistication	
Functional	0.74
Technological	0.80
Integration	0.70
Mortality	
Procedures:	
AAA Repair	0.79
CABG (Coronary Artery Bypass Graft mortality)	0.80
CRANI (Craniotomy mortality)	0.75
ESOPH (Esophageal Resection mortality)	0.80
PTCA (Percutaneous Transluminal Coronary Angioplasty mortality)	0.78
Conditions:	
AMI (Acute Myocardial Infarction mortality)	0.88
AMI wo Trans (AMI with out transfer cases mortality)	0.88
CHF (Congestive Heart Failure mortality)	0.62
GI Hem (Gastrointestinal Hemorrhage mortality)	0.56
PNEUM (Pneumonia mortality)	0.69
STROKE (Acute Stroke mortality)	0.59
Financial Performance	
Profitability:	
OM (Operating Margin)	0.88
ROA (Return on Assets)	0.87
Operational:	
DISC (Net Revenue Per Discharge)	0.79
PAT (Net Revenue Per Patient Day)	0.90
Patient Safety	
Peri-Operative	
HEM (Post Operative Hemorrhaging)	0.53
RESP (Respiratory Failure)	0.85
General:	
DVT (Deep Veing Thrombosis)	0.76
SEL (Selected Infections Due to Medical Care)	0.77
FTR (Failure To Rescue)	0.51
DEATH (Death in Low Mortality DRGs)	0.78

To further purify the measure a Confirmatory Factor Analysis on the fifteen items was performed using the Maximum Likelihood (MLE) in LISREL 8.45 in order to assess the psychometric properties of the scale developed in this study (Anderson and Gerbing 1988). All fifteen items (15) were retained for the analyses, which encompassed three second order constructs; financial performance, mortality, patient safey, and six first order constructs (see Table 10)

In order to test the validity and reliability of the constructs Rossiter (2002) procedure for scale development was followed. First, convergent and discriminate validity were determined and finally, reliability of the scale items was evaluated.

4.3.4 Convergent Validity

Convergent validity specifies that items that are indicators of a construct should share a high proportion of variance (Hair el al. 2006). Factor loadings are used to evaluate convergent validity. The factor loadings revealed support for convergent validity for the six constructs. All loadings were greater than .50, the cutoff proposed by Hair et al. (2006), with most loadings exceeding .60. The factor loadings ranged from .56 to .96. Items with loadings less than .70 can still be considered significant, but more of the variance in the measure is attributed to error (Hair et al. 2006). The high factor loadings give reason to conclude that the measures have convergent validity.

4.3.5 Discriminant Validity

The next step in the construct validation process is the assessment of discriminant validity. Discriminant validity reflects the extent to which the measure is unique and not simply a reflection of other variables (Peter and Churchill 1986). Each dimension of a construct should be unique and different from the other even though each reflects a portion of that construct. There are several ways to evaluate discriminant validity.

Average variance extracted is a common method of testing discriminant validity (Gerbing and Anderson 1988). Discriminate validity was evaluated using the average variance extracted (AVE) calculated by the SmartPLS software. The average variance extracted for all factors should be above the recommended cutoff of .50 (Fornell and Larker 1981). All constructs exceeded the .50 cutoff. with the exception of procedures (AVE=.4673) and general safety (AVE=.4293). However, the procedures and general safety dimensions were found to have adequate convergent validity based on their high factor loadings (>.50) (Gerbing and Andersen 1988; Das et al. 2000). Furthermore, the average variance extracted for each latent factor exceeded the respective squared correlation between factors, thus providing evidence of discriminant validity (Fornell and Larcker 1981). Construct composite reliabilities, average variances extracted, and correlations for all latent variables are identified in Tables 11 and 12.

4.3.6 Reliability

The final step in investigating construct validity is to determine the reliability of the construct items. Reliability is the degree to which a set of indicators are internally consistent, the extent to which the instrument yields the same results on repeated trials Reliability is necessary but not sufficient for validity of a measure, even measures with high reliability may not be valid in measuring the construct of importance (Hair et. al 2006). Reliable indicators should measure the same construct. A measure of internal consistency or composite reliability is a composite alpha value. This value was used to assess the reliability of the ten constructs. Construct reliability coefficients should all exceed the .70 lower limit (Hair et al. 1998; Rossiter 2002). However, Nunnally (1967) and Srinivasan (1985) suggest that values as low as 0.50 are acceptable for initial construct development. Additionally, Van de Venn and Ferry (1980) state that acceptable values may be as low as 0.40 for broadly defined constructs. The composite reliability and Chronbach's alpha values for the studied constructs were computed by SmartPLS and ranged from .68 to .93 and .50 and .85, respectively (see table 11). All values fall within the acceptable range to conclude good reliability.

Table 11 Measures of Reliability Among the Variables

Construct	R^2	Composite α	Chronbach's α
1. IT Sophistication	0.50	0.78	0.61
2. Procedures	0.65	0.74	0.57
3. Conditions	0.63	0.68	0.67
4. General Safety	0.83	0.71	0.51
5. Post-Op Safety	0.58	0.66	0.50
6. Profitability	0.80	0.93	0.85
7. Operational	0.52	0.90	0.80

Table 12 Correlations and measures of validity among variables

Construct	AVE	1	2	3	4	5	6	7
1. IT Sophistication	0.54	**.73**						
2. Procedures	0.47	.37	**.69**					
3. Conditions	0.56	.28	.28	**.75**				
4. General Safety	0.43	.46	.37	.11	**.66**			
5. Post-Op Safety	0.50	.43	.37	.25	.43	**.71**		
6. Profitability	0.87	.30	.28	.03	.38	.23	**.93**	
7. Operational	0.82	.16	.12	.21	.17	.17	.07	**.91**

Note: Square root of the AVE's are on the diagonal

In conclusion, the purified construct measures were found to exhibit validity and reliability as indicated by the validity checks and reliability values. Additionally, all quality indicators for PLS measurement models, as denoted by Rossiter (2002), were found to be in compliance.

4.4 Structural Model and Hypotheses Tests

In order to test the hypothesized relationships between variables, structural equation modeling was employed using *SmartPLS 2.0.M3*. All general hypothesized paths were included in the model depicted in Figure 5, and then subsequent hypothesized paths are included in the model depicted in Figure 6.

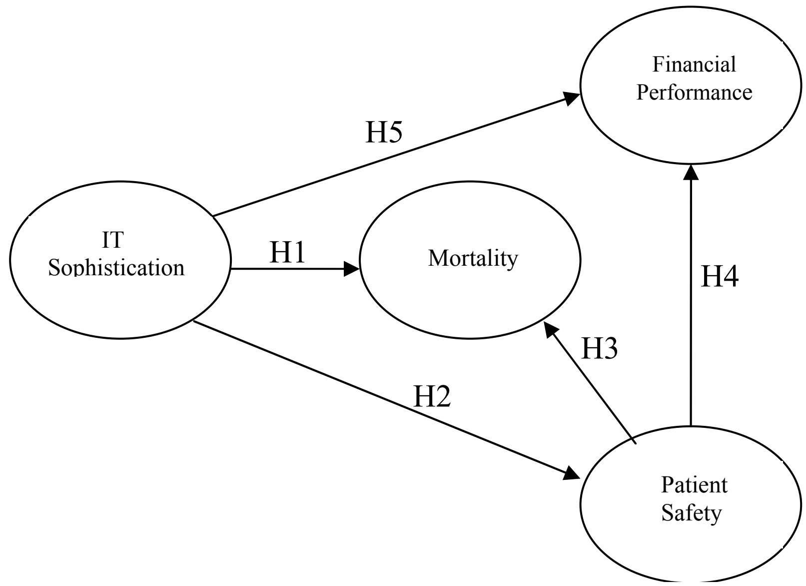

Figure 5 General Conceptual Model

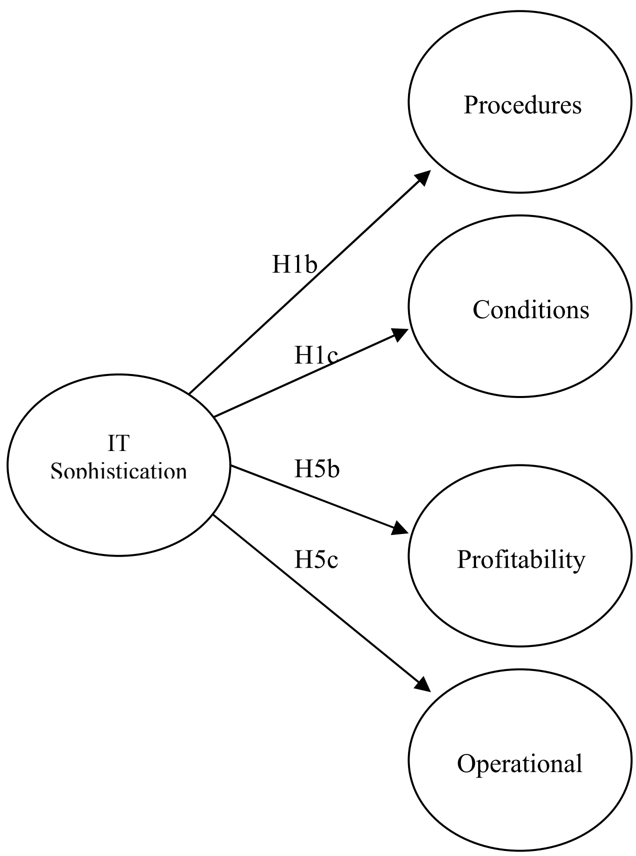

Figure 6 Subset Hypothesis Structural Model

4.4.1 Structural Model

Validation of the structural model was achieved using SmartPLS 2.0.M3. The model was designed in PLS per the guidelines given in the SmartPLS Guide (Ringle et al. 2005). Following Chin (1998), bootstrap resampling method was employed. Five hundred (500) iterations using randomly selected sub-samples were performed to estimate the theoretical model and hypothesized relationships.

The results of the structural model with all hypothesized paths revealed a model with adequate fit. The criterion put forth by Rossiter (2002) states that for the structural model all paths should result in a t-value greater than 2 and latent variable R-Squares (R^2) greater than 50%. SmartPLS calculated the R-Square and t-values for the full structural model and all path t-values met the required cut off with the exception of sophistication → financial performance (t-vale = 1.9970) and patient safety → financial performance (t-value = 1.9598). As the predicted paths for the structural model are all hypothesized unidirectional relationships, all t-values well surpass the t-critical value of 1.645. Additionally, all R-Square values, as seen in table 4.5, exceed the 50% threshold and therefore, adequate fit is concluded. Table 12 presents the path coefficient means, standard deviations, and t-values.

Table 13 Path Coefficient Means, Std Deviations, and T-statistics

Path	Mean	Std Deviation	T-Statistic
Mortality → Conditions	0.826	0.043	18.571
Mortality → Procedures	0.786	0.088	9.157
Sophistication → Mortality	0.219	0.128	2.241
Sophistication → Fin. Perform.	0.161	0.089	1.997
Sophistication → Patient Safety	0.468	0.071	6.607
Performance → Fin. Perform.	0.869	0.072	12.534
Performance → Operational	0.587	0.145	3.461
Patient Safety → General	0.918	0.019	47.184
Patient Safety → Post-Op	0.765	0.046	16.378
Patient Safety → Mortality	0.358	0.139	1.960
Patient Safety → Fin. Perform.	0.314	0.111	3.081

4.4.2 Power

In order to assess the power of the model, the software G*Power 3 was utilized (Faul et al. 2007). Sensitivity analyses was performed in order to compute required effect size. With an alpha of 0.05 and a sample size of 136, the effect size was computed as 0.27. The effect size was then applied in a post hoc computation of achieved power. Calculations yielded a critical t of 1.656 and power of 0.946, which falls well above the 0.80 threshold suggested by Hair et.al. (1998).

4.4.3 Individual Hypotheses Tests

This section presents the results of the specific hypotheses predicted in this study. The evaluation criteria for confirming each hypothesis was the use of t-values for each path loading. Significant t-values for path loadings signify support for the proposed hypothesis. The cutoff criteria used was a t-value greater or equal to 1.645 for an alpha level of .05 (Hair et al. 2006).

Hypothesis 1a states that there is a negative relationship between IT Sophistication and Mortality (see Figure 6). The t-value for this path was 2.241 which was significant. Thus hypothesis 1 was supported; IT sophistication has a negative relationship with Mortality

Hypothesis 1b explores IT sophistication's relationship to Mortality related to Procedures (see Figure 7). The t-value for this path was significant at t=6.178. The significant t-value provides support for the hypothesis, suggesting that mortality related procedures are directly and negatively related to IT Sophistication

Hypothesis 1c suggests that IT Sophistication has a negative effect on mortality related to conditions (see figure 7). This hypothesis is supported by the data with a significant t-value of 4.292 . Thus, support is found for a significant negative relationship between IT sophistication and mortality related to conditions.

Hypothesis 2 posits that there is a negative relationship between IT sophistication and Patient Safety (see Figure 6). The t-value for this path was significant at t= 6.607, however, the hypothesized direction of the relationship was not supported. Thus, it was found that IT sophistication has a positive relationship with Patient Safety.

Hypothesis 3 suggests that there is a positive relationship between Patient Safety and Mortality (see Figure 6). The hypothesis is supported by the data with a significant t-value of 1.960. Thus, support is found for a significant positive relationship between patient safety and mortality.

Hypothesis 4 explores the relationship between patient safety and financial performance (see Figure 6). The significant t-value provides support for the hypothesis, suggesting that patient safety and financial performance are negatively related.

Hypothesis 5a investigates the relationship between IT sophistication and a hospital's financial performance (see Figure 6). More specifically, the hypothesis identifies a direct positive relationship between IT sophistication and a hospital's financial performance. This relationship is supported with a t-value of 1.997.

Hypothesis 5b states that IT sophistication is positively related to a hospital's profitability (see Figure 7). The t-value for the significant path is 4.064. Thus, the data supports the hypothesized direct path from IT sophistication to profitability.

The final Hypothesis (5c) identifies a direct positive relationship between IT sophistication and a hospital's operational performance (see Figure 7). The t-value was significant with a value of 5.899. Thus, the data appears to support the proposed relationship; IT sophistication directly positively affects a hospital's operational performance.

Table 14 Hypotheses Summary

	Path	Parameter Estimates	
H1a	IT Sophistication → Mortality	-0.219**	Supported
H1b	IT Sophistication → Procedures	-0.401*	Supported
H1c	IT Sophistication → Conditions	-0.345*	Supported
H2	IT Sophistication → Patient Safety	0.468**	Not Supported
H3	Patient Safety → Mortality	0.358**	Supported
H4	Patient Safety → Financial Performance	0.870*	Supported
H5a	IT Sophistication → Financial Performance	0.161*	Supported
H5b	IT Sophistication → Profitability	0.309**	Supported
H5c	IT Sophistication → Operational Performance	0.425**	Supported

** Significant at .05
*Significant at .01

4.5 Summary

This chapter tested the IT sophistication construct in a hospital environment and investigated its relationship to mortality, patient safety, and financial performance. Support was found for the influence of IT sophistication on all constructs. However, there was a direct positive relationship found between IT sophistication and patient safety when theory predicts an inverse relationship. The next chapter provides a post hoc analysis of the data that was performed to further investigate the path relationships and to provide insight into the unexpected inverse relationship identified.

CHAPTER V

NEW AND UNEXPECTED INFORMATION

The unexpected results found in the relationship between IT sophistication and patient safety generate the need for further exploration. It has been noted that "…a data point that does not lie on a line or plane with (most of) the other points…may represent new and unexpected information" (Weisberg 1977, 60-61). Thus, it may also hold true that a path's coefficient that does not follow its theoretical direction may suggest the same occurrence of new information. Initial re-examination of the data led classification trees for additional partitioning. It was found that 27% of the variation occurring in the data could be attributed to hospitals of varying size. Through partitioning using JMP 7.0 hospitals were grouped into small, medium, and large size based on general and specialty beds available. The groups were defined as small being all hospitals with less than 94 beds, medium consisting of hospitals with between 94 and 277 beds, and large hospitals categorized as having more than 277 beds. This coincides with current nursing literature that suggests small hospitals should be categorized as less than 100 beds, medium between 100 and 299 and large greater 300 beds (Henderson 1965; General 1988; Khuspe 2004; Ward et al. 2005). Due to this new discovery, an exploratory investigation was performed to ascertain how hospital size impacts the previously discussed structural model seen in figure 5.

5.1 Descriptive Statistics

Division of the dataset into groups by size resulted in 3 subsets of data representing small hospitals with a sample size of 38, medium hospitals with a sample size of 68, and large hospitals with 30 observations. In order to determine if size was a determinant of technology applications available, descriptive statistics were calculated using *SPSS 11.5* and analysis of variance was performed (see table 15). The results indicate that there is a statistically significant difference in the amount of functional, technical, and integration applications available for use between hospitals of different size. This further supports the results from previous partitioning of the data and in return the investigation of how hospital size impacts the relationship between IT Sophistication and operational outcomes.

Table 15 Descriptive Statistics of IT Sophistication Across Hospital Size

Functional Scale: 0 to 100	M	SD	F	Sig
Small	42.93	2.077		
Medium	57.24	2.022	22.434	0.000*
Large	66.37	2.180		
Technical				
Small	27.64	1.797		
Medium	31.57	1.322	6.532	0.002*
Large	37.53	2.049		
Integration				
Small	39.63	3.234		
Medium	44.85	2.635	3.109	.048**
Large	52.78	4.022		

** Significant at .05
*Significant at .01

Additional analyses were performed to determine the possible effects of ‘For-Profit’ status on the availability of IT applications for use in hospitals. This follows previous research by Sobol and Smith (2001) who found a significant difference between ‘For-Profit’ and ‘Not-For-Profit’ hospitals with regard to hospital efficiency. Descriptive statistics revealed a fairly even division of ‘For-Profit’ hospitals across all three hospital sizes (see table 16). Unfortunately, the extremely small sample sizes in the small and large hospital categories prevent the ability to perform partial least squares regression, which is generally tolerable of small sample size. However, a two sample t-test was performed on the entire dataset grouped by profit status, and a statistically significant difference between the number of functional and technical applications available to institutions was found to exist (see table 17). This gives further insight into the different variables that possibly impact the use of IT applications in hospitals, and future research should examine the effects of status further.

Table 16 Sample size grouped by hospital status

	Sample Size		
Status	Small	Medium	Large
For Profit	17	37	14
Not For Profit	21	31	16

Table 17 Independent sample t-test across hospital size

	t-test			
Application	t	df	Sig	Std Error
Functional	2.067	134	0.041*	2.874
Technical	-2.327	134	0.021*	1.938
Integration	-1.699	134	0.092	3.678

* Significant at .05

5.2 Structural Model Validation

To asses how the structural relationships differ with hospital size, the structural equation model was analyzed separately for small, medium, and large firms as Chen 1998 advises against the use of covariates in partial least squares analysis. Fit analyses on the structural models were performed using *Smart PLS 2.0 M3* and following the criterion set forth by Rossiter (2002). All three models had sufficient R^2 above the 50% cutoff, and t-values greater than 2 with the exception of two paths (see figures18-19). For medium size hospitals, the path from Sophistication → Mortality had a t-value of 1.92 and the path Sophistication → Financial Performance had a t-value of 1.94. Finally, for small hospitals there was a t-value of 1.68 for the path Sophistication → Patient Safety. However, for unidirectional relationships a t-value of 1.645 is significant. Therefore, structural validation was concluded for all three structural models.

Table 18 Path t-values for small, medium, and large hospitals

Path	t statistic		
	Small	Medium	Large
Mortality → Conditions	15.06	22.28	15.24
Mortality → Procedures	2.20	4.88	12.85
Sophistication → Mortality	2.09	1.92	3.86
Sophistication → Fin. Perform.	2.48	2.31	2.24
Sophistication → Patient Safety	1.68	1.94	2.99
Performance → Fin. Perform.	11.01	5.49	6.52
Performance → Operational	10.54	7.33	11.25
Patient Safety → General	16.23	16.28	25.92
Patient Safety → Post-Op	4.83	9.28	18.17

Table 19 Construct R-square values

	R-Square		
Construct	Small	Medium	Large
1. IT Sophistication	0.81	0.61	0.51
2. Procedures	0.58	0.52	0.50
3. Conditions	0.70	0.88	0.81
4. General Safety	0.68	0.70	0.76
5. Post-Op Safety	0.57	0.63	0.76
6. Profitability	0.59	0.50	0.56
7. Operational	0.55	0.62	0.59

5.3 Results By Hospital Size

Hospitals with fewer than 94 general and surgical beds comprised the category of small hospitals. Removal of all other hospitals resulted in a dataset of 38 observations. Path analysis was performed and revealed that IT sophistication has a significant positive relationship to safety and insignificant negative relationships to mortality and performance. This coincides with the overall general model previously explored in this research. The subsequent breaking down of IT sophistication into its three components (functional, technical, and integration) and exploring the individual relationship each of the components has to the different operational outcomes did not change the positive relationship to safety. However, the implementation of integration applications alone caused the negative relationship to mortality to become statistically significant. Therefore, it is suggested to practitioners that they consider investing in applications that integrates communication and information availability across different departments both internally and externally. This should lead to a significant decrease in the mortality rates of smaller hospitals.

Medium sized hospitals were defined as having between 94 and 277 general and surgical beds. They comprised a dataset of 68 hospitals on which path analysis was performed. Initial results showed an insignificant negative relationship between the construct IT sophistication and performance, and a statistically significant positive relationship with safety and mortality. However, the removal of functional applications from the model created a statistically significant inverse relationship between IT sophistication and safety. Further investigation noted that the presence of integration applications alone produced a statistically significant inverse relationship to both safety and mortality rates. Therefore, consideration of investment into technological integration applications is recommended for hospitals of medium size. The data suggests that these applications can decrease mortality and safety rates without causing a statistically significant decrease in financial performance.

Finally, large hospitals with greater than 277 beds yielded a dataset of 30 observations. Full model analysis resulted in an insignificant positive relationship between IT sophistication and performance, a statistically significant negative relationship to safety, and statistically significant positive relationship to mortality. While the removal of functional applications from the model created a statistically significant positive relationship with performance, it also created a statistically significant positive relationship with safety and mortality. Analysis of individual components allowed us to discover, however, that functional and technical applications helped in larger hospitals by creating a statistically significant increase in performance and a statistically significant decrease in mortality and safety rates. Therefore, it is recommended that practitioners look to functional and technical applications first in larger hospital environments.

Table 20 Path analysis summary across hospital size

Small Hospitals	t statistic			
Path	F,T,I	Functional	Technical	Integration
Sophistication → Fin. Perform.	0.580	1.248	0.892	0.686
Sophistication → Mortality	-0.198	-0.742	1.371	- 2.098*
Sophistication → Patient Safety	2.516*	6.377 *	1.914 *	2.091 *
Medium Hospitals				
Sophistication → Fin. Perform.	-0.304	-0.522	-0.832	-1.636
Sophistication → Mortality	0.881	1.252	-1.062	-2.131*
Sophistication → Patient Safety	1.712*	2.265 *	-2.171*	-1.433*
Large Hospitals				
Sophistication → Fin. Perform.	0.283	3.194*	6.188*	1.013
Sophistication → Mortality	3.067*	-3.874*	-2.813*	8.396*
Sophistication → Patient Safety	-2.863*	4.375*	-1.460	2.297*

5.4 Summary

This chapter explored the IT sophistication construct in a hospital environment and investigated its relationship to mortality, patient safety, and financial performance across small, medium, and large hospitals. Breaking down the IT sophistication construct into the components functional, technical, and integration allowed the assessment of different types of technologies' impacts on operational outcomes. The next chapter provides a discussion of the results found in the empirical study along with implications, limitations and future research. .

CHAPTER VI

DISCUSSION, LIMITATIONS AND FUTURE RESEARCH

The importance of information technology in the healthcare environment has recently been given much attention. With the amount of money spent each year on IT, it is critical to understand what role these advancements play within the operational aspects of our healthcare system. The studies presented provide a starting point into investigations of information technology in healthcare, specifically in the domain of hospital operations. The question was posed as to whether or not information technology can build environments in which hospitals can provide higher quality of care and at the same time increase their profitability and operational performance. The answer based on the research presented is yes; the technology environment has the power to decrease mortality rates while improving financial performance.

Healthcare literature has began to recognize the crucial role that specific information technologies have in healthcare service settings, however studies of the overall impact of information technology have been void in the extant literature. The research presented sheds light on the importance of IT and its implications for healthcare.

6.1 Theoretical Implications

The effect of information technology in the healthcare setting has become an important area of scholarly research. However, the overall impact of IT on healthcare has been unobserved by researchers. Despite the enormous importance of the role of information technology in healthcare, it has received less than adequate attention in scholarly research. Healthcare organizations are encountering more competitive environments and success may hinge on the information technology they adopt. The importance of research in this area of healthcare cannot be overstated. While the importance of IT in healthcare has often been emphasized (Cleverley and Harvey 1992; Force 2000; HealthGrades 2004; Services 2004; Chaudhry et al. 2006), there has been very little theory-based, empirical research that examines HIT and its effects.

This research contributes to theory by providing a new perspective on IT in healthcare. Borrowing from value and supply chain literature, this study finds the need for examination of HIT from a direct measurement level. While prior research in HIT has looked at only certain subsets of HITs, we examine the impacts of overall IT sophistication in the healthcare context. Further, we examine the arguments of value chain theory that technology management will impact the value positioning and competitive advantage of the healthcare organization by investigating the relationship of HIT to patient safety, mortality, and financial performance. Our results find implicit support for the value-added theory, in that the quality of healthcare and the financial performance of the healthcare institution increased with the added application of HITs.

6.2 Managerial Implications

The results of this research have important managerial implications as the U.S. healthcare industry faces a more competitive environment. First, low profits, combined with increasing health care inflation, place health care organizations at a distinct disadvantage. Many hospitals are experiencing low return on assets which, when combined with high levels of debt, make further investment in expensive information technology difficult. Health care executives who wish to improve efficiency and profitability are challenged to implement meaningful programs that can positively affect the organization's financial status (Harrison and Sexton 2004). This study demonstrates that the implementation of HITs may be an opportunity to improve efficiency in their institutions and increase profitability. Additionally, this was supported by Harrison et al. (2004) who found that greater coordination of clinical services enhances operational efficiency and improves organizational profitability. Second, this research provides insight into the ability of different types of IT applications to impact aspects of quality, safety, and financial performance. Additionally, guidance is provided to practitioners on the types of information technology applications that will best benefit them based on their hospital characteristics.

6.3 Limitations

Limitations exist with any empirical research. The limitations of this study arise from many factors including measurement and choice of methodology. The study incorporated cross-sectional data. Inferring causality therefore becomes a problem. However, the study is based in well-grounded theory and therefore, the risk of inferring causality is acceptable. Further, the PSI risk adjusted incidence rates and IQI mortality rates were calculated from administrative discharge databases. The limitation of using administrative records to risk adjust patients has been discussed in previous literature (Quan et al. 2002; Roman et al. 2002). Also, the hospitals included in this study voluntarily report the information technology application data and thus, self-report bias may be a problem. There is the possibility that hospitals that have better HIT systems, are better managed, or have more resources reported IT information more accurately. Further, the sampling of hospitals was limited due to the inability to match data across the three datasets, loss of hospitals due to missing data, and removal of hospitals from a PSI/IQI category with less than 100 hospitalizations during 2005 in the PSI/IQI denominator. However, given we only had to remove 3 hospitals for having less than 100 hospitalizations, this limitation is minute. Finally, the counting of IT applications as a measure of IT sophistication has limitations. First, this approach does not account for length of time application was in place nor the degree of use of the IT application by the staff. Additionally, counting applications gives equal weight to all IT rather than identifying and weighting heavier those in specific areas of the hospital that are likely to have a more significant impact on patient outcomes.

The single research method used in this research also creates some concern. Triangulation of method types would provide richer insight into place attachment. The explanatory power would increase by combining several research techniques, thus providing greater generalizability and validity of the findings. Finally, while the use of partial least squares allows for use of smaller sample sizes, it limits the ability to incorporate moderating variables and interaction effects into the model.

6.4 Future Research

This study opens the door to many future research possibilities. First, the performance of case studies is necessitated to gather additional data on the length of implementation and degree of use of IT in the healthcare setting to extend current research. This will further enrich the knowledge of IT's impact on healthcare outcomes, while providing additional methodological explanatory power. Second, application of grants into IT usage in healthcare would offer very specific guidance to practitioners on what HITs would give greatest impact for IT dollars spent. Additionally, there is a need for the collection of data regarding the outsourcing of HITs to outside providers and the length of time the application had been contracted. Outsourcing proponents have claimed that, in one or more ways, outsourcing can help to reduce overall costs, increase efficiency, and improve performance. The gathering of said data would allow the investigation of these allegations and possibly identify additional areas in which healthcare providers can turn to secure competitive advantage through efficiency and effectiveness.

Finally, while the unexpected results found in the relationship between IT sophistication and patient safety in this research are at first glance alarming, a growing amount of literature exists on the unintended consequences of information technology implementation (Ash et al. 2003; Ash et al. 2004; Bar-Lev and Harrison 2005; Harrison et al. 2007; Stead 2007). Possible causes of adverse benefits range from cultural change and lack of training to communication breakdown among staff. Implementation lag time has long been known to exist in industry and it seems may carry across into the healthcare environment as well. These and other possible causes of the adverse findings in this study promote the need for more research into this area and provide good direction for future research.

In conclusion, health information technology is a broad topic that has potential to impact the quality of healthcare delivered and the healthcare organization's financial performance. The importance of this topic should not be overlooked, and the research presented provides a starting point for future investigations into the nature and effect of information technologies in the healthcare system.

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