The Impact of Information Technology Investments on Hospital Performance and Quality of Care

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The business value of Information Technology (measuring the impact of IT investments on organizational productivity and efficiency) and quantifying Information technology's tangible and intangible benefits havebeen significant areas of interest forresearchers and industry experts alike for more than threedecades. In healthcare, an information-rich industry that directly impacts peoples' lives, investing in IT is still being challenged by questions of payoffs and returns; thus understanding how IT impacts quality outcomes and organizational financial performancein healthcare organizations is important in IT investment decisions.

The goal of this research study is to critically examinethe business value of IT in healthcare. To this end, IT's impact on hospital outcomes is assessed throughmeasures such as increasedpatient satisfaction, improved clinical outcomes (i.e. reduced numbers of adverse events incidents and rates of readmissions), and enhanced hospital financial condition. Additionally, the effect of readily available clinical and administrative data and well-aligned process redesign initiatives to enhance strategic decision making by leadership teams is considered. To address these issues, panel data on 17 performance indicators from 107 hospitals were collected to analyze the impact of IT investment on hospital financial performance and quality of outcomes.

The study showsthat the relationship between IT investment and hospital performance measures is type dependent; community or small hospitals have different results from teaching hospitals,and IT investment has an impact on the financial condition of small hospitals only. Similarly, IT investments were shown to improve clinical outcomes in community hospitals but not in small or teaching hospitals. Finally, no direct relationship was found between IT investment and patient satisfaction in any type of hospital. The impact of IT investments is shown to be enhanced when combined with corresponding process-redesign initiatives; and making the right levels of investment in organizational corporate services such as administrative services, finance, human resources, and system support improved hospitals' financial performance.

Among the IT systems used in hospital organizationsare the decision support systems that enhance the decision-making capabilities of both clinicians and administrative leaders. The Hospital Analytics Dashboard is introduced as an example of the use of such systems to allow leaders to analyzehospital's performance as it relates to the impact of IT on patient satisfaction, clinical outcomes, and financial conditions. This proof-of-concept decision support tool can be adapted to include other performance measures, and has been devised to help hospital leadership teams visualize and analyze the relationships among performance measurespresented in a static scorecard format.It provides benchmarking information from similar-sized hospitals and is accompanied by an interactive dashboard where historical performance information can be analyzed to predict future performance according to different inputs.

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Dedication

To my husband, Sameer, my little baby angel, Najla,

my parents, Ibrahim and Mariam, my siblings, and to Nabil

My deepest love and appreciation for the encouragement, support, and sacrifices you made during the course of my Master's program and for your support during days and nights of typing

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"I have no special talent. I am only passionately curious"

Albert Einstein

Chapter 1

Introduction

1.1 Motivation: The Canadian Health Care System

The Canadian healthcare system is facing challenges posed by the soaring cost of healthcare delivery. These costs are driven by changing demographics, medication costs, demand for new medical technologies and new treatment patterns [1][2]. In its latest publication, "Health Care in Canada 2010", the Canadian Institute for Health Information (CIHI) forecast that Canadian healthcare spending would reach $191.6 billion in 2010 to become 11.7% of the gross domestic product (compared to 10.0% in 2002) [2]. The biggest three contributors to this budget are hospitals (accounting for 28.9%), drugs (accounting for 16.3%), and physicians (accounting for 13.7%), as shown in Figure (1) below [3].

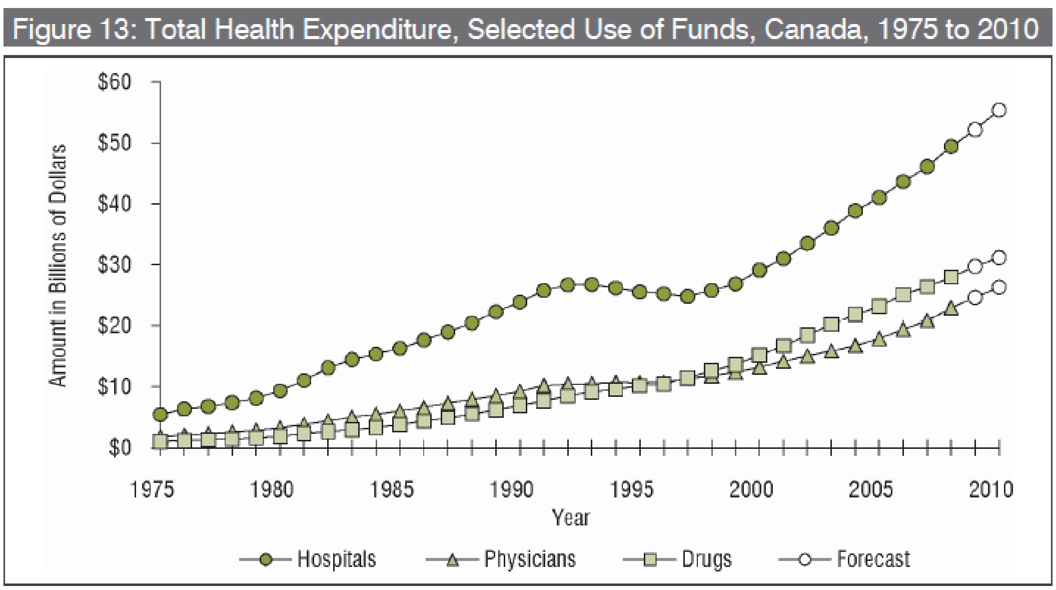


Figure 1: Total Health Expenditure Showing the Highest Contributors
Source: National Health Expenditure Trends, 1975 to 2010 (page 18) [3]

Consequent to fiscal constraints and current spending figures, the Canadian healthcare system overall and healthcare institutions individually are under pressure to be efficient and productive [9].Federal and provincial governments are addressing these issues strategically at the system level through initiatives, including the Canada Health Infoway's Electronic Health Records and the pan-Canadian standardization initiatives [4]. Similarly, individual hospitals and their departments, to improve productivity and balance their budgets as enforced by the provincial health ministries and health governance bodies [6][8], are increasingly promoting such initiatives as implementing standardized clinical pathways, enforcing hand hygiene policies, and investing in and deploying knowledge management resources. Among these resources, information technology systems are integrated into clinical areas to provide staff with timely access to critical information needed at the point of care, and to enable better decision making and the best treatment determinations. In view of the substantial amount of tax-payer dollars being spent on healthcare and the public's and the Ministries' demands for more spending accountability and transparency, the pressure is rising on Canadian hospitals intending to invest in IT to show that increasingIT spending would have a measurable positive impact on organizational performance and quality of care [9]. IT spending budget comes from different funding sources including federal and provincial governments as well as the private sector.

IT initiatives related to the pan-Canadian electronic health records are being managed through The Canada Health Infoway which has a total budget of $2.137 billion. The Canada Health Infoway is "an independent not-for-profit corporation created by Canada's First Ministers in 2001 to foster and accelerate the development and adoption of electronic health record (EHR) systems with compatible standards and communications technologies" [90, p. 20]. This funding started with a seed investmentof $1.2 billion from the Canadian governmentin 2001, continued when $400 million were given in 2007, and another $500 million were announced in 2009 as part of the Canadian government's economic action plan [90]. As of March 31, 2010, and out of the total $2.137 billion budget, Infoway had approved funding for 294 projects across the country, with a total budget of $1.634 billion, representing 76.5% of the total available funds. Table (1) shows the budget spent on each individual investment program out of the total budget.

Table 1: Canada Health Infoway Investment ProgramsBudget as of End of Fiscal 2009-2010

Investment Program	**Budget (Millions)**
Registries	134
Diagnostic Imaging Systems	365
Drug Information Systems	250
Laboratory Information Systems	170
Interoperable EHR	365
Telehealth	110
Public Health Surveillance	150
Innovation & Adoption	105
Infostructure	52
Patient Access to Quality Care	50
Consumer Health Solutions	340
Electronic Medical Records and Integration	45

As of December 31,2010, funding has been approved for 306 projects in hospitals across Canada. Of these, 193 projects are fully planned and have moved into either implementation or become fully operational. Table (2) shows a complete listing of those projects categorized by jurisdiction and investment program [91].

Table 2: Canada Health Infoway Investment Program Projects by Jurisdiction

	Jurisdiction												
Investment Program	AB	BC	MB	NB	NL	NS	NT	NU	ON	PE	QC	SK	YT
Registries	3	3	2	1	2				1	1	2	3	
Diagnostic Imaging Systems	1	3	1	1	1	1	1		8	1	3	1	
Drug Information Systems	1	2		1	2	1			3		2	3	
Laboratory Information Systems	1	1			1				1				
Interoperable EHR	3	1	2	1	1	1	1	1	2	1	2	1	1
Telehealth	3	4	6	1	2	3	1	2	8		10	1	3
Public Health Surveillance		1	1		1	1			1		1	1	
Innovation & Adoption	3	6	1	2	1	1			5	2	2		
Infostructure													
Patient Access to Quality Care		1	1	1		1			1		1	1	
Consumer Health Solutions													
Electronic Medical Records and Integration	1	1	1			1			1				
TOTAL	16	23	15	8	11	10	3	3	31	5	23	11	4

1.2 IT Investments and Performance Improvements

In this section, literature related to the topic of business value of IT will be further explored. The business value of IT has been much debated over the last three decades. The earliest explorations pointed to situations in which expected return on technology investments was not realized [13, 14, 16, 95-97], and in some cases, researchers reported a drop in net gains and overall productivity after a firm invested in technology [12,15, 92, 93]. This situation, referred to as the "IT productivity paradox", was first popularized by Nobel Prize Laureate economist Robert M. Solow in 1987, who said that "You can see the computer age everywhere but in the productivity statistics" [16, p. 36]. The paradox was said to exist because "the huge amount of investments in IT [had]been found uncorrelated with significant organizational performance improvement in aggregate output productivity" [23, p. 865]. In 1993, Erik Brynjolfsson extensively addressed the paradox when he examined the IT business value literature for the manufacturing and service industries through the 1980s and early 1990s. His work provided several explanations for the productivity paradox,including measurement errors, lag effects, redistribution, and mismanagement [10]. He pointed out that literature was focusing on economy- and sector-level gains, which made it harder for researchers to realize the true IT impacts on individual firms. Studies in the area of IT business value have continued since the early 1990s [14, 15, 17, 20, 24, 26, 27, 95-97],but the focus shifted to measuring the impact of IT at the firmlevel more than at the economy level [14, 17, 20, 94, 96,97]. A common consensus became more apparent among researchers: to successfully measure the impact of IT on productivity and performance, studies should include tangible benefits (improved financial performance, increased production levels, etc.), and also effectively measure the intangible benefits of IT (increased quality, more variety in products and services, better customer satisfaction, etc.) [17-19, 20, 66, 68, 75, 83, 96]. Chapter 2 provides a more comprehensive review of the literature relating to IT business value.

In the late 1990s and early 2000s, researchers were focusing on providing ways to effectively measure the intangible benefits of IT investments in service industries. However, after almost 30 years of research examining the impact of IT investments on the productivity and efficiency of organizations in several industry sectors, questions regarding the benefit of such investments in an information-rich industry such as healthcare are still ongoing [20, 21, 45, 47, 74, 85, 98]. Research continues but is hampered bythe variable nature and different environments of healthcare institutions, where organizational performance and clinical outcomes are profoundly affected by funding models, managerial and clinical practices, research activities, patient profiles and demographics, patients' socio-economic status, geographic distribution of healthcare institutions, etc. Moreover, healthcare institutions are more and more turning to process improvement initiatives that are considered by some researchers to be increasingly impacting organizational performance [20, 74, 75]. These factors have made it hard for decision makers in the healthcare industry to evaluate and measure the specific benefits of their IT investments, despite the rapid advances in the field of healthcare information systems. Given the significant IT investments being made in healthcare and the continuing debate regarding IT's benefits, **it is imperative to explorethe issue of IT payoffs in the healthcare industry by examining the effects of IT investments on organizational performance**, especially in the presence of well-aligned processes and proper strategic decisions**.** This exploration will help to clarify the extent of IT payoffs in healthcare institutions and how such payoffs are influenced by successful organizational improvement initiatives. Leaders in healthcare institutions will benefit from these findings in making future decisions on IT investments and performance improvement initiatives. Figure (2) shows the research constructs proposed by this study.

Figure 2: Research Proposition

1.3 Contribution

This study expands on previous research in the area of IT business value in healthcare [20-22] by examining how IT investment impacts three different but related perspectives of hospital performance—patient satisfaction, clinical outcomes (adverse events and readmissions), and financial performance—andhow such payoffs are influenced by successful organizational improvement initiatives and proper strategic decisions**.** Statistical analysis techniques, using data from 107 acute care hospitals across Ontario, are used to examine the impact of such investments on acute care settings. To demonstrate how the use of IT systems can impact hospital performance by enhancing the decision-making capabilities of clinicians and administrative leaders, this paper introducesthe Hospital Analytics Dashboard, a decision support tool that allows hospital leaders and CFOs to visualize and analyze the relationships between several hospital performance measures. This software artifact sheds light on the importance of providing tools that give decision makers the ability to examine and discover new relationships between hospital performance indicators not only in a static dashboard format but also in an interactive way wherein the relationships between the different performance measures can be examined and analyzed dynamically.

1.4 Thesis Organization

Chapter 2 provides the theoretical background for this study, exploring previous research in the areas of IT business value and IT productivity paradox. It builds upon what has been done in those areas and sets out the contributions of this study. Chapter 3 describes the data used in this study, how it was extracted, its limitations, the data analysis method used, and how the data analysis was applied in Phase I and II of the study. Chapter 4 describes the results of that analysis, the hypotheses that were supported by the results and justification for the non-supported ones. Chapter 5 describes the Hospital

Analytics dashboard, a decision support tool that provides historical and dynamic data that leaders can use to visualize relationships between hospitals' performance indicators. It also describes how such a tool can be extended to provide an interactive interface to help users visualize the relationships between different variables in a hospital setting. Finally, Chapter 6 concludes with a summary of the findings and a discussion of future work related to this study.

Chapter 2

Background and Related Work

This chapter presentsa comprehensive overview of literature on the IT productivity paradox and IT business value.This background provides the theoretical framework for our proposed linkages between investment in information technology and improved organizational financial performance and quality of service demonstrated by increased patient satisfaction and improved clinical outcomes.

2.1 IT Business Value and the “Productivity Paradox”

Since the early 1980s, numerous studies have been conducted to demystify the relationship between the investment in Information Technology (IT) and organizational productivity. Some studies show that IT had a positive impact on organizational performance and productivity [17 - 23], and others show that IT had no impact or even a negative impact [12 – 15]. The earlier studies supportthe concept of the “IT Productivity Paradox” [12 – 16], which was first noted in 1987 by Solow,who said that “You can see the computer age everywhere but in the productivity statistics”[16, p. 36]. Research has continued over the last two decades, with severalstudies measuring the impact of IT on productivity at the economy level, sector level, and firm level. Measures of IT impact on organizational performance included profitability, consumer surpluses [14, 18, 35, 36], costs [37], quality [38], and operational efficiency [39].

Research on the impact of IT investment has included several industrial domains, such as financial services and banking [35, 36, 40], manufacturing [41 – 44], the service sector [50, 51], and healthcare [20 – 22, 45 – 47] but has been inconclusive in providing support for the IT impact on productivity [10, 11, 48, 50]. Possible reasons for the Productivity Paradox elicited by researchers were summarized by Brynjolfsson in 1993:

- **Mismeasurement**: Lack of correct measurement of investment inputs (financial and human resources – software cost, training, support costs, etc.) and outputs (capital gain, information assets, and improved efficiency, quality of service, and customer satisfaction). These outputs are mostly intangible and hard to measure against unlike inputs of IT Investments, a situation which leads to mismeasurement [44, 52 – 54, 57].
- **Lag effects**: Realizing the full impact of many IT investments takes long periods of time, approximately twoto three years, due to learning curves, training, and adaptation periods [20, 55-57].
- **Redistribution of profit**: The profits gained from IT investments are redistributed between different departments of the organization without increasing the overall profit. At the economy level, while some firms might see financial gains from their IT investments, some others might not, and the effect of those who gained might not be significant at the industry or the economy levels [60].
- **Mismanagement of information and technology**: The deployment of Information technology solutions should be coupled with overall organizational cultural and business process changes; the gain from these solutions will then be maximized [10, 15, 20, 58, 59].

More recently the paradox was also attributed to the facts that massive investments in IT has been made only in recent years [61], and many companies are overinvesting in IT without aligning these investments with proper strategic planning [62].

As more and more research continued in the area, it became increasingly evident that firms who invested in IT have improved the quality of their products and services and increased their profits over time at the firm-level, and, in return, at the national economy level [18, 20, 23, 53, 54, 57, 61, 65]. Earlier studies that supported the Productivity Paradox had overlooked other important aspects of measuring organizational performance and productivity, such as improved quality of products and services [54, 63, 64]. Improved customer satisfaction, increased profits and market shares, and fewer inefficiencies are all examples of the intangible qualitative measures that were not sufficiently considered by researchers measuring the tangible quantitative impacts of IT but are nowshown by newer research. For example, in a study by Haynes and Thompson [64], introducing ATM machines across a sample of buildings resulted in increased productivity due to 24-hour access and multiple service locations. In the healthcare domain, Devaraj and Kohliconcludedthat IT investment has positive impacts on hospitals' performance in terms of financial performance, clinical outcomes, and patient satisfaction. They demonstrated that IT leads to increased profitability and decreased mortality rates, with a lag of three months for both from the initial investment time, and increased patient satisfaction, with a lag of four months [20]. These studies provided sufficient evidence that the paradox phenomenon was over. Solow's infamous 1987's "quip" that originated the phenomenon [16] finally stood corrected; "You can now see computers in the productivity statistics", Solow said in a 2000 interview reported by the *New York Times* [65].

After the paradox phenomenon been put to rest and research had provided evidence of the positive impact of IT investment, the focus shifted to identifying the organizational factors that maximize the effects of IT on productivity. There is a consensus among researchers and industry specialists that for companies to realize better performance and improved productivity, they need to align their IT investments with improved business strategiesand managerial practices as well as quality improvement initiatives. These requirements include Business Process Re-engineering (BPR) and management of change, which are all drivers for more robust and successful restructuring efforts that allow organizations to achieve full advantage of their IT investments [20, 47, 54, 63, 68].

2.2 IT Business Value and Business Process Re-engineering

Organizational business processes are the collection of all activities and tasks performed within an organization to create a product or service that generates value to the customers [69, 70]. Considering the competitive environment that organizations are operating in and the increased demands for high quality services and products to meet customers' needs, organizations are striving to improve their products, services, and performance so as to maximize customer satisfaction and their own profit. To this end, firms are becoming increasingly engaged in BPR initiatives to achieve their strategic growth goals. BPR is defined as "the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service, and speed" [70, p. 32]. BPR encompasses identifying areas of inefficiency, eliminating redundancies, rethinking the current workflow of business processes, as well as introducing new processes that dramatically changes the way the business is running, cutting operational costs, and improvingcustomer satisfaction. There are several BPR frameworks that firms can implement to achieve their desired strategic goals. These frameworks are applicable to many industry domains, including financial services, healthcare, manufacturing, etc. Among these standards are ISO 9000, Total Quality Management (TQM), Six Sigma, and Capability Maturity Model Integration (CMMI).

Devaraj and Kohli explained the relationship between IT, BPR (among other organizational factors), and organizational performance by the "contingency theory", in which organizational performance is a match between several factors. Combined, BPR and IT investments can positively affect organizational performance quantitatively, by increasing profit, and qualitatively, by improving quality of products and services and increasing customer satisfaction [20, 72]. They proved that the best performance can be achieved when there is a "good fit" between organizational factors;thus, when BPR and IT are implemented together, considerable positive impact on organizational performance is achieved. In analyzing IT investments payoffs, this study has analyzed the impact of such investments in the presence of process re-engineering initiatives, including implemented standardized protocols and safety reporting policies, utilized clinical guidelines, and applied clinical pathways among others.

2.3 IT Business Value and Organizational Factors

Kraemer and Dedrick[2001] explained another organizational factor that affects IT investment productivity. They focused on operational decentralization and proved that companies with decentralized business models achieve better return on their IT investments than those with more centralized business models. Dell Corporations used IT as an enabler for their “well-designed” direct sales, build-to-order business model that enabled them to increase their profits, meet customers’ orders in a timely manner, and reduce inventory [71, 72]. On the other hand, Compaq Computers struggled with itsindirect sales, build-to-forecast model and implementation of SAP to support itsmanufacturing and order-fulfillment operations, rendered poor results because of the company’s highly centralized IT organization. The company later moved to a more decentralize business model and delegated more responsibility and operations to individual business units [72, 73].

A third aspect of operational factors that affect IT investment productivity is the management of change. Investing in IT requires the adoption of new strategies, which, in turn, entails changes on several levels of the organization. To help maximize payoffs when investing in IT, organizational change management techniques and strategies will have to be implemented. The management of change is the “process of reducing resistance to change and increasing support and commitment for it” [66, p. 248]. Change can be seen in different aspects of an organization, such as processes, management practices, technologies, strategies, and culture. Change is a natural part of IT investment initiatives. Managing the change is an important part in ensuring successful payoffs from these initiatives. In their 2003 paper, Sherer, Kohli and Baron studied the relationship between change management, IT payoffs, and organizational change [67]. According to them, successful change management initiatives positively affect organizational change as well as IT payoffs. Examples of change management initiatives include internal and external communications, which results in reduced implementation time, cost, and errors and increasesstakeholders' participation. Another example is securing internal and external sponsors, which reduces resistance to the change and, in turn, increases the effects of IT assets. A third example is pilot studies and client surveys which can lead to increased sponsors adoption and client satisfaction. In their case study onCisco Systems, the company had successfully upgraded more than 34,000 computers to Win2K technology at 300 Cisco locations around the world, with total savings of 5.8 million from the total project cost, as successascribed to their successful and effective organization change management strategies [67].

Conclusion

From the above discussion it became apparent that IT investment payoffs are interrelated with organizational initiatives. The payoffs of IT investment are maximized when backed by proper strategic planning (enabled by the availability of relevant clinical and administrative information at all levels of anorganization), and accompanied by corresponding process re-engineering and management of change initiatives. Likewise, IT is considered by most to bethe major enabler of business transformation initiatives [68, 83] as it facilitates new forms of collaboration within the organization's borders and across multiple organizations. Newer technologies available today allow for non-traditional business processes and workflows to exist and eventually enhance organizational performance. Systems such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Decision Support Systems (DSS) are all examples of IT solutions that have enabled new forms of communication and collaboration by creating integrated views of the end-to-end business process within and across organizations. These systems are becoming increasingly vital for the success of leadership teams, providing them with the information they need, when they need it, and in a form they can rely on when making strategic decisions. Perhaps the most important tools that are becoming increasingly in demand are the decision support systems.

Building on the previous research in the area, this study analyzes the impacts of IT investments in the presence of organizational factors related to productivity and efficiency, including the availability of clinical and administrative information for decision makers, improved communications, the budget spent on corporate, finance, human resources, and administrative services; and the actual costs of treating patients compared to expected costs.Chapter 3, discusses the hypotheses proposed in this study to test the impact of IT investment on hospital performance and outcomes, including patient satisfaction, clinical outcomes, and organizational financial condition. Also discussed are the data used in this study, it extraction, its limitations, its analysis, and its application to Phases I and II of the study. Chapter 4, discusses the results of the data analysis in Phase I and Phase II, the hypotheses that were supported by the results, an analysis and justification for the non-supported ones, and the implications of the obtained results. Finally, Chapter 5 introduces and discusses in detailthe Hospital Analytics tool, a proof-of-concept decision support systemproposed for use by hospital leaders and CFOs. This tool enables users to visualize the relationships and dependencies between the different hospital performance measures and sheds light on the importance of using such tools for informing the decision making process.

Chapter 3
Study Design and Methodology

3.1 Hypothesis Development

As mentioned in the previous chapter, many researchers have studied the relationship between IT investments and hospital performance and productivity. However, challenges have existed in determining the best way to measure the IT payoffs in healthcare, especially when hospital performance is measured not only through tangible quantitative measures such as organizational financial condition but also through intangible qualitative measures such as quality of care and patient satisfaction. Thus, analyzing hospital performance has been done through the use of proxies when direct measurements were not available or were infeasible to capture. To proxy for IT investments in the healthcare domain, researchers have used factors such as IT capital (hardware and software), IT labor, IT support, and IT outsourcing [20, 21]. Researchers argued that earlier studies that tried to measure the impact of IT spending directly on productivity and performance were either weak or unsupported [21, 26]. Subsequently, they started to look deeper into the relationship between IT spending and productivity and proved that IT spending impacts organizational IT assets in the form of capital, labour, support, and outsourcing, and these assets bring about positive impact on organizational productivity and performance [21, 27]. This study adopts a similar view, proposing IT use and adoption as a proxy for the amount of IT investment in hospitals. When hospitals use electronic records as their main information source and more staff members are able to perform clinical and administrative tasks online, then it is proposed that these organizations are increasing their IT investments to support such availability and use, which could enhance the adoption of newer systems and make more patient and clinical data available for use by staff members in a timely manner. Originally, this study's proposition dealt solely with the effect of IT investments on organizational productivity and performance. However, after careful assessment and analysis of the literature in the area, complementary variables were also considered when creating the mathematical models to proxy for organizational factors and improvement initiatives, including the availability and dissemination of clinical and administrative data and organizational improvement initiatives. This approach allows the models to account for the reportedly more profound effect of IT investments on productivity and financial condition when combined with such organizational initiatives [20, 67, 69, 79, 83].

In the manufacturing and service industries, many profit-based productivity measures have been usedin examining IT payoffs including Return on Investment (ROI), Return on Assets (ROA), Return on Sales (ROS), and Tobin's q [14, 18, 23, 26, 28, 76]. In the healthcare domain, however, revenue-based measures [20, 21] are commonly used instead of profit-based measures because hospitals, examined in this study, operate on a non-for-profit basis. Measures such as Tobin's q [28] were deemed unsuitable for this study as it deals with healthcare firms that do not get evaluated on the basis of current market shares or future investments growth. Thus, financial measures including current ratios, total margins, and average cost per weighted cases [32] are used here to measure IT impacts on financial performance; such measures have been used previously in the literature to assess firms' financial performance [24, 25, 82]. Other quality measures such as consumer surplus, customer satisfaction, and clinical outcomes (in the case of healthcare firms) have also been used to examine IT payoffs in several industries [18, 20, 68]. Measuring quality in service industries is more difficult than in manufacturing because service outcomes tend to be intangible as compared to those of manufacturing industries (i.e. products). Thus, quality of care in the healthcare industry has been measured in patient satisfaction, clinical outcomes, and/or mortality rates. Previous studies [20-22, 46, 68, 79] used patient satisfaction measures as a relevant outcome of care; they surveyed patients' opinions about the care they received and their overall impression. Similarly, readmission rates and adverse events incidents have been used to proxy for clinical outcomes as a measure of hospital performance [46, 47, 66, 68, 79]. With these precedents as a guide, proxies for patient satisfaction, and clinical outcomes, including rate of readmissions and adverse events, have been constructed as measures of hospital productivity and performance. From the previous discussion, the hypotheses proposed by this study are constructed as follows:

H1: IT use and availability is positively associated with financial performance

H2: IT use and availability is positively associated with patient satisfaction

H3: IT use and availability helps decrease negative outcomes such as readmissions and adverse events

When analyzing the validity of the proposed hypotheses, the null hypothesis (H_0) will have to be tested. In this study, the null hypothesis is constructed as the follows:

H_0: IT use and availability does not impact hospital performance

To summarize, this study is proposing that *IT use and availability in a given organizationhas a positive impact on hospital outcomes in terms of patient satisfaction, clinical outcomes, and financial performance, especially when combined with the availability of clinical and administrative data and complementary organizational improvement initiatives*. The following sections explain these proxies in detail and how the relationships proposed here been mapped in the corresponding mathematical models.

3.2 Data Sources and Collection

To measure the impact of information technology on the performance and productivity of hospitals,it is important to capture how these hospitals are investing and using information technology systems, and to obtain exact performance measure numbers related to hospital financial performance, patient satisfaction, and clinical outcomes. Previous studies have used database lookups, field surveys, or a mix of both to gather such information from national databases and local health institutions. This was the initial approach considered for this study;performance data from hospitals in the province of Ontario were to be collected and analyzed.

Obtaining data regarding patient satisfaction and clinical outcomes in Ontario hospitals normally calls for the use of routinely collected data sources, including Statistics Canada data; the National Ambulatory Care Reporting System (NACRS),which “contains data for hospital-based and community-based emergency and ambulatory care” [109];the Discharge Abstract Database (DAD), which “contains data on facility discharges across the country” [110];the Hospital Morbidity Database (HMDB), which “captures administrative, clinical and demographic information on hospital inpatient events and diagnoses and procedures for all hospital separations (discharges and deaths)” [111], and others. All these materials are available from the Canadian Institute for Health Information (CIHI).Data collected in these databases are provided to submitting member hospitals in the form of reports accessible through a collection of e-tools available from CIHI’s website. Researchers wishing to obtain information on the financial performance of hospitals in Ontario, normally use databases available from the Ministry of Health and Long Term Care.

To answer the research question posed by this study, data regarding the amount of IT investment made in Ontario hospitals were needed as well as data pertaining to the proposed improved outcomes of IT investments in hospitals, such as improved patient satisfaction, improved clinical outcomes, and better financial performance. Data regarding the IT investment or patient satisfaction were not readily available in CIHI’s or the Ministry of Health and Long Term Care’s databases. Data regarding the clinical outcomes and financial measures were available; however, the varying formats and nature of data presentation posed a difficulty in creating a comparative database from the raw data that can compare a hospital’s financial performance and clinical outcomes in one location. In addition, to clean the raw data available in the dataset, several rounds of data extraction and aggregation from such databases would be required and the application of multiple rigorous data adjustments techniques and calculations to obtain a final dataset in a format that can be compared across hospitals. Additionally, these databases are not publically available, and permissions are needed to access their data tables for research purposes.

After searching the Canadian Institutefor Health Information website to obtain the hospital performance information needed for this study, references to the Hospital Reports of Ontario initiative were identified. These reports provided a unique dataset of hospital performance indicators for the majority of Ontario hospitals. The indicators covered aspects such as the availability and use of IT systems, patient satisfaction scores, clinical utilization information (including the rates of readmissions and adverse events), and finally, a list of financial performance measures.

The Hospital Reports initiative was started in 1997 by a team of six investigators from the University of Toronto and Wilfred Laurier University. In the years that followed, twelve other investigators joined the original team to form the Hospital Report Research Collaborative (HRRC) [29]. In January of 2008, the research activities of the HRRC were assumed by the System Performance Research Network (HSPRN) [30]. The reports include information about 123 small, community and teaching hospitals from 14 Local Health Integration Networks (LHIN) – not-for-profit corporations that work with local health providers, including hospitals, community care centers, long-term care, mental health and addictions services, community health centers, and other community health services to determine the health service priorities of all regions in Ontario [31]. The Hospital Reports include a set of performance indicators collected in a balanced scorecard that can provides a comprehensive view of a hospital's performance. In the latest reports (2008), each hospital was scored on 44 indicators distributed between four dimensions or "quadrants" that are essential to the "strategic" success of any hospital system: System Integration and Change (SI&C), Patient Satisfaction (PS), Clinical Utilization and Outcomes (CO), and Financial Performance and Condition (FP).

In contrast to other sources, the Hospital Reports of Ontario provide a more complete, peer-reviewed dataset of performance-related information on Ontario hospitals. They provide information on the amount of IT use and availability; many aspects of patient satisfaction; clinical utilization and outcomes, including readmissions and adverse events related to medical, surgical, and labour cases; and several financial performance indicators, including hospital viability, profitability and efficiency measures. Data regarding the specific amounts of IT investment in Ontario hospitals is not directly available in the databases available from the Canadian Institute for Health Information (the National Ambulatory Care Reporting System (NACRS), the Discharge Abstract Database (DAD), the Hospital Morbidity Database (HMDB), etc.). Thus, a dataset based on the Hospital Reports was chosen for this study. The Hospital Reports data is based on those databases published by CIHI, surveys sent to participating hospital organizations, and patient satisfaction surveys.

Acute care hospital reports have been published since 1998, and this study uses those reports from years 2003 to 2008, excluding the year 2004 for which acute care data is not available. To study the impact of IT use and availability on hospital outcomes, data regarding IT use in hospitals, patient satisfaction, clinical outcomes, and financial performance were obtained from the Hospital Reports in the form of organizational performance indicators. Each hospital was given a score that can be compared to those of other hospitals and that placed it above, below, or within the provincial average for each indicator. The Hospital Reports provide organizational measures and performance indicators that are suitable as proxies for the IT investment amounts and the proposed hospital outcomes, including IT use and availability, patient satisfaction, clinical outcomes, and financial performance. Additionally, the Hospital Reports were deemed a reliable data source considering that they are publically available and, prior to publishing, are subject to rigorous rounds of peer-reviews and data quality checks, including risk adjustments and bias prevention techniques.

The System Integration and Change data is based on an “SIC Survey” that was mailed to participating acute care hospitals. In 2008, survey questions covered several quality improvement and patient safety topics, including use of clinical information technology, use of data for decision-making, healthy work environment, patient safety reporting and analysis, performance management in ambulatory care, formalized audit of hand hygiene practices, and medication documentation and reconciliation. For the same year, the survey was answered by 103 of the total 125 acute care hospitals participating in the Hospital Reports (82% small, community, and teaching hospitals) [34].

The Patient Satisfaction data is based on survey questionnaires mailed to patients discharged, from participating hospitals, during the year prior to each report's release; representing different age ranges and demographics. The Patient Satisfaction surveys were administered by NCR + Picker Canada -- "a Canadian research company, with 26 years' experience, specializing in conducting survey research designed to uncover what is most important to patients" [33, p. 22]. In 2008, a total of 132,518 surveys were mailed to patients, out of which, 56,183 surveys were returned. Of these, a total of 54,760 have met the inclusion criteria and were included in the 2008 Patient Satisfaction data (97.5% of returned patient surveys) [80].

The Clinical Utilization and Outcomes is based on abstract data from the Discharge Abstract Database (DAD) and the National Ambulatory Care Reporting System (NACRS). Inpatient abstract records come from the DAD, while same-day surgery and mandated cardiac catheterization records comes from the NACRS [33]. In view of the substantial differences in structure and formatting between these two databases, the Canadian Institute for Health Information has conducted a "comprehensive analysis and re-formatting" process of the NACRS data to achieve consistency with the DAD records [33, p. 35].

Finally, the Financial Performance and Condition data is based on information extracted from a financial database provided by the Ministry of Health and Long Term Care (MOHLTC) that contains "the internally generated, year-end general ledger balance of each hospital in the province" [32, p. 4]. This submitted data has been checked by MOHLTC annually before being added to the databaseand CIHI had applied other several data checks routines before using the data in calculating the Financial Performance and Condition indicators [32].

The following sections explain how the data was extracted from the Hospital Reports, how it was validated, and the indicators used in this study; later, a summary of the proposed mathematical models is presented.

Data Extraction from Hospital Reports to Excel

Hospital Reports are available to the public via online access at the HSPRN's website [30]. Years 2003 to 2007 are available in pdf format; years 2007 and 2008 are also available in an online scorecard format in Adobe Captivate. The raw data were extracted into Excel to facilitate importing it into the SAS statistical software for analysis. The HRs categorized the hospitals in each Local Health Integration Network according to their type; Teaching (acute and pediatric hospitals that are members in the Council of Academic Hospitals of Ontario (CAHO) that are affiliated with a medical or health sciences school and have significant research activity and postgraduate training), Small (hospitals with a total number of cases of inpatient acute, complex continuing care, and day surgeries that is under 2700 a year), and Community hospitals (the rest of the hospitals that are not defined as small or teaching) [33, p. 7]. A column was added to the Excel data set to identify each hospital by type, see Figure 3. This column was utilized in Phase II of the data analysis explained in details in the following sections.

Figure 3: Sample of the current data set used in regression analysis and model creation

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1		Type	HospitalName	ITUse	DataUse	StandardizedProtocols	SafetyReporting	Satisfaction	Communication	MedicalAdverseEvents	SurgicalAdverseEvents	LabourAdverseEvents	MedicalReadmissions	SurgicalReadmissions	LabourReadmissions	TotalMargin	CurrentRatio	EquipmentExpense	CorporateServices	UnitCostPerformance
2	63	S	Alexandra Hospital	65.00	42.80		100.00	91.40	79.90	2.90			1.70			2.60	1.10	9.20	18.50	18.60
3	64	S	Alexandra Marine and General Hospital	73.10	61.60		100.00	88.80	82.30	1.10	0.00	0.00	6.50	2.90	0.00	0.20	1.80	5.00	10.30	11.70
4	65	S	Almonte General Hospital	50.30	61.50		100.00	88.90	84.30	0.00	0.00	3.30	23.80	8.10	1.00	5.60	2.00	3.20	13.40	-25.40
5	66	S	Arnprior & District Hospital					88.10	82.70											
6	67	S	Atikokan General Hospital	58.50	20.90		46.70			0.00		11.80	7.10		0.00	6.30	3.20	6.50	11.50	-10.30
7	2	C	Bluewater Health	67.10	61.00		80.00	81.70	74.00	0.50	0.00	1.70	5.80	0.90	0.40	-0.70	0.30	7.50	7.90	16.60
8	3	C	Brockville General Hospital	85.90	61.20		56.70	83.60	78.70	0.40	0.00	5.60	4.80	2.60	2.30	-1.70	0.90	8.50	7.80	10.10
9	4	C	Cambridge Memorial Hospital	74.20	40.40		46.70	82.60	77.60	0.60	0.30	4.30	4.90	0.20	0.40	0.10	1.10	6.40	9.10	2.00
10	69	S	Campbellford Memorial Hospital	63.50	67.10		86.70			0.00			5.20			-0.10	0.80	4.60	12.50	-7.10
11	70	S	Carelton Place and District Memorial Hospital	43.00	61.30		76.70	88.40	80.10	0.00			2.70			2.70	1.50	5.20	11.40	-23.90
12	5	C	Chatham-Kent Health Alliance	86.10	83.50		90.00	85.70	82.10	0.20	0.30	1.30	5.50	0.60	0.40	1.70	1.10	8.50	10.70	-1.10
13	101	T	Children's Hospital of Eastern Ontario	53.20	84.20		90.00			0.00			0.00			3.00	1.00	3.60	6.60	
14	6	C	Collingwood General & Marine Hospital	62.50	56.20		33.30	87.70	80.70	0.00	1.30	2.40	3.90	1.20	0.20	-0.70	1.00	6.50	9.50	-13.00
15	7	C	Cornwall Community Hospital	41.00	43.60		56.70	81.80	79.10	0.30	0.30	0.80	3.60	2.20	0.60	0.00	0.50	5.30	7.00	4.40
16	71	S	Deep River and District Hospital	53.30	31.80		80.00	91.70	85.20	0.00			0.00			4.20	0.80	7.90	13.10	-8.20
17	72	S	Dryden Regional Health Centre	52.40	47.70		86.70	83.20	77.30	0.00	2.00	5.30	2.90	3.30	0.90	4.20	1.50	5.50	14.40	-5.00
18	73	S	Englehart & District Hospital																	
19	75	S	Glengarry Memorial Hospital	32.60	43.80		80.00	89.00	81.00	0.00			5.10			2.00	1.40	7.00	11.60	-19.20
20	8	C	Grand River Hospital	89.80	91.50		76.70	83.10	77.00	0.70	0.20	0.80	2.50	0.80	1.10	1.00	1.20	6.00	8.70	5.60
21	9	C	Grey Bruce Health Services	60.30	75.00		100.00	87.40	79.80	1.30	0.20	1.90	5.60	1.60	0.40	-0.40	1.00	9.00	9.60	2.00
22	10	C	Groves Memorial Community Hospital	45.40	80.60		86.70	92.20	82.40	0.90	0.00	1.70	3.00	2.90	0.70	-8.30	0.90	8.30	9.40	14.70
23	11	C	Guelph General Hospital	88.50	70.60		80.00	83.90	76.50	2.40	0.40	0.80	4.10	2.00	0.80	0.90	0.70	8.20	9.60	3.10
24	76	S	Haldimand War Memorial Hospital	27.10	42.10		100.00			0.00	0.00	0.00	1.50	4.20	0.00	5.20	2.60	7.00	13.30	-18.00
25	77	S	Haliburton Highlands Health Services	3.90	42.60		90.00													
26	12	C	Halton Healthcare	82.00	89.90		100.00	82.50	74.90	1.30	0.10	1.00	3.30	1.50	0.50	0.70	1.10	5.50	6.80	-3.50
27	102	T	Hamilton Health Sciences Corporation	70.80	67.50		100.00	83.30	76.60	1.40	0.50	7.10	3.10	1.70	0.90	0.20	1.30	5.70	8.20	14.50
28	78	S	Hanover and District Hospital	55.30	60.30		80.00	83.80	77.10	3.20		3.20	4.80		0.00	5.20	2.20	7.40	13.80	-0.90
29	13	C	Headwaters Health Care Centre	71.30	57.60		90.00	86.60	79.50	0.30	0.00	1.50	6.00	0.00	0.40	-1.90	0.80	6.50	7.80	-10.90
30	14	C	Hopital General de Hawkesbury and District Gener	71.30	58.00		80.00	87.10	81.00	0.00	0.00	2.20	4.00	0.00	0.50	3.90	2.50	6.70	11.60	0.50
31	103	T	Hopital Montfort Hospital	74.70	67.40		66.70	86.50	79.20	0.50	0.00	2.70	2.30	1.90	0.50	12.40	1.10	5.70	11.20	-6.40
32	104	T	Hopital regional de Sudbury Regional Hospital	68.20	56.90		86.70	85.90	78.90	0.70	0.00	1.00	4.30	1.60	0.80	0.10	0.20	6.00	7.80	-1.10
33	15	C	Hotel-Dieu Grace Hospital	72.70	85.80		100.00	82.60	76.00	1.20	0.40		4.30	2.00		1.60	0.60	6.00	7.50	21.10
34	105	T	Hotel-Dieu Hospital Kingston	87.00	63.90		90.00			0.70	0.00	5.90	2.90	2.70	1.40	1.50	0.50	7.30	10.10	19.20
35	16	C	Humber River Regional Hospital	73.10	88.50		90.00	75.20	72.90	1.90	0.10	1.00	3.70	1.50	0.50	0.10	0.70	4.80	8.00	-5.30
36	17	C	Huron Perth Healthcare Alliance	95.30	72.40		76.70	88.80	82.60	0.30	0.20	1.10	4.40	1.80	0.50	2.10	1.00	5.80	7.10	-3.50
37	18	C	Huronia District Hospital - North Simcoe Hospital A	61.60	72.50		86.70			0.00	0.00	7.20	6.90	3.60	1.20	1.00	0.30	6.10	9.80	-13.90
38	19	C	Joseph Brant Memorial Hospital	67.10	94.50		90.00	80.00	71.10	0.80	0.00	1.70	3.00	1.40	0.10	1.50	1.10	6.00	7.30	-1.10
39	80	S	Kemptville District Hospital	47.40	62.30		60.00			4.60			2.60			-0.10	4.00	7.80	13.10	-13.30
40	106	T	Kingston General Hospital	98.40	93.20		90.00	84.30	76.80	0.70	0.00	5.90	2.90	2.70	1.40	-2.10	0.60	5.70	8.70	-4.20
41	20	C	Kirkland and District Hospital	73.00	70.00		90.00	84.00	80.50	0.00	0.00	0.00	4.50	3.20	0.00	2.10	1.20	6.90	9.30	12.70
42	81	S	Lady Dunn Health Centre	57.00	42.40		100.00			0.00			0.00			-2.60	3.30	11.90	14.70	38.00
43	21	C	Lake of the Woods District Hospital	63.00	73.10		100.00	82.10	76.50	0.00	0.00	6.20	3.90	0.00	1.70	1.70	1.50	7.50	7.30	8.70

2003 2005 2006 2007 2008

Preliminary Data Checks

This preliminary data check included analyzing the excel data files to eliminate any rows or columns with large number of missing data values. This resulted in removing all empty and nearly empty rows from the Excel sheets for the 5-year data set and replacing all NR (not reported) values originally appeared in the Hospital Reports with empty cells (appear in pink in the screenshot above). A second round of data checks involved checking the calculation method of each indicator for every year as explainedin the technical reports published alongside the final public reports. This to ensure there were no significant differences between the components that went into calculating these indicators which will make them invalid for year over year comparisons. For consistency purposes, all data values in the worksheet are formatted to two decimal places and each hospital was listed in each worksheet; if a hospital did not report any data for a given year, it was assigned empty data cells in the corresponding worksheet.

3.3 Data Elements and Variables

The proxies for the variables proposed in the hypotheses were taken from the list of Hospital Reports indicators. In this study, proxies for IT use and availability, data use and dissemination, and organizational improvement initiatives make up the list independent variables. The hospital performance outcomes, including patient satisfaction, clinical outcomes, and financial performance, constitute the dependent variables.To help explain these variables, the next few paragraphs provide an overview of the Hospital Reports data and show how it was used to proxy for the needed variables. To analyze how IT use and availability combined with other organizational factors that impact hospital outcomes, the relationships between these measures were mapped using predictive mathematical models in which the value of one variable (the dependent variable that is typically on the left side of the equation) is estimated or predicted using values of the remaining variables in the equation (the independent variables on the right side of the equation)[99].

3.3.1 Dependent Variables

To proxy for the dependent variables that will be used in the models, indicators from the Patient Satisfaction, Clinical Utilization and Outcomes, and Financial Performance and Condition data were utilized. The Patient Satisfaction indicators describe overall patients' overall perception of the hospital care provided by evaluating their experiences, care received, and interaction with clinical and administrative staff. For the year 2008, they covered patients' overall impression, quality and quantity of information and communications, patient's perception of respect and consideration from staff, and staff responsiveness.

The second type of measures of hospital quality and performance used in this study deals with clinical outcomes such as complications, including readmissions and adverse events. Unexpected readmissions for some conditions suggest the original treatment was not successful which is considered a measure of the quality of care provided. Similarly, adverse events include cases related to patient's stay in the hospital including post-admission pressure ulcers, hip and knee fractures from falls, pneumonia, and urinary tract infections (for surgical patients) [35, page 17]. The dataset scored each hospital according to its rate of readmissions and adverse events, using indicators in the Clinical Utilization and Outcomes quadrant. Hospitals whose scores are closer to 0 were considered better performers, as this score indicates fewer complications and better quality of care.

Finally, to proxy for hospital financial performance, revenue-based data were extracted from the dataset. Devaraj and Kohli [20, p. 51] provided justification for why revenue-based measures are more appropriate to use in comparison with costs when analyzing IT payoffs in hospitals: the "hospitals' lack of accurate cost accounting systems and the use of cost-to-charge ratios"(the ratio between a hospital's total expenses exclusive of bad debtto its total patient and operating revenues) [108]in determining the cost of services; the effect of "varying contractual agreements" on costs; and the "increase in managed healthcare,[in which]premium revenues are considered as profits and expenses are treated as charges against those profits". As such, they have used net patient revenue per day and net patient revenue per admission as their financial condition measures. The data set utilized here included financial performance indicators for each hospital in the Financial Performance and Condition quadrant. These indicators describe the financial performance and condition of hospitals in five dimensions including financial viability—"the ability to generate the financial resources required to maintain services, replace assets, acquire new technology, and meet changes in patient need and volume", liquidity—"the ability to meet cash obligations in a timely manner", capital—"the ability to meet long-term debt obligations and how capital assets are being maintained, efficiency—"the ability to provide services at the expected cost and to minimize administrative costs, and human resources—"the effectiveness of hospital human resource management and practices" [32, p. 3].

The dependent variables used in the regression models demonstrate the proposed positive outcomes of IT investments made in hospitals. As measuring these outcomes might not be feasible, appropriate indicators were taken from the Hospital Reports data to proxy for such outcomes. Thus, to proxy for patients' satisfaction with the quality of care they received in the analyzed hospitals of this study, the *Overall Impression (Satisfaction)* indicator was used as the first measure of hospital performance outcomes and used as the dependent variable in models based on hypothesis H1. Similarly, to proxy for quality of care in the models based on hypothesis H2, six indicators were extracted from the dataset that deals with adverse events and readmissions due to medical, surgical, and labor and delivery related conditions. These categories include the following:*Readmissions – Specific Medical Conditions (MedicalReadmissions), Readmissions – Specific Surgical Procedures (SurgicalReadmissions), Readmissions – Labour and Delivery (LabourReadmissions), Nurse Sensitive Adverse Events – Medical (MedicalAdverseEvents), Nurse Sensitive Adverse Events – Surgical (SurgicalAdverseEvents), and Nurse Sensitive Adverse Events – Labour and Delivery (LabourAdverseEvents)*. Finally, data provided in the *Total Margin (TotalMargin)* and *Current Ratio (CurrentRatio)* indicators were used as proxies for organizational financial condition and as dependent variables in the models based on hypothesis H3 to measure IT impacts on financial performance and outcomes.Table (3) provides summaries of the definitions of the dependent variables mentioned above.

Table 3: Dependant variables used in this study

Outcome	Proxy	Definition[1]	Abbreviation
Patient Satisfaction	**Overall Impression**	The patients' views of their overall hospital experience including the overall quality of care and services they received at the hospital, and their level of confidence in the clinicians who provide the care	Satisfaction
Quality of Care	**Readmissions: Specific Medical Conditions**	"The rate of unplanned readmissions within 7 days in patients following hospitalization for gastrointestinal (GI) bleed, OR within 28 days for patients following hospitalization for acute myocardial infarction (AMI)[2], heart failure, asthma or stroke"	MedicalReadmissions
	Readmissions: Specific Surgical Procedures	"The rate of unplanned readmissions within 28 days for patients following cholecystectomy or prostatectomy surgery, OR within 7 or 28 days for women following a hysterectomy"	SurgicalReadmissions
	Readmissions: Labour and Delivery	"The rate of unplanned readmissions within 14 days following hospitalization for Labour and/or delivery (includes both vaginal and C-section deliveries)"	LabourReadmissions

[1]Source: "Hospital Report 2007: Acute Care" [33]
[2] Acute Myocardial Infarction is the death of some heart cells caused by the sudden interruption of the blood supply.

	Adverse Events: Nurse-Sensitive Medical	"The rate of post-admission pressure ulcers, post-admission fractures from falls, and post-admission pneumonia for patients admitted with Acute Myocardial Infarction (AMI), heart failure, asthma, gastrointestinal bleed or stroke"	MedicalAdverseEvents
	Adverse Events: Nurse-Sensitive Surgical	"The rate of post-admission urinary tract infection, post-admission pressure ulcers, post-admission fractures from falls, post-admission pneumonia for patients who had cholecystectomy, prostatectomy, or hysterectomy"	SurgicalAdverseEvents
	Adverse Events: Labour and Delivery	"The rate of adverse events such as uterine rupture, pulmonary or cardiac events, or wound infection and hemorrhage in patients undergoing labour and/or delivery"	LabourAdverseEvents
Financial Condition	**Total Margin (Financial Viability)**	The percent of difference between hospital's total revenues and its total expenses	TotalMargin
	Current Ratio (Liquidity)	How many times a hospital's short-term obligations can be paid using the hospital's short-term assets	CurrentRatio

3.3.2 Independent Variables

To analyze how IT use and availability impacts hospital performance in the presence of complementary organizational improvement initiatives, data elements were extracted from the System Integration and Changequadrant of the Hospital Reports to proxy for variables dealing with the amount of IT use and the availability of IT systems in hospitals; the use of clinical and administrative data in clinical and managerial decision making; and the existenceof process improvement initiatives.The System Integration and Changeindicators have been changed over the years since the first report was published in 1998. These indicators varied from 11 indicators in 1998 to 7 indicators in 2008. These indicators, for the year 2008, covered organizational processes such as the use of information technology, the use of data for decision making, healthy work environment policies, patient safety reporting and analysis, performance management in ambulatory care, formalized audit of hand hygiene practices, and medication documentation and reconciliation practices. Changing the number of indicators every year of the published reports probed a closer examination of the selected indicators to ensure their availability in at least three of the five years under consideration. As such, 'medication documentation and reconciliation practices' was originally to be included in the models as a proxy for organizational improvement initiatives as a best practice approach; however, the lack of enough data points for this indicator in the dataset hindered its use as it was a newer indicatoravailable only in the 2008 data.

The independent variables used in the regression models include a set of measures that are proposed to be influential in affecting hospital performance. In the context of this study and as proposed by hypotheses H1 – H3, the amount of IT investment in hospitals is proposed to have a positive effect on hospital outcomes. Considering that the IT investment numbers are not available in this study's dataset, the *Use of Clinical Information Technology (ITUse)* indicator was utilizedto proxy for the IT investments in hospitals. Other complementary factors that are related to the availability and use of IT were added to the regression models as independent variables, including

- The *Use of Data for Decision Making (DataUse)* indicator wasmade the proxy for the amount of data available for decision making.
- *The Use of Standardized Protocols (StandardizedProtocols)* and *Patient Safety Reporting and Analysis (SafetyReporting)* indicators werebecame proxies for the presence of organizational improvement initiatives in hospitals as previously used in the literature [20, 68, 75, 81],especially those initiatives enabled by the use and availability of IT, the utilization of knowledge to enhance decision making in information-rich industry such as healthcare, and for their effect on patient and clinical outcomes.

Table (4) provides summarized definitions of the indicators used as independent variable and detailed explanations of their use as proxies.

Contextual Variables

It is conceivable that hospital outcomes are affected by many factors other than the availability and use of IT, data use and dissemination, and the different process re-design initiatives. Therefore, contextual independent variables were selected from the dataset as complementary data elements to enhance the proposed regression models and to account for other factors that might affect hospital performance. These factors include patient judgment of the amount of information provided to them*(Communication)* from the patient satisfaction quadrant, and the budget spent to acquire and operate capital equipment *(EquipmentExpense)*, the budget spent on administrative services (finance, human resources, information systems, etc.) *(CorporateServices)*, and the actual costs of each admitted patient as opposed to the budget costs *(UnitCostPerformance)* from the financial performance quadrant. These factors proved influential in affecting the outcomes considered in this study as hospital performance measures; therefore, it was appropriate to add these contextual variables to the corresponding models related to each individual hypothesis. As such, Communication was added to the model related to H2, and all of EquipmentExpense, CorporateServices, and UnitCostPerformance were added to the models related to H3. Table (5) provides summarized definitions and detailed explanationsof the use of each indicator used as a contextual independent variable.

3.4 Models and Regression

The three proposed hypotheses are tested using predictive models to analyze the impact of IT availability and utilization combined with the availability and dissemination of clinical and administrative data complemented with organizational improvement initiatives on patient satisfaction, clinical outcomes, and financial performance of hospitals. Previous studies employed several analyses techniques when analyzing IT's impact on organizational performance, for instance, non-parametric measures such as Data Envelopment Analysis (DEA) [84, 85],or production-based econometric measures such as the Stochastic Frontier Analysis (SFA) [23, 37], but the majority utilized predictive ordinary least squares (OLS) and regression analysis [21, 22, 24, 47, 74, 79, 82].Non-parametric measures provide lower statistical power than those of parametric measures and normally are used for smaller samples of data that are categorical or ranked in nature or those samples that do not follow a normal distribution.

The Data Envelopment Analysis methodology is applied to estimate the efficiency of a decision making unit (a group of individuals responsible for finalizing majordecisions). Such measure would not applyfor this study in measuring efficiency at an organization level (hospital) because data for specificdepartmental efficiencies is not available. Stochastic Frontier Analysis

Table 4: Independent variables, their definitions, explanation and precedents in literature

Input	Proxy	Definition[3]	Abbreviation
IT Investments (represented by IT use and availability)	**Use of Clinical Information technology**	The availability of clinical information in an electronic format to care providers inside and outside of the organization	ITUse
Explanation			
Previous researchers used factors such as IT capital, IT labour, IT support, and IT outsourcing to proxy for the availability, use, and budget spent on IT [20, 21, 26]. The ITUse indicator was chosen to proxy for the IT investment values because the HRs dataset did not provide specific figures for the exact budget spent on IT for each participating hospital. However, this indicator reflects a rather accurate measure of information technology use in surveyed hospitals as it was created based on questions that addressed many aspects of the use of IT and access to information technology systems in each hospital. These questions included the existence of Telehealth or video care coordinator roles, the use of electronic records as the principal information source, staff members' ability to perform several clinical and administrative functions online, and the availability of IT resources for clinicians [34].			

Input	Proxy	Definition	Abbreviation
Data Use	**Use of Data for Decision-Making**	The degree of dissemination and utilization of both administrative and clinical data within an organization	DataUse
Explanation			
The DataUse indicator was chosen to reflect the degree of organizational information availability and use in the hospital system by covering aspects such as dissemination and benchmarking of clinical and administrative data, information utilization and safety management, and information-based roles for hospital staff [34]. In an information-rich industry such as healthcare, literature had proved that organizational performance is affected by the effective management and utilization of information resources in which IT plays a key role in being an enabler of such effective management [20, 28, 66-68] through decision support systems, knowledge management systems, data warehouses, etc.			

Input	Proxy	Definition	Abbreviation
Process Improvement Initiatives	**Use of Standardized Protocols**	How hospitals are developing and using standardized protocols for the diagnosis and treatment of a broad range of clinical conditions and procedures that are common	StandardizedProtocols
	Explanation		
	The StandardizedProtocols indicator was used to proxy for the development and use of clinical protocols or "care plans" in the management and care for patients. These protocols are normally developed by a multi-disciplinary team of care providers using the latest research and medical evidence of best-practices, what is applicable to the institution's administrative and clinical practices, and care plans implemented by other similar sized hospitals in the province. Examples of these protocols include pre-defined orders (in printed or electronic format) and clinical practice guidelines and pathways. The use of these protocols can result in better patient outcomes (patient satisfaction and clinical outcomes) by providing comprehensive tools that help identify patient needs and improve coordination of activities among the care team interacting with the patient [77, page 20].		
	Proxy	**Definition**	**Abbreviation**
	Patient Safety Reporting and Analysis	The extent to which patient safety reporting processes and analysis activities are implemented and monitored within the organization	SafetyReporting
	Explanation		
	The SafetyReporting indicator refers to strategies implemented by hospitals to enhance their ability to report and analyze safety issues and incidents and reduce the cases of adverse events. These strategies include safety briefings in care units, patient safety rounds performed by leadership members to educate staff regarding general safety issues and practices, and appointing safety champions and patient safety steering committees to promote the culture of patient safety and adverse events reporting and prevention practices [78, page 24].		

[3] Source: "Hospital Report 2007: Acute Care" [33]

Table 5: Contextual variables, their definitions, and justification for use

<table>
<tr><th>Variable</th><th>Definition[4]</th><th>Abbreviation</th></tr>
<tr><td>Communication</td><td>Patients' judgment on the amount and quality of information they received during their hospital stay in three key areas: information regarding their condition, progress, and treatment (including medications); information regarding the continuity of care patients need after discharge and services and support options; and the amount of information provided to their care givers (family, friends, etc) when appropriate to keep them informed and provide them the support and tools they need to provide care to those patients after discharge [80, p. 9].</td><td>Communication</td></tr>
<tr><th colspan="3">Explanation</th></tr>
<tr><td colspan="3">It is particularly important to consider the effect of this indicator as the lack of caregiver-patient communication regarding treatments and new medications can result in patients' non-understanding of their conditions and treatments which in turn can lead to serious side effects or medications' adverse reactions. In 2007, 78% of patients surveyed reported that they have received comprehensive information regarding their treatments and new medications, but 26% of patients reported receiving no information whatsoever regarding the potential side effects and adverse events that can be caused by their medications which shows that hospitals should improve the education given to patients regarding their treatments, and prepare them to identify possible side effects or adverse events happening after they are discharged from the hospital [33, p. 25]. This indicator was used to complement the patient satisfaction measure depicted in the Satisfaction indicator.</td></tr>
<tr><th>Variable</th><th>Definition</th><th>Abbreviation</th></tr>
<tr><td>% Equipment Expense</td><td>The percentage of total expenses spent on acquiring and operating computer systems, X-ray machines and other capital equipment</td><td>EquipmentExpense</td></tr>
<tr><th colspan="3">Explanation</th></tr>
<tr><td colspan="3">The EquipmentExpense indicator measures the percentage of hospital's expenditures spent on capital equipments acquisition and maintenance out of the hospital's total operating expenses. This equipment budget is affected by hospital's tertiary role, research and teaching activities, service mix, and funding sources and other asset management decisions. This indicator is also directly affected by the amount of ITUse in hospitals as more IT systems investments mean bigger equipment budgets.</td></tr>
<tr><th>Variable</th><th>Definition</th><th>Abbreviation</th></tr>
<tr><td>% Corporate Services</td><td>The percentage of hospital's expenditures spent on administrative services (finance, human resources, information systems, etc) out of the its total operating expenses</td><td>CorporateServices</td></tr>
<tr><th colspan="3">Explanation</th></tr>
<tr><td colspan="3">This administrative budget is affected by several factors including hospital size, service mix and complexity, management models, implemented information systems, etc. Most hospital staff are clinicians who provide services directly to patients in several clinical roles. The remaining staff is needed to manage the hospitals daily operations including financial and human resources management, information systems support, and to perform other corporate services activities. Leadership aims at providing corporate support at the lowest possible cost, however, it is important to get the right balance in the amount of corporate services spending. Hospitals who over spend on corporate and administrative services may be taking away financial resources needed for patient care, however, under spending might result in having insufficient managerial and financial resources which can slow down the decision making process, inadequate technology to support clinical work, dissatisfied employees, among other negative outcomes of lack of management and leadership resources. This indicator is also affected by the amount of ITUse in hospitals. One can argue that hospitals needs to hire more support staff when implementing more information systems, but at the same time these systems can provide better decision support tools for clinicians to perform their daily work, and for leaders to better achieve organizational goals and objectives [77, p. 84].</td></tr>
<tr><th>Variable</th><th>Definition</th><th>Abbreviation</th></tr>
<tr><td>Unit Cost Performance</td><td>The extent to which a hospital's actual cost per equivalent weighted case differs from its expected cost</td><td>UnitCostPerformance</td></tr>
<tr><th colspan="3">Explanation</th></tr>
<tr><td colspan="3">This indicator measures the expected cost per equivalent weighted case taking into account several factors including teaching and research activities, chronic care programs, hospital size and complexity, hospital's tertiary care role and hospital's geographical isolation from other institutions. Hospitals aim at increasing their unit cost efficiency by reducing the UnitCostPerformance to a zero or negative values. This is affected by factors such as service and staff mix, managerial practices, clinicians' practices, and the cost of local goods and services. It is worth noting that UnitCostPerformance indicator should be considered as a measure of efficiency in combination with other quality factors such as patient satisfaction and clinical outcomes. This is due to the fact that a hospital can achieve high unit cost efficiency but if combined with bad patient and clinical outcomes, it means that this hospital is efficient in providing 'low' quality service [77, p. 82-83].</td></tr>
</table>

[4]Source: "Hospital Report 2007: Acute Care" [33]

is a parametric methodology based on determining production factors that contribute to overall organizational efficiency in the presence of favorable and unfavorable efficiency determinants. This approach might not be easily applicable in healthcare organizations becauseadministrative and clinical outcomes are affected by many internal and external factors such as hospital size;a hospital's tertiary role; patients' demographics and socio-economic status; complexity, research and teaching activities; service mix; funding sources and asset management decisions; and management models, to name a few. Additionally, this methodology, although it accounts for statistical "noise" in the form of error terms, makes specific assumptions about those terms, including half-normal distribution for technical inefficiency and constant stochastic (random) inefficiency term over time, which might be restrictive and not suitable when analyzing hospital efficiency [106][107]. Time-series or longitudinal methodologies [20] are another parametric approach that can be used. However, panel data from a five-year series with a maximum of five data points for each hospital in the data set were utilized in this study, which did not lead itself to a time-series or longitudinal analysis. Such studies require a minimum of 30 data points-series as described in a Box and Jenkins' widely cited book in the area of time series analysis [89].

Regression analysis provides more accurate results and better estimates when a predictive model is needed as it focuses on creating mathematical equations that relate dependent (predicted) variables to independent (explanatory) ones [99, p. 305]. Thus, this study uses multiple regression analysis to develop predictive models in which generalized regression models have been created to establish the relationships between the dependent and independent variables as proposed in the hypotheses. Prior to creating the models and considering the small sample size, the datasets were tested fornormality and assumptions were met, so there was no need to use log transformations [21,22]. Previous studies have used similar mathematical models [20, 21] to analyze the impact of IT investment on hospital outcomes.

For this study, nine regression equations were created to test the three hypotheses, as summarized in Table (6). In general, multiple regression equations are written as

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots.. + \beta_j X_{ip} + e_i \quad (\text{for } j = 1, \ldots, p)$$

where p is the number of independent variables, Y is the value of the dependent variable being predicated or explained by the equation, X_{ij} is the i^{th} observation on the j^{th} independent variable that is predicting or explaining the value of Y , β_0 (beta) is the intercept value of the regression line – that is, the value of Y when X is equal to 0, β_j is the coefficient of X and the slope of the regression line – that is, the change in the value of Y for each one unit change in the value of X. and e_i represents the error in predicting the Y value for the given value of X. (Normally 'e' is not displayed for most regression equations.) [86, 87]

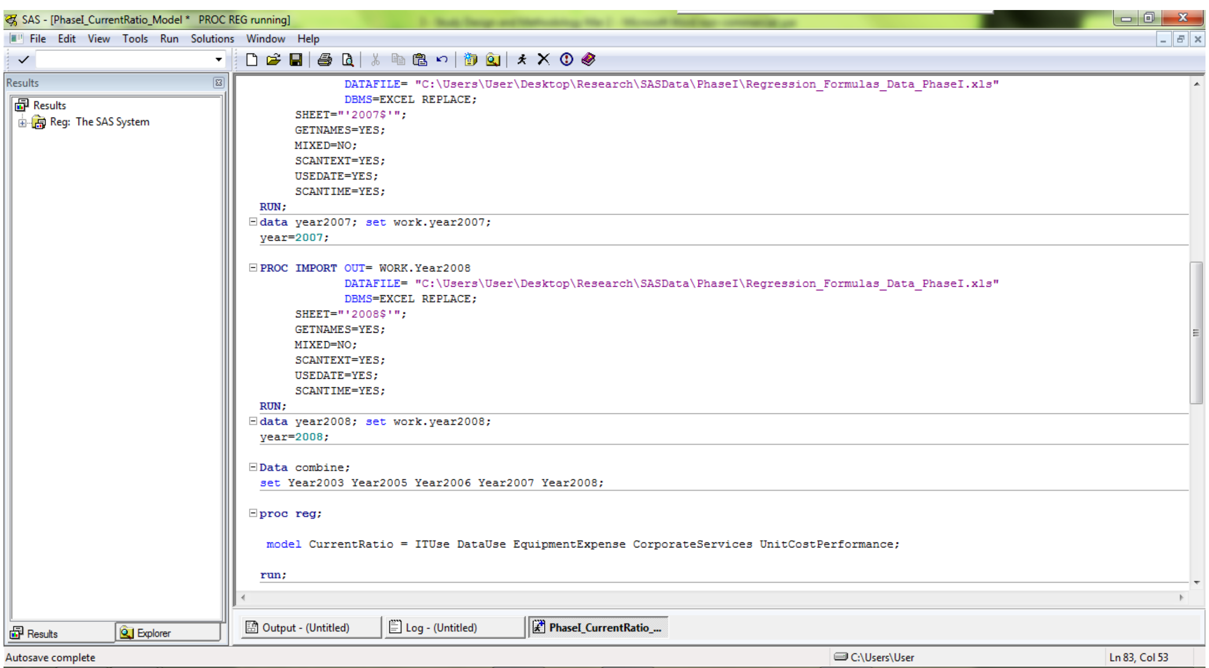
Table 6: Proposed Hypotheses and their corresponding regression equations

	Equations
Hypothesis (H1) (*IT use and availability is positively associated with financial performance*)	**TotalMargin** = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * EquipmentExpense + β_4 * UnitCostPerformance + β_5 * CorporateServices
	CurrentRatio = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * EquipmentExpense + β_4 * UnitCostPerformance + β_5 * CorporateServices
Hypothesis (H2) (*IT use and availability is positively associated with patient satisfaction*)	**Satisfaction** = β_0 + β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting + β_5 * Communication
Hypothesis (H3) (*IT use and availability helps decrease negative outcomes such as readmissions and adverse events*)	**MedicalReadmissions** = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting
	SurgicalReadmissions = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting
	LabourReadmissions = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting
	MedicalAdverseEvents = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting
	SurgicalAdverseEvents = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting
	LabourAdverseEvents = β_0+ β_1 * ITUse + β_2 * DataUse + β_3 * StandardizedProtocols + β_4 * SafetyReporting

Data Analysis

To analyze the relationships and dependencies among the performance indicators, regression analysis was performed in two phases: the overall generalized data analysis (Phase I), and the type-dependent data analysis (Phase II) in which models were analyzed for each hospital type separately. The SAS statistical package was used to perform the regression analysis on the five-year data set. To achieve this, SAS data files were created for each regression formula (listed in Table 5) and [the files?] contains data and information about the data in SAS-specific variables and value labels and are stored with the extension [.sas] in the SAS system library [88], Figure (4) shows a sample of the SAS data files. Appendix I provides a complete listing of all the SAS regression analysis data files.

Figure 4: Sample SAS data file showing the regression equation and stored procedure



When running a SAS REG stored procedure, an output list file is created containing the results of the regression analysis. The analysis results include information such as the analysis of variance of the model variables (including the F value and the R^2coefficient of determination values) and the analysis of the parameter estimates. To evaluate thesignificance of the regression models, the value and sign of the estimated parameters, the standard errors and t-test values, and the p-value significance level of each of the tested independent variables were examined. Each variable was considered significant when it had a p-value test of less than 0.1 (for a 90% confidence level) or less than 0.05 (for a 95% confidence level), and a t-value of |2.0| or greater [86, Simple Regression].

- **Phase I – Overall Generalized Data Analysis:** The first round of data analysis was performed by importing all data rows (a total of 535 rows) into SAS from Excel. Each row in the five-year Excel sheets was considered an independent data point for regression analysis purposes, as the purpose of this modeling exercise was to create mathematical equations to test the impact of IT use and data availability on hospital outcomes in the presence of complementary organizational factors.
- **Phase II - Categorized Data Analysis:** in the second phase of the data analysis, hospital type was incorporated into the regression analysis stored procedure, allowing the regression analysis to be performed on a subset of the original dataset according to that hospital type. In the Excel dataset, the '**type**' column contains a letter corresponding to each hospital type - 'T' for Teaching, 'C' for Community, and 'S' for Small hospitals. The resulting subsets contained 300 rows for community hospitals, 150 rows for small hospitals, and 85 rows for teaching hospitals. Just as in Phase I, a SAS data file was created for each of the original regression formulas listed in Table (5), and each formula went through several modifications before reaching its final best fit form.

3.5 Data Quality

In regression analysis studies, the quality and accuracy of the resulting models depend mainly on the quality and completeness of the dataset used for analysis. Thus, any inherentissues or weaknesses in the dataset will affect the accuracy of the analysis. While efforts were made to eliminate sources of inaccuracies in the data used as input for the regression analysis, the small number of data points (a total of 535) posed the major limitation affecting the dataset. The dataset used in this study was extracted from the Hospital Reports published for Ontario hospitals over the years 2003 – 2008.

The dataset included 'not reported' (NR) values for the data elements used in this study. NR values were used in the Hospital Reports when the data elements had data quality issues such as too-small volumes of patients to allow for valid calculations, a small number of survey respondents (in the case of patient satisfaction), or less than five cases or physician confidentiality rules (in the case of readmissions or adverse events) [33]. Additionally, many reported hospital scores were distinctly different from the provincial average, and concerns were raised that replacing the NR values with the average might result in inaccurate estimates being created by the equations, especially since these equations were intended to be used in the Hospital Analytics decision-support tool described in Chapter 5. This tools usefulnesshinges on it providing users with the ability to compare their hospital's performance against the 'provincial average' values extracted from the Hospital Reports. Thus, all NR values in the dataset were replaced by empty cells as the regression analysis in SAS will process only numerical values, and the equations calculated will provide estimates based solely on the data reported. *This step was done to mitigate the inaccuracies resulting from replacing NR values with the average values of each indicator and considering that NR means different things across the different indicators, as explained at the beginning of this section.* Replacing the NR values with empty cells did not affect the quality of the dataset as to the types of hospitals included in the analysis after SAS excludes all the empty cells in regression analysis as the excluded data represents a small percentage of the hospitals included in the dataset.

As for the accuracy of the data reported in the Hospital Reports, prior to publishing each report, the Canadian institute for Health Information (CIHI) applied formal data checks and verification techniques to account for any discrepancies in the data. For example, for the Financial Performance and

Condition indicators used to proxy for hospital financial condition, financial information was checked by CIHI against the Ministry of Healthand the other national financial information data-reporting standards. Any discrepancies found were sent back to hospitals for review and amendments. To reduce the effect of “social desirability bias” where survey respondents may consciously or unconsciously respond to questions in a manner that sheds the best possible light on their institutions, survey questions provided to hospitals were constructed in a way that focuses more on specific behaviors rather than attitudes [34, page 5]. Even though those verification techniques are used, it is still practically impossible to eliminate the effects of these biases completely, and opportunities remained for different interpretations of survey questions.

For the Patient Satisfaction and Clinical Utilization and outcome indicators used to proxy for patient satisfaction measures and quality of care provided by hospitals, CIHI applied formal risk adjustment techniques (defined in clinical research as the adjustment of hospital data to remove pre-existing influences) to account for systematic differences in patient characteristics such as age, gender, medical history prior to their hospitalization encounter, social status, etc. These factors can result in variations in patients’ course of treatments and length of stays, which can affect their responses to survey questions. For patient satisfaction responses, men reported slightly higher satisfaction with the care provided than women did, and older patients tend to be somewhat more satisfied than younger patients.Researchers also found that less healthy patients reported varying satisfaction results (either higher or lower) than did healthier patients. To reduce the chances of unfair scoring for hospitals that receive disproportionate numbers of specific patient demographics, these influences were accounted for and eliminated as much as possible when calculating the final indicator scores for each hospital [80, page 9].

To ensure the accuracy of the dataset manually extracted into the Excel workbook and used as the data source for the SAS programs, data checks were performed using pair-wise comparisons with the same data extracted into Excel using PDF-to-Excel convertor. This resulting dataset from the automatic conversion process was arranged into columns to allow for the cell-by-cell comparison using the EXACT function in Excel. When a discrepancy was identified (the Exact function returned False), the values were checked against the original PDF reports and manually corrected were applicable.

To check the accuracy of the mathematical models proposed, the regression equations underwent two more rounds of verification. After the first run for the regression analysis in SAS, some of the variables that were originally proposed in the models in Table 4 proved to be statistically insignificant aftera diagnostic best fit analysis was run using the R^2 values of the overall models. Subsequently, these variables were removed from the "best-fit" equations that were implemented in the decision support artifact (Chapter 5), as their impact on the dependent variable in their corresponding equations was not supported. A sample of an updated formula is provided in Table (7).

Table 7: Original vs. updated regression formula after running best fit analyses

Original Formula
CurrentRatio = β0 + β1 * ITUse + β2 * DataUse + β3 * EquipmentExpense + β4 * UnitCostPerformance + β5 * CorporateServices
Updated Formula I (Confidence Level = 95%)
CurrentRatio = β0 + β1 * ITUse + β2 * UnitCostPerformance

The second round of verification involved testing the predictive accuracy of the resulting 'best-fit' equations. To explain this process, an example using the data elements and models proposed in this study is used. One of the final best fit equations created in this study predicted the TotalMargin value using both CorporateServices and UnitCostPerformance (this equation is discussed in detail in the Chapter 4 – Discussion section). To verify how well the regression equation can predict the

TotalMargin’s values, a subset of data was created in Excel to include only the independent and dependent variables in the equation in question. In this example, the dataset includes the TotalMargin, CorporateServices and UnitCostPerformance columns. In this dataset, the TotalMargin column has then been duplicated as a new column, TotalMargin1, and some of the values in the original TotalMargin column were randomly removed.A new column called ‘inclusion’ was then added and assigned the values 0 or 1 according to the values in the TotalMargin column. For each data point removed from the TotalMargin column, the inclusion column was assigned the value of 0, otherwise it was assigned the value 1 for the remaining non-omitted values in the TotalMargin column. To perform the check, the regression equation was run, and the resulting predicted values for each data point were captured in the ‘pred’ column. The differences between the predicted values (pred column) and the original TotalMargin values (TotalMargin1 column) were also captured in the dynamic dataset ‘diff’. This test aimed at verifying whether the predicted values are significantly different from the original values of the dependent variable, TotalMargin in this example. The results of the test were then analyzed using the PROC MEANS in SAS for statistical significance. Figure (5) shows the results of the example above.

Figure 5: Model Verification Example

```
-------------------------- inclusion=0 --------------------------

                        The MEANS Procedure

                     Analysis Variable : diff

     N            Mean         Std Dev    t Value    Pr > |t|
    ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
    39      -0.2509090       4.2898771      -0.37      0.7169
    ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ


------------------------- inclusion=1 -------------------------

                     Analysis Variable : diff

    N            Mean         Std Dev    t Value    Pr > |t|
    ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
    246    -1.48165E-15       3.3384941      -0.00      1.0000
    ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

In this example, 39 random values have been omitted from the original TotalMargin column. The mean for the predicted values is a negative value (-0.2509), which indicates that the regression model tends to slightly underestimate the TotalMargin values. The most important value in this test is the p-value for the predicted values. In this example,p is equal to 0.7169, which is **not** significant at either the 90% or the 95% levels. Thus, the differences between the predicted and original values are *not* statistically significant. This verification technique was applied to all regression equations for both Phases I and II, and all of these equations fit well to the selected randomly removed values. The above results verify the validity of the regression models that are used in this study to test hypotheses 1 to 3. See Appendix II for complete listing of verification data files.

Chapter 4

Results and Discussion

This chapter analyzes the results of the regression analysis performed to test the proposition that IT use and availability in a given organization combined with the availability of clinical and administrative data and the existence of complementary organizational improvement initiatives has a positive impact on hospital outcomes in terms of patient satisfaction, clinical outcomes, and financial performance. To test this proposition, three hypotheses were created, and corresponding regression equations were tested using SAS in two different phases. Section 4.1 provides a listing of the results of the two phases, section 4.2 discuss the implications of these results, and finally, section 4.3 discusses the limitations posed and future work.

4.1 Results

In Phase I of the data analysis, the regression models were run using all 535 rows in the Excel dataset as input for the regression stored procedures. The resulting formulas varied in their confidence levels—significant 'best-fit' equations had 95% confidence levels for all of their variables. The rest of the regression models tested were insignificant, falling under the 90% confidence level where a best fit model could not be created for the combination of dependent and independent variables proposed. Table (8) shows the regression analysis results for Phase I and the significance levels for each variable. The first 4 equations tested hypothesis H1 for which the impact of IT use and availability is positively associated with hospital financial performance. The Satisfaction equation tested hypothesis H2 for which the impact of IT use and availability is positively associated with patient satisfaction. Finally, the last 6 equations related to clinical outcomes tested hypothesisH3 for which the impact of IT use and availability helps decrease hospital negative outcomes such as readmissions and adverse events.

Table 8: Regression analysis results for Phase I equations[5]

Dependant Variable	Independent Variables	Coefficient	Standard Error	t-value	Pr> |t|
TotalMargin I (H1.1)	Intercept	-2.92169	0.91407	-3.20	0.0015
	UnitCostPerformance	-0.12289	0.01891	-6.50	**<.0001**
	CorporateServices	0.43625	0.09056	4.82	**<.0001**
TotalMargin II (H1)	Intercept	2.78537	0.72179	3.86	0.0001
	ITUse	-0.02536	0.01225	-2.07	**0.0394**
	UnitCostPerformance	-0.11725	0.02043	-5.74	**<.0001**
CurrentRatio I (H1)	Intercept	1.74246	0.40923	4.26	<.0001
	ITUse	-0.01849	0.00419	-4.42	**<.0001**
	EquipmentExpense	0.10700	0.05434	1.97	**0.0499**
	UnitCostPerformance	-0.02177	0.00717	-3.04	**0.0026**
CurrentRatio II (H1)	Intercept	1.18733	0.38325	3.10	0.0021
	ITUse	-0.01569	0.00347	-4.53	**<.0001**
	CorporateServices	0.11185	0.02794	4.00	**<.0001**
Satisfaction (H2)	Intercept	58.12784	2.54144	22.87	<.0001
	ITUse	-0.03966	0.00956	-4.15	**<.0001**
	DataUse	-0.01696	0.00989	-1.71	**0.0874**
	Communication	0.39096	0.02922	13.38	**<.0001**
MedicalAdverseEvents (H3)	Intercept	0.44397	0.38531	1.15	0.2506
	ITUse	-0.00004849	0.00545	-0.01	0.9929
	DataUse	0.01583	0.00562	2.82	0.0053
	SafetyReporting	-0.00592	0.00463	-1.28	0.2031
SurgicalAdverseEvents (H3)	Intercept	0.50320	0.18376	2.74	0.0069
	ITUse	-0.00024815	0.00226	-0.11	0.9125
	DataUse	-0.00073392	0.00239	-0.31	0.7591
	SafetyReporting	-0.00267	0.00200	-1.34	0.1831
LabourAdverseEvents (H3)	Intercept	2.49947	0.76675	3.26	0.0014
	ITUse	0.02009	0.01013	1.98	0.0491
	DataUse	-0.01904	0.01043	-1.82	0.0699
	SafetyReporting	-0.00263	0.00874	-0.30	0.7642
MedicalReadmissions (H3)	Intercept	4.31629	0.49687	8.69	<.0001
	DataUse	-0.01818	0.00855	-2.13	**0.0343**
	StandardizedProtocols	0.01836	0.00810	2.27	**0.0241**
SurgicalReadmissions (H3)	Intercept	4.70905	2.18347	2.16	0.0326
	ITUse	-0.05136	0.02680	-1.92	0.0571
	DataUse	-0.00902	0.02839	-0.32	0.7511
	SafetyReporting	0.01585	0.02371	0.67	0.5050
LabourReadmissions	Intercept	5.07734	2.28978	2.22	0.0280

[5] Light grey shading corresponds to confidence levels at 95% and dark grey corresponds to confidence levels at 90%. Note that non shaded results represent the models that were not statistically significant.

(H3)	ITUse DataUse SafetyReporting	-0.06372 -0.01339 0.01310	0.03026 0.03116 0.02611	-2.11 -0.43 0.50	0.0368 0.6679 0.6165

In this table,

- The coefficient column shows the least estimates for the parameters β_j
- The standard error column shows the standard errors for each of coefficient estimate
- The t-value column shows the estimated t-value for each independent (explanatory) variable. The value is calculated as the ratio of the estimated coefficient over its standard error
- The p-value (Pr> |t|) column shows the results of the tested hypothesis as significance confidence levels.

When evaluating the regressors, a p-value of less than 0.1 (for a 90% confidence level) or less than 0.05 (for a 95% confidence level) were considered significant. The regression analysis also provides other measures of how well the regression equation fits the data set provided:

- The R^2: the coefficient of determination, which indicates the "goodness-of-fit" of the overall regression equation. It is a representation of the percentage of the variance in the values of the independent variable Y that can be explained by knowing the values of the independent variables X_i. A value of 1 is a perfect fit, and a value closer to 0 indicates that the independent variables have no explanatory powers on the dependent variable. When adding more independent variables, the value of R^2 will always increase even if the added variable has no predictive powers (its p-value ≥ 0.1) in the regression equation. To overcome this limitation, the adjusted-R^2 value is also observed. It is similar to the R^2 value but does not increase when variables are added to the equation unless they are capable of predicting the independent variable (i.e. significant) [101]

- The F-statistic tests the statistical significance of the overall regression equation. It is the ratio of the explained variance divided by the unexplained variance. Generally, if the regression equation has an F-value greater than 4.0, then it is considered statistically significant. When manual regression is performed, testing the F-value against an F distribution table is recommended to ensure that the received F-value is significant; however, SAS provides the probability of F (Pr> F) value, which shows whether F is significant or not.

The R^2 and F-value analysis were performed for the regression models listed in the table above, but results are not shown due to space concerns. The regression equations used to test hypotheses H1 - H3 were considered significant when the p-values for each variable in the equation was significant at either the 90% ($p < 0.1$) confidence level or at the 95% ($p < 0.05$) confidence level. As such, the F-value andR^2 value for the every equation was considered as a secondary significant test, but the focus was given to the p-value testing as the main determinant of statistical significance of each regression equation. The null hypothesis H_0 will either be rejected or fail to be rejected according to the obtained results of Phase I and Phase II, as discussed in the following section.

In Phase II, the original regression equations were used again to obtain significant 'best-fit' forms in which a 95% or a 90% confidence level is achieved. In this phase, the hospital type (community, small, and teaching) was a significant input into the regression equation in which those equations were fitted for each type separately and the results analyzed. Table (9) shows the results for Phase II for each hospital type.In the Type column, C=community, S=small, and T=teaching. In this table, the first five equations retested hypothesis H1 (where the impact of IT use and availability proposed to be is positively associated with hospital financial performance). The Satisfaction equation tested hypothesis H2 where the impact of IT use and availability is proposed to be positively associated with patient satisfaction. Finally, the last six equations related to clinical outcomes tested hypothesis H3,for which the impact of IT use and availability is proposed to help decrease hospital negative outcomes such as readmissions and adverse events.

Table 9: Regression analysis results for Phase II equations[6]

Dependant Variable	Type	Independent Variables	Coefficient	Standard Error	t-value	Pr> |t|
TotalMargin I (H1)	C	Intercept	-3.58807	1.54121	-2.33	0.0211
		UnitCostPerformance	-0.12604	0.02871	-4.39	**<.0001**
		CorporateServices	0.46448	0.16930	2.74	**0.0067**
	S	Intercept	1.67527	2.65689	0.63	0.5306
		UnitCostPerformance	-0.11559	0.03149	-3.67	0.0005
		CorporateServices	0.08686	0.20898	0.42	0.6791
	T	Intercept	-4.80922	2.47918	-1.94	0.0595
		UnitCostPerformance	-0.04060	0.05937	-0.68	0.4980
		CorporateServices	0.76291	0.25918	2.94	0.0054
TotalMargin II (H1)	C	Intercept	-5.70747	1.67867	-3.40	0.0008
		DataUse	0.03390	0.01438	2.36	**0.0192**
		CorporateServices	0.47084	0.15978	2.95	**0.0035**
	S	Intercept	3.64322	2.62125	1.39	0.1680
		DataUse	0.02073	0.02699	0.77	0.4443
		CorporateServices	-0.13349	0.17622	-0.76	0.4508
	T	Intercept	-1.09021	2.84794	-0.38	0.7032
		DataUse	-0.03083	0.02839	-1.09	0.2816
		CorporateServices	0.58095	0.22539	2.58	0.0123
CurrentRatio I (H1)	C	Intercept	1.46738	0.39228	3.74	0.0003
		ITUse	-0.01954	0.00470	-4.16	**<.0001**
		EquipmentExpense	0.13602	0.05565	2.44	**0.0156**
		UnitCostPerformance	-0.02629	0.00828	-3.18	**0.0018**
	S	Intercept	1.12165	1.17993	0.95	0.3454
		ITUse	0.02015	0.01344	1.50	0.1387
		EquipmentExpense	0.05015	0.15270	0.33	0.7437
		UnitCostPerformance	-0.01820	0.01605	-1.13	0.2609
	T	Intercept	1.00565	0.57408	1.75	0.0877
		ITUse	-0.00236	0.00612	-0.39	0.7015
		EquipmentExpense	-0.00383	0.05898	-0.06	0.9486
		UnitCostPerformance	0.00548	0.01036	0.53	0.5997

[6] Light grey shading corresponds to confidence levels at 95% and dark grey corresponds to confidence levels at 90%. Note that non shaded results represent the models that were not statistically significant.

CurrentRatio II (H1)	C	Intercept	0.43793	0.41770	1.05	0.2956
		ITUse **CorporateServices**	-0.01672 0.19401	0.00366 0.03875	-4.56 5.01	**<.0001** **<.0001**
	S	Intercept	3.61465	0.97488	3.71	0.0004
		ITUse **CorporateServices**	0.02444 -0.18939	0.01122 0.07430	2.18 -2.55	**0.0320** **0.0125**
	T	Intercept	0.37121	0.50030	0.74	0.4609
		ITUse **CorporateServices**	-0.00156 0.06065	0.00466 0.03476	-0.34 1.74	0.7385 0.0859
Satisfaction (H2)	C	Intercept	16.31249	4.23220	3.85	0.0002
		SafetyReporting Communication	0.00796 0.86652	0.00918 0.05418	0.87 15.99	0.3880 <.0001
	S	Intercept	15.24470	8.41906	1.81	0.0852
		SafetyReporting **Communication**	0.04210 0.85668	0.01819 0.10252	2.32 8.36	**0.0313** **<.0001**
	T	Intercept	87.10368	2.88160	30.23	<.0001
		SafetyReporting **Communication**	-0.06871 0.05058	0.03503 0.02808	-1.96 1.80	**0.0615** **0.0842**
MedicalAdverseEvents (H3)	C	Intercept	3.90277	1.22508	3.19	0.0017
		ITUse **DataUse** **Communication**	-0.00682 0.00670 -0.03962	0.00352 0.00303 0.01473	-1.94 2.21 -2.69	**0.0545** **0.0284** **0.0079**
	S	Intercept	-3.47578	6.18208	-0.56	0.5775
		ITUse DataUse Communication	0.01143 0.03796 0.02539	0.01324 0.01576 0.07386	0.86 2.41 0.34	0.3939 0.0214 0.7330
	T	Intercept	-0.67455	1.05237	-0.64	0.5254
		ITUse DataUse Communication	0.02231 0.01238 -0.00780	0.01178 0.01103 0.01061	1.89 1.12 -0.74	0.0658 0.2687 0.4665
SurgicalAdverseEvents (H3)	C	Intercept	0.33738	0.17965	1.88	0.0631
		ITUse DataUse SafetyReporting	- 0.00091272 -0.00143 0.00021538	0.00223 0.00210 0.00173	-0.41 -0.68 0.12	0.6831 0.4955 0.9012
	S	Intercept	1.87520	1.14535	1.64	0.1298
		ITUse DataUse SafetyReporting	0.01086 0.00034702 -0.02440	0.01704 0.02064 0.01419	0.64 0.02 -1.72	0.5370 0.9869 0.1135
	T	Intercept	-0.26307	0.50228	-0.52	0.6044
		ITUse DataUse SafetyReporting	0.00662 0.00111 -0.00132	0.00635 0.00480 0.00422	1.04 0.23 -0.31	0.3057 0.8184 0.7570
LabourAdverseEvents (H3)	C	Intercept	3.77162	0.83017	4.54	<.0001
		ITUse DataUse SafetyReporting	-0.01302 -0.00890 -0.00566	0.01036 0.00961 0.00814	-1.26 -0.93 -0.69	0.2114 0.3561 0.4887
	S	Intercept	2.64455	1.85553	1.43	0.1703
		ITUse	0.09166	0.03137	2.92	0.0088

		DataUse	-0.06946	0.05259	-1.32	0.2023
		SafetyReporting	-0.00803	0.02851	-0.28	0.7813
	T	Intercept	-5.17675	3.43210	-1.51	0.1445
		ITUse	0.16413	0.04662	3.52	0.0018
		DataUse	-0.05790	0.03333	-1.74	0.0952
		SafetyReporting	0.00344	0.02966	0.12	0.9085
MedicalReadmissions (H3)	C	Intercept	7.63276	0.99149	7.70	<.0001
		ITUse	-0.02717	0.01253	-2.17	0.0322
		DataUse	-0.00344	0.01190	-0.29	0.7731
		SafetyReporting	-0.01037	0.00997	-1.04	0.3002
	S	Intercept	4.05802	2.41873	1.68	0.1002
		ITUse	-0.00352	0.04252	-0.08	0.9343
		DataUse	0.07850	0.05280	1.49	0.1439
		SafetyReporting	-0.02670	0.03251	-0.82	0.4157
	T	Intercept	4.44061	2.43866	1.82	0.0793
		ITUse	0.04402	0.02728	1.61	0.1179
		DataUse	-0.04280	0.02258	-1.90	0.0684
		SafetyReporting	-0.02080	0.02201	-0.94	0.3528
SurgicalReadmissions (H3)	C	Intercept	2.10408	0.50277	4.18	<.0001
		ITUse	-0.01432	0.00624	-2.30	0.0237
		DataUse	0.00584	0.00587	1.00	0.3218
		SafetyReporting	-0.00139	0.00484	-0.29	0.7742
	S	Intercept	12.34573	20.03525	0.62	0.5503
		ITUse	-0.18483	0.29809	-0.62	0.5479
		DataUse	-0.18600	0.36109	-0.52	0.6167
		SafetyReporting	0.12253	0.24818	0.49	0.6312
	T	Intercept	1.33223	4.59345	0.29	0.7739
		ITUse	-0.04441	0.05807	-0.76	0.4505
		DataUse	0.05453	0.04392	1.24	0.2243
		SafetyReporting	0.00298	0.03859	0.08	0.9389
LabourReadmissions (H3)	C	Intercept	-0.56223	0.72897	-0.77	0.4414
		ITUse	-0.00353	0.00207	-1.70	**0.0900**
		Communication	0.01854	0.00893	2.08	**0.0391**
	S	Intercept	-29.96052	72.40218	-0.41	0.6825
		ITUse	-0.33077	0.17804	-1.86	0.0750
		Communication	0.60704	0.87969	0.69	0.4965
	T	Intercept	0.15030	0.29412	0.51	0.6117
		ITUse	0.00719	0.00246	2.93	0.0052
		Communication	0.00173	0.00318	0.54	0.5892

4.2 Discussion

Implications: *IT Use and Hospital Financial Condition*

The results of Phase I of the analysis are presented in Tables (6). The relationship between IT use and availability and hospital Financial Condition, represented by the hospital total margin and current ratio, is the subject of hypothesis H1. In three of the four models that were used to test the hypothesis**, IT use and availability were found to have an inverse relationship with both hospitals financial performance measures**;that is, increasing IT use and availability affected hospital financial condition by reducing both the total margin and current ratio of sampled hospitals. Conceivably, investing in IT with the corresponding short-term budget and resource allocation does in fact lower the short-term assets of the organization (taking into consideration that these investments are normally paid for by liquid assets or with short-term financing periods), consequently lowering the hospital's current ratio. Additionally, increasing the amount of spending on IT whether by buying new systems or upgrading existing systems does require budgets that are normally booked as cash outflows from the hospital's total operating budget and increases the short-term expenses compared to short-term revenues. The hospital's overall total margin is thus decreased.

As for the complementary factors that affect organizational financial condition, Phase I analysis shows that lowering the cost per average weighted case (UnitCostPerformance) does improve hospital financial condition by improving both total margin and current ratios. As hospitals are increasing their unit cost efficiency by lowering the total costs per equivalent cases, this does positively affect the overall short-term assets (CurrentRatio). Similarly, increased UnitCostPerformance values reveal relatively high organizational inefficiencies, which result in the actual costsof treating each patient climbing compared to forecasted costs,and results in increasing the hospital's overall expenses compared to its revenues (TotalMargin). A positive relationship was also noticed between the amount spent on equipment (EquipmentExpense) and a hospital's short-term assets. Higher values in EquipmentExpense indicate that hospitals are allocating higher budgets to buying and maintaining equipment, which in return increases the overall organizational capital assets.

Lastly, the results showed a **direct relationship between the amount spent on corporate and administrative services (CorporateServices) and a hospital'sfinancial condition**. Higher values in CorporateServices reveal that hospitals are spending more on administrative, finance, human resources, and systems support services out of their overall operating expenses. This is an interesting finding, because despite the common belief that spending on administrative services might be taking away already scarce resources from other direct patient care areas, the results show that those hospitals who increase their CorprateServices spending in areas such as financial planning and short-term support staffing are getting relatively quick returns on their investment, indicated by better assets and debt management (CurrentRatio). Moreover, they are managing their cash flows more efficiently by decreasing their expenses compared to their revenues (TotalMargin).

Phase II results, shown in Table (7), varied from those of Phase I. **The impact of IT use and availability on hospital financial conditionand short-term assets (CurrentRatio) was noted only for small hospitals**. This finding might be caused by the smaller asset pools and assigned budgets of smaller hospitals and the fact that investing in IT systems can add to that asset pool. Additionally, the environment in small hospitals might not be affected by many stakeholders or factors that impact the budgets of bigger community and teaching hospitals, including complex care activities, case mixes, teaching and research, etc. Thus, the impact of IT use and availability has proved to be harder to measure in more complex environments where many factors can affect organizational performance. The availability and dissemination of data for decision making has proved significant in improving hospital financial performance in community hospitals. The availability and dissemination of the right amount of clinical and administrative data for leadership teams can enhance their ability to make better decisions that would be reflected in improved financial performance of their organizations.

The results of Phase I and II prove that **organizational efficiencies lead to better organizational financial performance and found support for the impact of IT use and availability on financial performance in small hospitals. However, the results found no direct support for the impact of IT use and availability on financial performancefor community and teaching hospitals**. The results also support that the availability and dissemination of data for decision making has a positive impact on hospital financial performance. While IT use and availability is considered an enabler for the improved efficiency, the ease of access and sharing of data, and the process re-design initiatives, the reported measure for IT use dealt with the use and availability of IT within clinical settings. Thus, the results did not yield a direct relationship with the financial performance of hospitals for bigger hospitals where this impact is affected by many factors, including hospital size, case mix, teaching and research, management models, funding, etc.

Test Results: Hypothesis H1(IT use and availability is positively associated with financial performance) is rejected, as a direct relationship between IT use and hospital financial performance was not proven. As such, and according to the results of both Phase I and Phase II, the null hypothesis for H1 failed to be rejected.

Implications: *IT Use and Patient Satisfaction*

The relationship between IT use and availability and patient satisfaction, represented by the satisfaction score, is the subject of hypothesis H2. **The model used to test the hypothesis in Phase I showed that IT use and availability has an inverse relationship with patient satisfaction**. While investing in IT systems can improve the care process by providing clinicians with better means to access data and facilitates the implementation of better clinical pathways, it can negatively affect the quality of patient-clinician interaction as clinicians spend more time typing or reading off a computer screen than taking directly to the patient [102]. Although, this concern was reported in the literature to be more evident in community care practice and outpatient clinics, there is no evidence to suggest that acute care inpatients are not faced with these same interaction concerns.

Data availability and dissemination results also show a negative effect on patient satisfaction. Again, this can be attributed to the reduced patient-clinician interaction as more and more information is provided to patients and their families and caregivers in generic brochures, home-care toolkits, and online resources, etc. Patients can easily be overwhelmed by the amount of information provided to them, especially if it is not tailored to their specific condition or direct needs [103, p. 336]. This discussion ties back to the positive effect of care giver-patient communication on patient satisfaction as proved by the results above. Patient were more satisfied when their caregivers provided them with proper information regarding their condition, treatment options and drugs and their possible side effects, the continuity of care after discharge, and adverse events prevention tools and support services. Consequently, increasing the amount of data provided to the patient would improve patient satisfaction only when accompanied by the proper amount of patient and family education.

Phase II results, shown in Table (7), varied from those of Phase I. The model used to test the impact of IT use and data availability and dissemination on patient satisfaction proved statistically insignificant when applied for individual hospital types. The results **prove that effective communication leads to improved patient satisfaction and found support for the impact of safety reporting practices on improved satisfaction in small hospitals. However, the results found no direct support for the impact of IT use and availability on patient satisfaction**. IT is considered an enabler for improved clinician-patient communications through the use of Telehealth resources; the use of patient portals; and the availability of online medical information sites and databases that are rich sources of information that patient can use to access information specific to their conditions or symptoms. IT use and availability is also considered an enabler for improved safety reporting practices by making data easily accessible to clinicians at the point of care and by providing improved reporting means through email alerts or aggregate reports. The IT use and availability measures in the dataset dealt with the use and availability of IT within clinical settings. Thus, the results did not yield a direct relationship with patient satisfaction.

Test Results: Hypothesis H2 (IT use and availability is positively associated with patient satisfaction) is rejected, as a direct relationship between IT use and patient satisfaction was not proven. Therefore, and according to the results of both Phase I and Phase II, the null hypothesis for H2 failed to be rejected.

Implications: *IT Use and Clinical Outcomes*

The relationship between IT use and availability and clinical outcomes, represented by adverse events and readmission rates, is the subject of hypothesis H3. The results of Phase I analysis showed no support for the impact of IT use and availability on clinical outcomes in all 6 measures. In Phase II results, however, **IT use and availability was shown to impact a hospital's clinical outcomes by reducing the number of medical adverse events and all three readmission measures (medical, surgical, labor) in community hospitals.** These results show that investing in IT systems can improve the care process by providing clinicians with better means to access data and facilitates the implementation of better clinical pathways,both of which positively affect the care provided to patients and reduce the cases of adverse events. The results also showed that improved communications result in reducing the number of medical adverse events in community hospitals. Improved patient-clinician communication provides patients with the proper information regarding their condition, treatment options and drugs and their possible side effects, the continuity of care after discharge, and adverse events prevention tools and support services, and do in fact reduce the number of adverse events case significantly.

The **results showed no support for IT impact on clinical outcomes in teaching hospitals**. However, they supported the impact of data availability and dissemination on reducing medical readmission rates and adverse events related to labor and delivery. In complex hospital settings that are typical for teaching hospitals, where clinicians, administrators, and trainees deal with a multitude of different cases, lack of clinical and administrative information dissemination with the appropriate stakeholders can impede proper decision making and might resultin staff overlooking better treatment choices. Insufficient internal and external benchmarking of outcomes and safety records can lead hospitals and departments to lose important improvement opportunities if they cannot compare their performance with that of similar-sized institutions or departments. Finally, relevant safety and risk information might not be used, collected or analyzed properly when hospitals are understaffed in proper information-based roles such as quality and risk management analysts, decision support specialists, and infection control practitioners whocanfacilitate the use of such information in improving organizational performance.

Phase II results **found support for the impact of IT use and availability on hospital clinical outcomes in community hospitals.** Similarly, effective communication was shown to lead to improved clinical outcomes by reducing the rate of medical adverse events in community hospitals. The availability and dissemination of data for decision making was shown to reduce the number of readmissions and labor-related adverse events in teaching hospitals. IT is considered an enabler for improved clinician-patient communications through the use of Telehealth resources; the use of patient portals; and the availability of online medical information sites and databases that are rich sources of information patient can use to access information specific to their conditions or symptoms, available treatment options, drugs and their possible side effects, and adverse events prevention tools and support service.

The results did not yield a direct relationship between the impact of IT use and availability on reducing adverse events or readmissions in teaching hospitals as performance could be affected by other factors, including complexity, case mix, teaching and research activities, management models, funding, etc. However, IT use and availability is considered an enabler of data availability and dissemination, providing repositories, databases, knowledge bases, and reporting solutions that facilitate information sharing and access.

Test Results: Hypothesis H3 (IT use and availability helps decrease negative outcomes such as readmissions and adverse events) is supported in community hospitals as IT use and availability help decrease negative outcomes,including readmissions and adverse events. In small and teaching hospitals, H3 is rejected, as a direct relationship between IT use and availability and the decrease of readmissions or adverse events was not supported. As such, and according to the results of both Phase I and Phase II, the null hypothesis for H3 was rejected for community hospitals and failed to be rejected for small and teaching hospitals.

4.3 Limitations

As it is acknowledged that the Hospital Reports dataset might not represent up-to-date information (2003 – 2008) about today's hospital performances, it is worth mentioning that these indicators do provide valuable tools for creating comparable performance measures that hospitals regularly use for benchmarking against other hospitals and provincial information applicable to that period of time. They also provide comparable measures that are used in the decision support tool(discussed in the next chapter), to assist hospitals' CFOs and CIOs in visualizing the impact of IT use and availability on the different performance measures within their organization and benchmarking their organization's performance against other hospitals of the same type category.

4.4 Future Work

The IT productivity paradox has been shown to be resolved in many industries, but in healthcare, it seems that the benefits of IT investments are still hard to quantify and measure. Opportunities for measurement improvements include quantifying the IT investments in hospitals by analyzing the exact amounts spent on system capital, labour, support, and outsourcing. IT expenditure data was not provided in the dataset utilized by this study, but including such data in the analysis will result in more accurate measures for IT investments, especially when combined with the IT use and availability measures used here, as doing so will combine the budget information with the utilization information and will overcome a limitation in many previous studies that used budget information only with the assumption that the bigger the IT budget, the more the use of IT within the organization, which is not only inaccurate, but might also result in misleading decision makers making investment decisions.

While judgment cannot be passed on the validity of the regression models if a newer or bigger dataset is analyzed, validating those models represents an important extension of this study, as a bigger dataset (e.g. one that includes more hospitals and possibly hospitals from other provinces) will enhance the reliability of the mathematical models and might positively affect the results, as they could cover hospitals affected by different demographics and funding models, and include both rural and urban area hospitals that are affected by the different socio-economic status of their surroundings. While this study sheds light on the relationship between IT use and availability on organizational financial performance, patient satisfaction, and clinical outcomes; and considering that some of these relationships were supported and some were not, the goal is not just to prove or disprove the relationships between the different indicators and whether they still hold until today, although such proof is important, the goal is to shed light on important issues that face hospital CFOs and CIOs on a daily basis: 1) deciding on the right amount of IT investment needed to achieve maximum impact on the care provided to patients and 2) determining the checks and balances that must be implemented by healthcare institutions to ensure the benefits of such IT investments are realized by aligning those investments with organizational strategic directions and proper process redesign initiatives to ensure the maximum adoption and utility of IT.

Another important extension of this study would include studying the effect of different IT governance models on organizational performance in hospitals. Considering how centralized vs. decentralized IT implementations affect the performance and the efficiency of departments and organizations would enhance the understanding of the relationship between the IT governance models and the management strategies that are geared towards improving organizational efficiencies and how IT implementations can be an enabler to such initiatives.

Chapter 5

The Hospital Analytics Tool

5.1 Purpose and Description

The previous chapters discussed the issue of IT business value and analyzed IT's impact on organizational performance in terms or financial performance and quality of outcomes using measures provided by the Hospital Reports of Ontario. This chapter, building on the mathematical models provided in Chapters 4 and 5, introduces the Hospital Analytics dashboard, a decision-support tool created to enable users to visualize the relationships between the different performance indicators measures provided in this study's dataset. This chapter also discusses how these relationships can be used to dynamically change and retrieve indicator values by the user according to set criteria. The tool is created as a proof-of-concept of system that can be used to enhance the decision-making process in hospital organizations. Staff can analyze performance measures in different areas of the institution and how they interact with one another. The following section explains the theoretical basis for the proposed decision-support tool and its proposed applications, provides a summary of the functional and technical specifications, and finally, discusses intended users and possible expansion opportunities.

Decision Support Systems (DSS)

Arnott and Pervan [104, p. 657] define DSS as the "area of the information systems (IS) discipline that is focused on supporting and improving managerial decision-making" where IT systems are developed and implemented to facilitate decision-making processes. Since their emergence in the 1970's, DSS have been of interest for both researchers and practitioners alike due to their significant effects on the "nature and performance of organizations". Business Intelligence (BI) systems have been the strongest DSS investment since the early 2000s. It grew by 12% from 2003 to 2004 and was expected to continue growing by 7.4% by 2009 to reach about $3 billion [105]. This is not surprising giving the diverse applications and types of DSS and BI systems, including [104]:

- Personal Decision Support Systems: small scale systems used by managers for to support small decision tasks;
- Group Support Systems: used by working groups to facilitate communication and collaboration;
- Negotiation Support Systems: which enable negotiations between parties in different settings;
- Intelligent Decision Support Systems: more dynamic systems that apply artificial intelligence techniques to DSS;
- Knowledge Management DSS: which support decision making by facilitating knowledge storage, retrieval, and portability
- Data Warehousing DSS: widely used DSS that store large-scale data and enable users to view data at different levels and with different formats
- Enterprise Reporting and Analysis Systems: comprised of major BI systems, Executive Information Systems (EIS) and Corporate Management Systems (CMS) which allow leadership teams to drill down into corporate information at a high level using reporting and query software and analysis tools.

Out of these systems, BI systems, Personal Decision Support Systems, and Enterprise Decision Support Systems are the most used by organizations today. The ability for leaders to make the right decisions is largely based on their ability to access the right information in the right format. When evaluating performance, leaders need to be able to compare their organization’s performance using industry-level benchmarking tools. In the healthcare industry there are not many industry standard decision support tools available. Most of these tools come in the format of static dashboards and balanced score cards. While providing leaders with large amounts of information using drill-down levels, data tables, charts, and comparative reports, many of such systems have limited or no dynamic capabilities. In such systems, all the user can do is view the information presented in different formats, without being able to calculate new data values from old ones or receive predictive figures. To this end, the Hospital Analytics tool is proposed.It is a proof-of-concept DSS demonstrates how some of these dynamic capabilities can be used to obtain and visualize the relationships between several organizational performance indicators, as well as how these capabilities can be scaled and extended to include virtually any performance indicator or any type of data that might be important to leaders making decisions.

5.2 Functional Requirements

The tool provides functionality in two main areas: a visual and numerical representation of hospital performance compared to other hospitals of the same type, overall provincial average performance, and a basic predictive capability that allows users to set a specific target for a particular performance measure and dynamically see how that target can be reached. Below is the list of functional requirements included in this tool:

R1: Choose a specific hospital from a list of hospitals

R2: Retrieve hospital indicator data over collection period and display it along with comparative provincial averages

R3: Provide side-by-side graphical representation of the hospital performance vs. type and provincial averages

R4: Provide trend information using color coding when indicator values are above, below, or within the target (in this case the provincial average) as follows:

- Green: score is above target
- Red: score is below target

- Yellow: score is equal or within (±0.1) of the target

R5: Provide dynamic graphical representation of the four Hospital Reports quadrants over the data collection period

R6: Provide dynamic graphical representation of the four Hospital Reports quadrants showing indicator scores vs. type and provincial averages for the latest year

R7: Provide help buttons to explain the functionality of each section

R8: Select an indicator from a list of indicators and view its detailed information

R9: Enable users to set a target for a performance indicator and show them how they can reach that target by calculating a new value for an independent indicator also chosen by the user

R10: Provide side-by-side graphical representation of the dependent indicator current values vs. calculated target value as described in requirement 8

R11: Provide dynamic graphical representation of the current indicator values vs. the target values

5.3 Technical Specifications

The following technical specifications were implemented to address the functional requirements of the Hospital Analytics tool:

No.	Addressed Requirement	Requirement Description	Specification Description
SP 1	R1	Choose a specific hospital from a list of hospitals	The top part of the first sheet includes a drop down menu where users can select their own or any other hospital. This list is drawn from the master Hospital Reports dataset. When a hospital is selected, it populates both worksheets with that hospital's information and the hospital name is displayed at the top part of each sheet
SP 2	R2	Retrieve hospital indicator data over collection period and display it along with comparative provincial averages	The 'Historical Benchmarking' sheet displays historical static data of the 4 Hospital Reports quadrants and their indicator values of the 5-year dataset for the selected hospital
SP 3	R3	Provide side-by-side graphical representation of the hospital	A table is created to include a column for the indicator values for the latest year (2008) as well as columns for the type average and

		performance vs. type and provincial averages	provincial average of the same year. The year 2008 is considered the latest current information and all target and predictive values are utilizing the scores from 2008 as the current scores
SP 4	R4	Provide trend information using color coding when indicator values are above, below, or within the provincial average as a target	Trend information is provided through a status column where the indicator is assigned a status score indicated by a colored arrow as follows: Green (above target), Red (below target), Yellow (score in equal or within (±0.1) of the target). These colors are assigned arbitrarily and are different from those used in the Hospital Reports
SP 5	R5	Provide dynamic graphical representation of the four Hospital Reports quadrants over the data collection period	The 'Historical Benchmarking' sheet contains a dynamic chart area on the upper right corner that allows users to pick which quadrant to be charted from 2003 to 2008 dataset. The user selects the quadrants from a drop down menu at the bottom of the chart. Although the quadrants may have different number of indicators to be graphed, the dynamic chart was carefully designed to show only the lines belonging to relevant indicators and clear the rest for a clear polished look.
SP 6	R6	Provide dynamic graphical representation of the four Hospital Reports quadrants showing indicator scores vs. type and provincial averages for the latest year	The 'Historical Benchmarking' sheet contains a dynamic chart area on the lower right corner that allows users to pick which quadrant to be charted for the latest year (2008) and shows the hospital performance in that quadrant compared to the type and provincial averages for each indicator. The user selects the quadrants from a drop down menu at the bottom of the chart. This chart operates independently form the other chart on the sheet allowing the user to the select different quadrants in both charts.
SP 7	R7	Provide help buttons to explain the functionality of each section.	Each section of the two sheets in the tool provide a help button at the top right corner where users can click to receive a popup window that provides information on the functionality and data displayed in each section
SP 8	R8	Select an indicator from a list of indicators and view its detailed information	At the top part of the "Improving Performance" sheet a dynamic dropdown menu is created that includes hospital performance indicators. Users can select any indicator from the

			dropdown menu to drill down to its component variables and set new target values. These indicators represent the dependent variables used in the regression equations. The list is created according to the hospital type as not all predictive equations were applicable to each hospital type. As such, if a user selected a community hospital in 'Historical Benchmarking' sheet, the indicator dropdown menu at the top of the 'Improving Performance' sheet will only display the following indicators: Satisfaction, Total Margin, Current Ratio, Medical Readmissions, Labour Readmissions, and Labour Adverse Events. The bottom part of the sheet displays the values for the selected indicator (dependent variable) and it is component indicators in a status column that shows the trend over the 5-year period (increasing, decreasing, or stable scores)
SP 9	R9	Enable users to set a target for a performance indicator and showthemhow they can reach that target by calculating a new value for an independent indicator also chosen by the user	In The 'Indicator Details' section, the current value for the indicator (dependent variable) is listed which displays the most recent value it contained in the dataset (i.e. the 2008 for all indicators except for the StandardizedProtocols where it displays the 2007 information as it was not reported for 2008). The current values for its component independent variables are also listed along with a 'Target' and 'Status' values for both the independent and dependent variables. When the dashboard loads for the first time and before the user changes any values, the target fields display the current values for the variables (so the 'Current' and 'Target' columns are the same) and the status column will show a 0 value with an orange circle. Users can use this part to predict values for the dependent variables by choosing specific target values, and then specifying which independent variable can be changed to obtain that desired target value. An illustrative example is provided in the Use Case provided below.
SP 10	R10	Provide side-by-side graphical representation of the dependent	A table is created to include a column for the indicator values for the current indicator value (2008) as well as a column for the calculated

		indicator current values vs. calculated target value as described in requirement 8	target value. The target column is listed for both dependent and independent variables where users first can change the value for the dependent variable and choose which independent variable to be changed when recalculating the new target value using the toggle functionality. As such, a new value for the chosen independent variable will then be displayed as a result of the recalculated target.
SP 11	R11	Provide dynamic graphical representation of the current indicator values vs. the target values	The "Improving Performance"' sheet contains a dynamic chart area on the upper right corner that will update automatically when the new targets are calculated. It shows the current indicator values for all independent variables and the new target values calculated for the independent variables selected through the toggle functionality

5.4 Intended Users

The Hospital Analytics tool can be used by hospital administrators and staff to view their comparative performance and see how they and their hospital measure against their provincial counterparts. It also provides graphical and quantitative functionality to assist users in setting targets for some of the hospital indicators and the adjustments in the related factors that need to be made to achieve those targets. The use of this tool is illustrated through the following use case.

Representative Use Case

A CIO of a community hospital, X, is examining the effect of IT adoption on hospital financial performance and how it can be improved. To analyze this, the user (CIO) utilizes a model relating the hospital'sCurrentRatiowith ITUse. As a built-in equation in this tool, the equation that will be provided to the user is

$$\textbf{CurrentRatio} = \textbf{0.4379} - \textbf{0.0167} \times \textbf{ITUse} + \textbf{0.1941} \times \textbf{CorporateServices}$$

If the hospital has a CurrentRatioscore of 0.7, ITUse score of 73.1, and CorporateServices score of 8.0; then to reach a target value above or equal to the provincial average of 0.8, the user will need to specify which value to change, either ITUse or CorporateServices, to obtain the desired target value. If the user choses to change ITUse, the tool will automatically replace the remaining variables with the new target value for CurrentRatio and the current value of CorporateServices, and the resulting equation that will calculate the new target ITUse will look like this:

$$\mathbf{0.8 = 0.4379 - 0.0167 \times ITUse + 0.1941 \times 8.0}$$

The newITUsevalue is 71.29. This is expected given the inverse relationship between ITUse and CurrentRatio. On the other hand, if the user choses to change CorporateServices, then the resulting formula would be

$$\mathbf{0.8 = 0.4379 - 0.0167 \times 73.1 + 0.1941 \times CorporateServices}$$

and the new CorporateServices value will be 8.1. This result is aligned with the proposed regression equations adapted from the research results and built into this tool; i.e., increasing the amount of CorporateServices (budget spent on administrative and corporate services)is positively associated with an increase in the CurrentRatio, i.e., Hospital financial condition.

5.5 Data Structures and Data Quality

This tool uses the same five-year dataset utilized in constructing the regression formulas discussed earlier. The dataset has been aggregated into a hidden single worksheet that is dynamically linked to the functionality supported in by this tool. This dynamic link allows for expanding the data or uploading a newer dataset when one becomes available. This extensibility will allow for improved predictive capability of the tool as it enhances the strength of data used and allows for overcoming some of the inherent data quality issues described in the data quality section (3.5). T dataset does not have data from 2004 as none was offered by the original source, and there are significant gaps in indicator scores for many hospitals in 2003 as it was the first year of data collection.

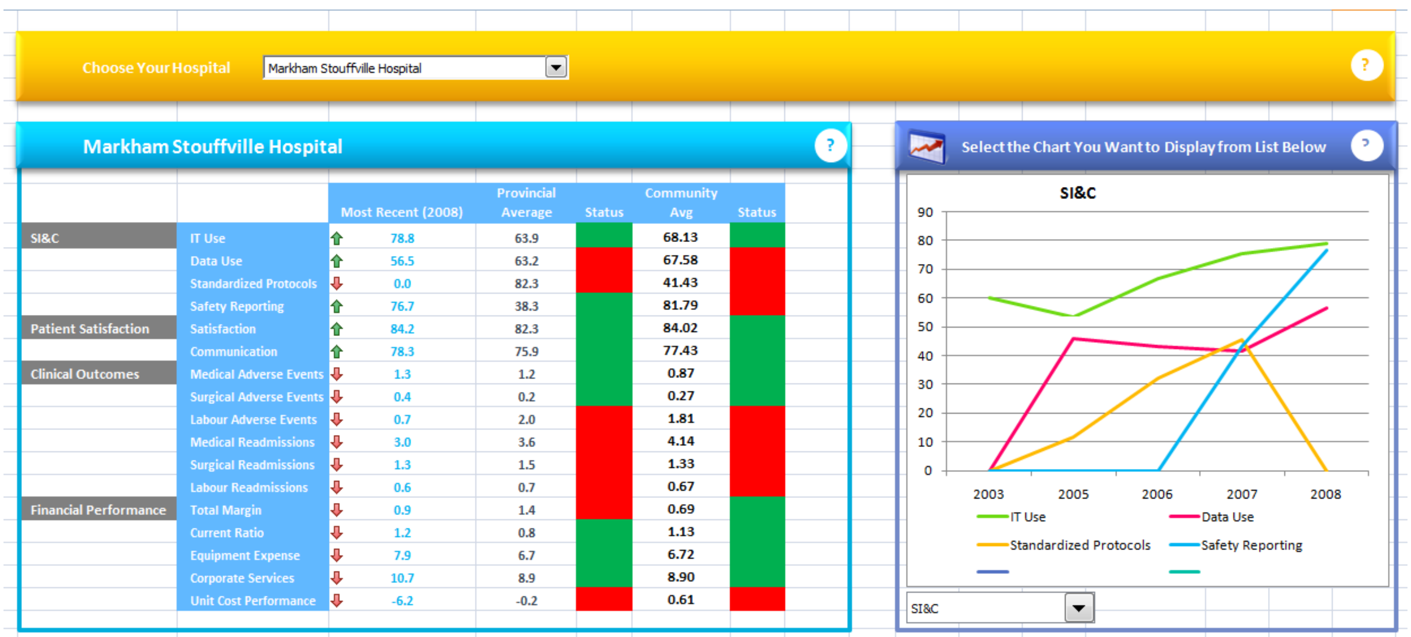
5.6 Design Limitations and Improvement Opportunities

Every effort was made in the design of this tool to make its functionality fully dynamic so that minimal work would be required as the data evolve in the future. However, the inclusion of more recent datawould require future users to update the master table located at ('Historical Benchmarking'!B84:TQ101) and make minor adjustments to the*Indicator Values by Hospital Report Quadrant (Yearly Figures)* table in the bottom part of the “'Historical Benchmarking” sheet. These adjustments would include the addition of new columns representing the years (beyond 2008) and tweaking the formula carried over from the existing adjacent columns.

The list of indicators in the drop down menu on the “Improving Performance” sheet includes only those indicators that were found to be significant in the analysis of existing data. The inclusion of data from other years would likely results in changes to the table ‘Improving Performance’!B67:D100, as the indicator coefficients would change. Indicators within the table may become insignificant with the new data thus should be dropped, and others may become significant thus requiring inclusion in the table. If the new indicators have four or more independent variables, then the Indicator Detail box on the same sheet would require the extrapolation of the formulas from cells C18:F18 to columns 19 and 20 if needed.

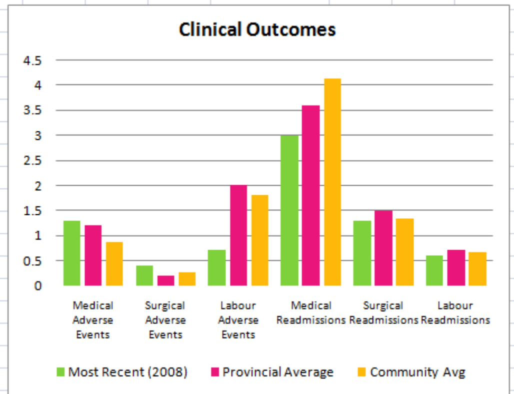
As discussed above, the Hospital Analytics dashboard is a tool that can be used to visualize the data presented in the Hospital Reports in a dynamic fashion whereby users can examine the kind of changes they can apply to indicator scores to reach the target values for the selected performance indicators discussed in this study. The applicability of this tool can be expanded to include other variables related to the clinical and managerial performance of hospitals. Other financial performance or clinical outcomes indicators can be modeled using the same techniques applied in this study if the data is available to support the creation of the underlying mathematical models. The accuracy can also be increased when large datasets are used, as many more data points will be available when performing analysis.

5.7 Screenshots



Indicator Values by Hospital Report Quadrant (Yearly Figures)

	Indicator	2003	2005	2006	2007	2008
SI&C	IT Use	60.1	53.5	66.6	75.4	78.8
	Data Use	0.0	46.0	43.2	41.6	56.5
	Standardized Protocols	0.0	11.8	32.0	45.6	0.0
	Safety Reporting	0.0	0.0	0.0	43.3	76.7
Patient Satisfaction	Satisfaction	84.4	84.9	84.6	84.7	84.2
	Communication	81.3	78.4	77.5	78.4	78.3
Clinical Outcomes	Medical Adverse Events	0.0	0.0	0.3	0.0	1.3
	Surgical Adverse Events	0.0	0.0	0.0	0.3	0.4
	Labour Adverse Events	0.0	1.2	1.2	1.4	0.7
	Medical Readmissions	7.5	2.6	3.2	7.5	3.0
	Surgical Readmissions	0.0	2.6	2.0	1.9	1.3
	Labour Readmissions	0.0	0.4	0.6	1.0	0.6
Financial Performance	Total Margin	9.8	2.2	-3.1	1.2	0.9
	Current Ratio	0.0	2.0	2.1	0.0	1.2
	Equipment Expense	0.0	8.0	8.9	8.7	7.9
	Corporate Services	0.0	12.6	10.9	10.5	10.7
	Unit Cost Performance	0.0	-2.8	-0.9	0.0	-6.2



Clinical Outcomes

Markham Stouffville Hospital

Select The Indicator You Want to Drill Down Into: Medical Adverse Events

Indicator Details

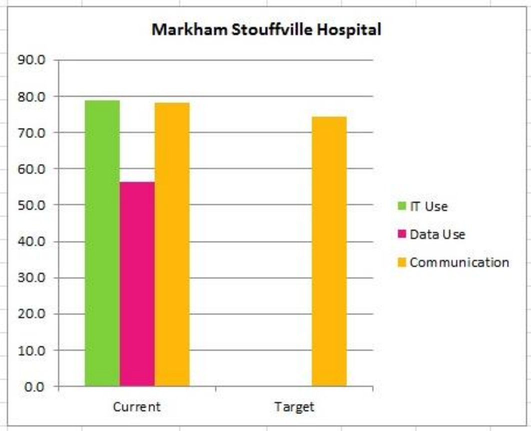
Start by setting your target value for the indicator

	Current	Target
Medical Adverse Events	1.300	0.8

Now, choose one of the following significant indicators to help you reach your target

	Current	Toggle	Target
IT Use	78.8	☐	
Data Use	56.5	☐	
Communication	78.3	☑	74.30348309

Select the Chart You Want to Display from List Below



Indicator Listings by Year

Indicator	2003	2005	2006	2007	2008	Status
IT Use	60.1	53.5	66.6	75.4	78.8	
Data Use	0.0	46.0	43.2	41.6	56.5	
Standardized Protocols	0.0	11.8	32.0	45.6	0.0	
Safety Reporting	0.0	0.0	0.0	43.3	76.7	
Satisfaction	84.4	84.9	84.6	84.7	84.2	
Communication	81.3	78.4	77.5	78.4	78.3	
Medical Adverse Events	0.0	0.0	0.3	0.0	1.3	
Surgical Adverse Events	0.0	0.0	0.0	0.3	0.4	
Labour Adverse Events	0.0	1.2	1.2	1.4	0.7	
Medical Readmissions	7.5	2.6	3.2	7.5	3.0	
Surgical Readmissions	0.0	2.6	2.0	1.9	1.3	

Chapter 6

Conclusion

In this study, the impact of IT investment on organizational performance was analyzed in healthcare organizations. An overview of the literature in the area of IT business value and IT payoffs was provided, in addition to a discussion of the IT productivity paradox phenomenon. It was shown that the paradox was supported in earlier studies due to factors such as methodological inaccuracies or mismeasurements, lag effect, and profit distribution at the economy-level. It was also shown that the mismanagement of IT investments also resulted in the loss or unrecognized productivity in organizations; thus, it was shown that the impact of IT investments on organizational efficiency is maximized when aligned with improved business process redesign initiatives and proper strategic decisions.

This study used IT use and availability as a proxy for the amount of IT investment and proposed that IT use and availability impacts hospital performance by improving hospital's financial performance, patient satisfaction, and clinical outcomes. The results of Phase I found IT use and availability to have an inverse relationship with both hospitals financial performance measures; in which increasing IT use and availability affected hospital financial condition by reducing both the total margin and current ratio of sampled hospitals. Similarly, these results showed that IT use and availability has an inverse relationship with patient satisfaction. Phase I results also showed that no support for the impact of IT on clinical outcomes in all 6 measures. Phase II results proved that organizational efficiencies lead to better organizational financial performance and found support for the impact of IT use and availability on financial performance in small hospitals. However, the results found no direct support for the impact of IT use and availability on financial performance for community and teaching hospitals. Similarly, these results proved that effective communication leads to improved patient satisfaction and found support for the impact of safety reporting practices on improved satisfaction in small hospitals. However, the results found no direct support for the impact of IT use and availability on patient satisfaction. Finally, Phase II results showed that IT use and availability was shown to impact hospitals' clinical outcomes by reducing the number of medical adverse events and all three readmission measures (medical, surgical, labor) in community hospitals. The results did not yield a direct relationship between the impact of IT use and availability on reducing adverse events or readmissions in teaching hospitals, but it was shown that IT affects these outcomes indirectly by being a major enabler of process re-design and performance improvement initiatives, which were shown to have a positive impact on enhancing hospital financial performance, improving patient satisfaction, and improving clinical outcomes by reducing readmissions rates and adverse events incidents.

The results of this study showed that the productivity paradox in hospitals is still present. The lack of available data points in the used dataset and not having exact IT investment numbers in each hospital posed a limitation on the ability to quantify the impact of IT investments on the proposed hospital performance measures and resulted in the study findings to be inconclusive as to the original question – do IT investments have an impact on improving hospital performance. The future work section discussed how collecting more data points and exact IT investment numbers as well as collecting data regarding the IT governance model and how the centralization or decentralization of IT affect its payoffs.

Finally, a proof-of-concept decision support tool was introduced in the last chapter. Using it, relationships between several hospital performance measures were modeled and presented in an interactive dashboard where users can dynamically provide inputs and view their effects on several output measures. This chapter complemented the discussion on the impact of information systems in enhancing the decision-making capabilities of leadership teams. Suitable IT provides the right information, at the right level of detail, and in the right format so that such teams can visualize the relationships between the different performance-improvement measures within their organization. Organizational performance can then be improved by ensuring that the right balance of process inputs and outputs are available.

Appendix I

SAS Data Files

Phase I

```
PROCIMPORTOUT= WORK.Year2003
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year=2003;

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year=2008;

Data combine;
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procreg;

* model CurrentRatio = ITUseEquipmentExpenseUnitCostPerformance;

modelCurrentRatio = ITUseCorporateServices;

run;
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Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

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modelLabourAdverseEvents = ITUseDataUseSafetyReporting ;

run;
```

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RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procreg;

modelSurgicalAdverseEvents = ITUseDataUseSafetyReportingStandardizedProtocols
Communication;

run;
```

```
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Data combine;
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procreg;

modelLabourReadmissions = ITUseDataUseSafetyReporting ;

run;
```

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     USEDATE=YES;
     SCANTIME=YES;
RUN;
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RUN;
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year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procreg;
```

```
modelMedicalAdverseEvents = ITUseDataUseSafetyReportingStandardizedProtocols
Communication;

run;
```

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DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
```

```
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procreg;

* model TotalMargin = ITUseUnitCostPerformance;

modelTotalMargin = UnitCostPerformanceCorporateServices;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
```

```
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
```

```
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procreg;

modelMedicalReadmissions = DataUseStandardizedProtocols;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
```

```
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procreg;

model Satisfaction = ITUseDataUse Communication;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
```

```
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
```

```
"C:\Users\User\Desktop\Research\SASData\PhaseI\Regression_Formulas_Data_Phase
I.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procreg;

modelSurgicalReadmissions = ITUseDataUseSafetyReportingStandardizedProtocols
Communication;

run;
```

Phase II

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
```

```
      SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
      SHEET="'2006$'";
      GETNAMES=YES;
      MIXED=NO;
      SCANTEXT=YES;
      USEDATE=YES;
      SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
      SHEET="'2007$'";
      GETNAMES=YES;
      MIXED=NO;
      SCANTEXT=YES;
      USEDATE=YES;
      SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
      SHEET="'2008$'";
      GETNAMES=YES;
      MIXED=NO;
      SCANTEXT=YES;
      USEDATE=YES;
      SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;
```

```
procsort; by type;

procreg; by type;

* model TotalMargin = DataUseCorporateServices;

modelTotalMargin = EquipmentExpenseUnitCostPerformance;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;
```

```
PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelTotalMargin = DataUseCorporateServices;

* model TotalMargin = EquipmentExpenseUnitCostPerformance;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
```

```
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
```

```
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelCurrentRatio = ITUseEquipmentExpenseUnitCostPerformance;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
```

```
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelCurrentRatio = ITUseCorporateServices;
```

```
run;
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
```

```
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelLabourReadmissions = ITUseDatausestandardizedprotocols;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
```

```
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
```

```
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelLabourAdverseEvents = ITUseDataUsestandardizedprotocols;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
```

```
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelSurgicalAdverseEvents = ITUseDataUseSafetyReporting ;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
```

```
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
```

```
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelMedicalAdverseEvents = ITUseDataUse Communication;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;
```

```
PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

model Satisfaction = SafetyReporting Communication;
```

```
run;
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
```

```
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelSurgicalReadmissions = ITUseDataUseSafetyReporting Communication
StandardizedProtocols;

run;
```

```
PROCIMPORTOUT= WORK.Year2003
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2003$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2003; set work.year2003;
year=2003;

PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
```

```
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\PhaseII\Regression_Formulas_Data_Phas
eII.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
```

```
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2003 Year2005 Year2006 Year2007 Year2008;

procsort; by type;

procreg; by type;

modelMedicalReadmissions = ITUseDataUseSafetyReporting;

run;
```

Appendix II

Model Verification Results

Phase I

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;
```

```
PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2007 Year2008;

procreg;

modelCurrentRatio = ITUseCorporateServices;

outputout = new p = pred;

data find; set new;

 diff = pred - CurrentRatio1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Medical
Readmissions.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;
```

```
PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Medical
Readmissions.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Medical
Readmissions.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

Data combine;
set Year2005 Year2006 Year2007;

procreg;

model MedicalReadmissions1 = DataUseStandardizedProtocols;

outputout = new p = pred;

data find; set new;

 diff = pred - MedicalReadmissions1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tablesMedicalReadmissions;
```

```
procmeans; varMedicalReadmissions;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_TotalMa
rgin_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_TotalMa
rgin_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_TotalMa
rgin_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2008;

procreg;
```

```
modelTotalMargin = CorporateServicesUnitCostPerformance;

outputout = new p = pred;

data find; set new;

 diff = pred - TotalMargin1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tablesTotalMargin;

procmeans; varTotalMargin;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Satisfa
ction.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Satisfa
ction.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
```

```
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Satisfa
ction.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Satisfa
ction.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2007 Year2008;

procreg;

model Satisfaction = ITUse Communication;

outputout = new p = pred;

data find; set new;

 diff = pred - satisfaction1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tables Satisfaction;

procmeans; var Satisfaction;
```

```
run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_Current
Ratio_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2008;

procreg;

modelCurrentRatio = ITUseEquipmentExpenseUnitCostPerformance;
```

```
outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - CurrentRatio1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_TotalMa
rgin_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_TotalMa
rgin_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseI_Prediction_TotalMa
rgin_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
```

```
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2008;

procreg;

modelTotalMargin = ITUseUnitCostPerformance;

outputout = new p = pred;

data find; set new;

 diff = pred - TotalMargin1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tablesTotalMargin;

procmeans; varTotalMargin;

run;
```

Phase II

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Curren
tRatio_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;
```

```
PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Curren
tRatio_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Curren
tRatio_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2008;

if type = 'C';

procreg;

modelCurrentRatio = ITUseEquipmentExpenseUnitCostPerformance;

outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - CurrentRatio1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;
```

```
var diff;

run;
```

```
PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Medica
lAdverseEvents_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;
PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Medica
lAdverseEvents_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Medica
lAdverseEvents_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2006 Year2007 Year2008;

if type = 'C';
```

```
procreg;

modelMedicalAdverseEvents = ITUseDataUse Communication;

outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - MedicalAdverseEvents1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_CurrentRatio_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_CurrentRatio_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
```

```
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Curren
tRatio_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Curren
tRatio_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2007 Year2008;

if type = 'C';

procreg;

modelCurrentRatio = ITUseCorporateServices;

outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - CurrentRatio1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;
```

```
run;
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model1.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
```

```
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2007 Year2008;

if type = 'C';

procreg;

modelTotalMargin = DataUseCorporateServices;

outputout = new p = pred;

data find; set new;

 diff = pred - TotalMargin1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tablesTotalMargin;

procmeans; varTotalMargin;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Medica
lReadmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
```

```
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Medica
lReadmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Medica
lReadmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

Data combine;
set Year2005 Year2006 Year2007;

if type = 'C';

procreg;

modelMedicalReadmissions = DataUseStandardizedProtocols;

outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - MedicalReadmissions1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;
```

```
procfreq; tablesMedicalReadmissions;

procmeans; varMedicalReadmissions;

run;
```

```
PROCIMPORTOUT= WORK.Year2005
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Labour
Readmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Labour
Readmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Labour
Readmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Labour
```

```
Readmissions_Community.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2007 Year2008;

if type = 'C';

procreg;

model LabourReadmissions1 = ITUse Communication;

outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - LabourReadmissions1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

run;
```

```
PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Satisf
action_Small.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;
```

```
PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Satisf
action_Small.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2007 Year2008;

if type = 'S';

procreg;

model Satisfaction = SafetyReporting Communication;

outputout = new p = pred;

*Proc print data = new;

data find; set new;

 diff = pred - satisfaction1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tables Satisfaction;

procmeans; var Satisfaction;

run;
```

```
PROCIMPORTOUT= WORK.Year2007
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Satisf
action_Teaching.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2007$'";
```

```
      GETNAMES=YES;
      MIXED=NO;
      SCANTEXT=YES;
      USEDATE=YES;
      SCANTIME=YES;
RUN;
data year2007; set work.year2007;
year=2007;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_Satisf
action_Teaching.xls"
DBMS=EXCEL REPLACE;
      SHEET="'2008$'";
      GETNAMES=YES;
      MIXED=NO;
      SCANTEXT=YES;
      USEDATE=YES;
      SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2007 Year2008;

if type = 'T';

procreg;

model Satisfaction = SafetyReporting Communication;

outputout = new p = pred;

data find; set new;

 diff = pred - satisfaction1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tables Satisfaction;

procmeans; var Satisfaction;

run;
PROCIMPORTOUT= WORK.Year2005
```

```
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2005$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2005; set work.year2005;
year=2005;

PROCIMPORTOUT= WORK.Year2006
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2006$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2006; set work.year2006;
year=2006;

PROCIMPORTOUT= WORK.Year2008
DATAFILE=
"C:\Users\User\Desktop\Research\SASData\Predictions\PhaseII_Prediction_TotalM
argin_Community_Model2.xls"
DBMS=EXCEL REPLACE;
     SHEET="'2008$'";
     GETNAMES=YES;
     MIXED=NO;
     SCANTEXT=YES;
     USEDATE=YES;
     SCANTIME=YES;
RUN;
data year2008; set work.year2008;
year=2008;

Data combine;
set Year2005 Year2006 Year2008;

if type = 'C';

procreg;

modelTotalMargin = EquipmentExpenseUnitCostPerformance;
```

```
outputout = new p = pred;

data find; set new;

 diff = pred - TotalMargin1;

Procprintdata = find;

procsort; by inclusion;

procmeansnmeanstdtprt; by inclusion;

var diff;

procfreq; tablesTotalMargin;

procmeans; varTotalMargin;

run;
```

Appendix III

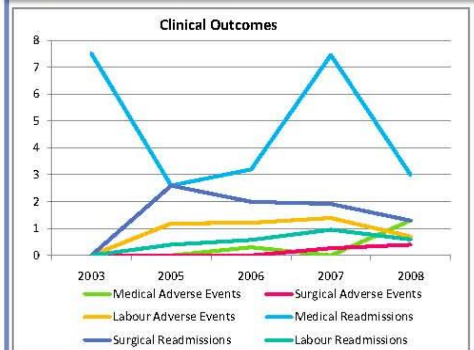
Hospital Analytics Dashboard

Choose Your Hospital: Markham Stouffville Hospital

Markham Stouffville Hospital

		Most Recent (2008)	Provincial Average	Status	Community Avg	Status
SI&C	IT Use	78.8	63.9		68.13	
	Data Use	56.5	63.2		67.58	
	Standardized Protocols	0.0	82.3		41.43	
	Safety Reporting	76.7	38.3		81.79	
Patient Satisfaction	Satisfaction	84.2	82.3		84.02	
	Communication	78.3	75.9		77.43	
Clinical Outcomes	Medical Adverse Events	1.3	1.2		0.87	
	Surgical Adverse Events	0.4	0.2		0.27	
	Labour Adverse Events	0.7	2.0		1.81	
	Medical Readmissions	3.0	3.6		4.14	
	Surgical Readmissions	1.3	1.5		1.33	
	Labour Readmissions	0.6	0.7		0.67	
Financial Performance	Total Margin	0.9	1.4		0.69	
	Current Ratio	1.2	0.8		1.13	
	Equipment Expense	7.9	6.7		6.72	
	Corporate Services	10.7	8.9		8.90	
	Unit Cost Performance	-6.2	-0.2		0.61	

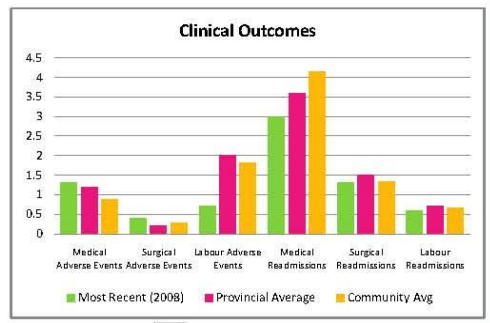
Select the Chart You Want to Display from List Below



Clinical Outcomes

Indicator Values by Hospital Report Quadrant (Yearly Figures)

	Indicator	2003	2005	2006	2007	2008
SI&C	IT Use	60.1	53.5	66.6	75.4	78.8
	Data Use	0.0	46.0	43.2	41.6	56.5
	Standardized Protocols	0.0	11.8	32.0	45.6	0.0
	Safety Reporting	0.0	0.0	0.0	43.3	76.7
Patient Satisfaction	Satisfaction	84.4	84.9	84.6	84.7	84.2
	Communication	81.3	78.4	77.5	78.4	78.3
Clinical Outcomes	Medical Adverse Events	0.0	0.0	0.3	0.0	1.3
	Surgical Adverse Events	0.0	0.0	0.0	0.3	0.4
	Labour Adverse Events	0.0	1.2	1.2	1.4	0.7
	Medical Readmissions	7.5	2.6	3.2	7.5	3.0
	Surgical Readmissions	0.0	2.6	2.0	1.9	1.3
	Labour Readmissions	0.0	0.4	0.6	1.0	0.6
Financial Performance	Total Margin	9.8	2.2	-3.1	1.2	0.9
	Current Ratio	0.0	2.0	2.1	0.0	1.2
	Equipment Expense	0.0	8.0	8.9	8.7	7.9
	Corporate Services	0.0	12.6	10.9	10.5	10.7
	Unit Cost Performance	0.0	-2.8	-0.9	0.0	-6.2



Clinical Outcomes

Clinical Outcomes		Most Recent (2	Provincial	Community Avg
	Medical Adverse Event:	1.3	1.2	0.869491525
SI&C	Surgical Adverse Event:	0.4	0.2	0.266666667
3 Patient Satisfaction	Labour Adverse Events	0.7	2	1.814285714
Clinical Outcomes	Medical Readmissions	3	3.6	4.142372881
Financial Performance	Surgical Readmissions	1.3	1.5	1.333333333
	Labour Readmissions	0.6	0.7	0.666071429

Charting	Clinical Outcomes		2003	2005	2006	2007	2008
		Medical Adverse Event:	0	0	0.3	0	1.3
	SI&C	Surgical Adverse Event:	0	0	0	0.27	0.4
	3 Patient Satisfaction	Labour Adverse Events	0	1.19	1.21	1.39	0.7
	Clinical Outcomes	Medical Readmissions	7.5	2.6	3.2	7.45	3
	Financial Performance	Surgical Readmissions	0	2.6	2	1.92	1.3
		Labour Readmissions	0	0.4	0.58	0.96	0.6

HospitalName	Alexandra Hospital	Alexandra Hospital	Alexandra Hospit	Alexandra I	Alexandra Hospi	Alexandra	Alexandra	Alexanc	Alexandra	Alexandra	Almonte G	Almonte General Ho	Almonte G	Almonte G	Almonte G
IT Use	25.00	27.30	52.10	70.30	65.00		49.10	70.70	55.20	73.10	14.30	25.90	46.90	37.80	50.30
Data Use		44.40	53.80	53.90	42.80		50.50	59.00	62.40	61.60		50.10	71.50	44.50	61.50
Standardized Protocols		31.10	31.10	36.10			36.40	59.10	74.10			44.80	32.80	23.80	
Safety Reporting				100.00	100.00				90.00	100.00				100.00	100.00
Satisfaction	91.10	87.40	89.60	89.20	91.40		87.00	86.10	86.30	88.80	91.10	91.30	93.80	92.20	88.90
Communication	87.90	78.00	82.00	80.30	79.90		82.50	78.40	80.50	82.30	91.25	88.70	86.40	85.50	84.30
Medical Adverse Events			4.70	2.84	2.90			0.00	0.00	1.10			0.00	0.00	0.00
Surgical Adverse Events								0.00	0.00	0.00				0.00	0.00
Labour Adverse Events		0.00					3.58	1.93	3.88	0.00		4.08	3.43	3.11	3.30
Medical Readmissions	16.35	0.00	2.60	8.95	1.70		2.60	5.40	6.90	6.50		5.40	0.00	7.97	23.80
Surgical Readmissions							1.10	1.60	0.00	2.90		0.00		0.00	8.10
Labour Readmissions		0.00					1.69	0.00	1.91	0.00		0.79	0.00	1.85	1.00
Total Margin	-8.60	-0.90	-5.10	0.10	2.60		1.10	1.40	-0.60	0.20	9.80	14.00	18.80	10.10	5.60
Current Ratio		1.10	0.75	0.80	1.10		4.00	4.59	5.00	1.80		3.70	5.84	5.30	2.00
Equipment Expense		5.40	5.50	7.20	9.20		5.30	4.90	5.80	5.00		2.90	3.40	3.00	3.20
Corporate Services		12.50	14.00	15.30	18.50		11.30	10.40	10.40	10.30		14.20	14.70	15.50	13.40
Unit Cost Performance		27.60	3.70		18.60		9.40	7.30		11.70		-28.20	-29.70		-25.40

Markham Stouffville Hospital

Select The Indicator You Want to Drill Down Into: Medical Adverse Events

Indicator Details

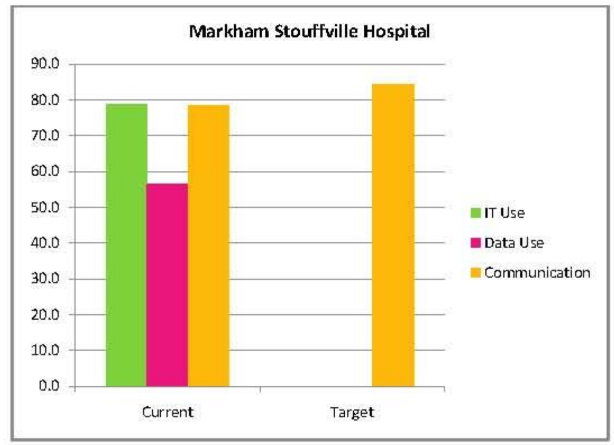
Start by setting your target value for the indicator

	Current	Target
Medical Adverse Events	1.300	0.4

Now, choose one of the following significant indicators to help you reach your target

	Current	Toggle	Target
IT Use	78.8	☐	
Data Use	56.5	☐	
Communication	78.3	☑	84.39939425

Select the Chart You Want to Display from List Below



Indicator Listings by Year

Indicator	2003	2005	2006	2007	2008	Status
IT Use	60.1	53.5	66.6	75.4	78.8	
Data Use	0.0	46.0	43.2	41.6	56.5	
Standardized Protocols	0.0	11.8	32.0	45.6	0.0	
Safety Reporting	0.0	0.0	0.0	43.3	76.7	
Satisfaction	84.4	84.9	84.6	84.7	84.2	
Communication	81.3	78.4	77.5	78.4	78.3	
Medical Adverse Events	0.0	0.0	0.3	0.0	1.3	
Surgical Adverse Events	0.0	0.0	0.0	0.3	0.4	
Labour Adverse Events	0.0	1.2	1.2	1.4	0.7	
Medical Readmissions	7.5	2.6	3.2	7.5	3.0	
Surgical Readmissions	0.0	2.6	2.0	1.9	1.3	
Labour Readmissions	0.0	0.4	0.6	1.0	0.6	
Total Margin	9.8	2.2	-3.1	1.2	0.9	
Current Ratio	0.0	2.0	2.1	0.0	1.2	
Equipment Expense	0.0	8.0	8.9	8.7	7.9	
Corporate Services	0.0	12.6	10.9	10.5	10.7	
Unit Cost Performance	0.0	-2.8	-0.9	0.0	-6.2	

Satisfac	**IT Use**	-0.03966
Satisfac	**Data Use**	-0.01696
Satisfac	**Communication**	0.39096
Satisfac	Intercept	58.12784
Medica	**Data Use**	-0.01818
Medica	**Standardized Protocols**	0.01836
Medica	Intercept	4.31629
Total N	**IT Use**	-0.02536
Total N	**Unit Cost Performance**	-0.11725
Total N	Intercept	2.78537
Total N	**IT Use**	-0.01849
Total N	**Equipment Expense**	0.107
Total N	**Unit Cost Performance**	-0.02177
Total N	Intercept	1.74246
Current	**IT Use**	-0.01569
Current	**Corporate Services**	0.11185
Current	Intercept	1.18733
Current	**Unit Cost Performance**	-0.12289
Current	**Corporate Services**	0.43625
Current	Intercept	-2.92169
Labour F	**IT Use**	-0.00353
Labour F	**Communication**	0.01854
Labour F	Intercept	-0.56223
Medical	**IT Use**	-0.00682
Medical	**Data Use**	0.0067
Medical	**Communication**	-0.03962
Medical	Intercept	3.90277

	Coeffecients		
IT Use	-0.006820	78.8	-0.5
Data Use	0.006700	56.5	0.38
Communicatio	-0.039620	0	0
Intercept	3.90277	1	3.9
		Sum	3.74

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