INVESTIGATION OF HEALTHCARE INFORMATION SYSTEM IMPACTS ON ORGANIZATIONAL WORK

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Summary

The question of information technology (IT) value and impact is of great concern and interest to practitioners and researchers alike. Despite its long history of research, past studies have yielded conflicting results, thus motivating the need for further studies. In addition, there is a lack of research on IT impact at the individual level. Hence, the objective of this thesis is to address this gap by investigating the impact of IT at both firm and individual levels. Due to the tremendous potential yet lack of understanding of IT impacts in healthcare organizations, healthcare is chosen as the context for the studies. This thesis aims to investigate the impact of clinical information systems (IS) on organizational work. It documents a qualitative study to investigate the net benefits of a clinical IS and its antecedents (Essay 1), and a quantitative (supplemented with qualitative interviews) study to investigate the link between IS use and its impact on individual work (Essay 2).

Essay 1 – Antecedents and Net Benefits of Healthcare IS

IT value is a broad concept that encompasses various areas and levels. This makes it difficult to operationalize and measure IT impact. In this essay, we use the updated IS Success Model to study the impact or net benefits of healthcare IS at both the organizational and individual levels. We aim to assess the net benefits of a clinical IS and investigate its antecedents. A case study is conducted based on the use of an emerging clinical IS, i.e., the vital signs monitoring system. The net benefits of the system are assessed by studying the two dimensions of performance, i.e., efficiency and effectiveness. The case study gives us insights into how such IT impacts the work and

performance of a healthcare organization. Through this study, we also see the importance of using appropriate measures to study IT impacts. In terms of practical contributions, this case provides guidance to healthcare organizations considering the adoption of similar healthcare IS, as well as insights on how individual work of nurses can be improved through the use of technology.

Essay 2 – Impact of Healthcare IS on Individual Work

One of the newer clinical IS is the electronic medication administration system (EMAS), which aims to reduce prescribing and medication errors. While there are studies on the clinical benefits of the EMAS, the impact on the users (healthcare workers) is under-researched. This essay investigates how the use of healthcare IS such as EMAS impacts individual job performance. We use the job characteristics, relational job design, and social cognitive theories to develop a model to understand the impact of EMAS on the healthcare professional's work. The model is tested through survey methodology. In addition to quantitative data, qualitative data in the form of interviews and feedback section of the survey are collected and analyzed to improve our understanding of the impact of healthcare IS. Our findings show that the use of EMAS and individual characteristics such as prosocial values and self-efficacy affect job characteristics, which in turn affect job performance. The results are expected to contribute theoretical insights as well as practical suggestions on the use of healthcare IS for greater benefit.

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Essay 1

Antecedents and Net Benefits of Healthcare IS

1 Introduction

1.1 Practical Motivation

The question of information technology (IT) value and impact is of great concern to practitioners (Thatcher and Pingry 2007). As organizations' reliance on IT increases, their IT investments also increase. However, different organizations and industries experience different outcomes in deploying IT. Does IT add value? If so, in what way does it add value to the organization? According to a recent IBM CIO Leadership Forum survey, 84% of CIOs believed that IT is significantly transforming their industries, but only 16% felt that their firms were maximizing the potential of IT (IBM 2007). The same survey indicates that CEOs and other business leaders have yet to recognize the strategic role of IT in the organization. Important issues for managers include where and how much to invest in IT spending and how to assess the impact of IT (Barua and Mukhopadhyay 2000). Organizations spend millions of dollars on IT, yet it is unclear how their investments will impact individual and organizational performance and whether it will translate into competitive advantage for the organization.

In the early 1990s, the *IT productivity paradox* was uncovered (Brynjolfsson 1993). Despite the increase in computing power and IT investments since 1970, productivity appeared to stagnate, thus leading to the term "productivity

paradox". Brynjolfsson (1993) offered four explanations for the IT productivity paradox. The first two explanations are due to measurement errors of inputs and outputs, and the fact that benefits from IT can take years to show results. The third explanation is that IT may be productive at firm level, but unproductive when measured at industry level, that is, profits are redistributed and dissipated. The fourth possible explanation is that IT is really not productive at firm level due to mismanagement by the decision makers.

To add to the productivity debate, Carr (2003) asserted in a controversial article that IT does not matter to organizations. The assumption that the strategic value of IT has increased together with its ubiquity was questioned, because it is the scarcity of a resource that provides sustainable competitive advantage. Carr (2003, p.42) argued that IT's "power and presence have begun to transform from potentially strategic resources into commodity factors of production" and hence IT is diminishing as a source of strategic differentiation. However, as a response to Carr's article, Brown and Hagel III (2003) argued that IT does matter, and its differentiation comes from the new practices it enables, and the complementary skills required to innovate using IT. It is also evident that firms like Wal-Mart and General Electric have used IT to enhance their competitiveness and create differentiation and value (Mata et al. 1995). A study by McKinsey and Company on the impact of IT on three sectors (retail, retail banking and semiconductors) also established that IT enabled productivity gains in these three sectors, but the impact was complex and varied (McKinsey and Co. 2002). With the divergent views and findings on either side and the changing nature of IT, the question of how IT impacts

individual and organizational performance is still a major concern to practitioners.

1.2 Theoretical Motivation

Although the topic of IT value and impact has a long history of research, determining how IT contributes to individual and organizational performance is still an ongoing academic concern (Chau et al. 2007; Kohli and Grover 2008). While technology adoption and acceptance studies are well-established, there has not been much theorizing in the area concerning individual performance and impact from using an information system (IS) (Burton-Jones et al. 2004). Indeed, research in the area of IT value in both individual and organizational levels has met with challenges (Chau et al. 2007). A possible reason is that IT value is a broad concept that encompasses various areas and levels. This makes it difficult to theorize about, operationalize and measure IT value and impacts. Based on our review of the previous literature, the following observations about research in this area can be made: (1) Mixed findings from past research; (2) Shift in theoretical perspective; (3) Difficulty in operationalization and measurement; and (4) Lack of research at individual level.

1.2.1 Mixed Findings

Despite its importance to researchers and practitioners, there is still much uncertainty about how IT adds to firm performance (Melville et al. 2004). While it is intuitive to think that the use of IT contributes to firm performance, research has shown conflicting findings. For example, findings from a study

conducted in the US retail banking sector indicate that additional capital investments in IT have no real benefits (Prasad and Harker 1997). Another study on the relationship between IT investments and administrative performance of 50 U.S. state governments indicate a negative relationship (Jain 2003). Yet on the positive side, a study on IT capital based on various sectors of the economy indicates that IT investment leads to higher returns (Dewan and Min 1997). Bharadwaj's (2000) study indicates that superior firm performance can result from combining IT related resources to create unique IT capabilities. While many studies demonstrate the relationship between IT and firm performance, it is evident that there are a number of issues in linking IT capabilities to firm performance (Santhanam and Hartono 2003; Kohli and Grover 2008). Table 1, taken from a literature review conducted by Devaraj and Kohli (2003), provides a sample of studies that reveal mixed findings about IT value, i.e., positive, nil, or contingent impacts on performance. The ambiguity of findings calls for further research studies to improve our understanding in this area.

While recent research has indicated that IT does create value, it is also clear that IT only creates value under certain conditions (Kohli and Grover 2008), which may explain the mixed findings from past studies. IT does not create value in isolation, but works together with other organizational factors such as management and business processes. It is thus critical to understand and identify how IT creates and contributes value.

Table 1: Sample Studies on IT Value (from Devaraj and Kohli 2003)

Study	Variables	Key Findings
Diewert and Smith (1994)	Inventory holding costs, growth rate, purchases, sales, inventory levels	IT led to large productivity gains
Barua et al. (1995)	Capacity utilization, inventory turnover, quality, relative price, and new product introduction	IT was positively related to some intermediate measures of profitability, but the effect was generally too small to measurably affect final output
Hitt and Brynjolfsson (1996)	Value added, IT stock, noncomputer capital, ROA, labor expense, ROE, shareholder return, IT stock/employee, capital investment, sales growth, market share, debt, R&D stock firm	IT leads to increased productivity and consumer surplus, but not higher profitability
Prasad and Harker (1997)	IT capital, non-IT capital, IS labor expense, non-IS labor expense	Additional capital investment in IT may not have real benefits
Dewan and Min (1997)	IT capital, non-IT capital, labor expense, value added, sales, number of employees	IT capital is a net substitute for ordinary capital and labor, i.e., IT investment leads to higher returns
Mukhopadhyay et al. (1997)	Total output, on-time output, labor hours, machine hours, level of automation, absenteeism rate, degree of supervision	IT investment leads to higher productivity and quality
Prattipati and Mensah (1997)	Number of years CIO in the position, proportion of software resources spent on client server applications, percentage of software budget spent on new development	Highly productive firms spent more on client-server and less on in-house application development
Francalanci and Galal (1998)	IT investments; clerical and managerial, and professional composition; income per employee; total operating expense	Increases in IT expenses are associated with productivity benefits when accompanied by changes in the worker composition
Menon et al. (2000)	IT capital, medical capital	IT contributes positively to the production of services in the healthcare industry
Devaraj and Kohli (2000)	Revenue, number of BPR initiatives, quality indicators, IT capital, labor, support investment	IT investment contributes to higher revenue, but the effect is more pronounced when combined with BPR initiatives

1.2.2 Shift in Theoretical Perspective

There has been a paradigm shift in the underlying theories to explain why and how IT contributes to firm performance, moving from the structure-conduct-

performance model of industrial organization economics to the resource-based view and its extensions (Ravichandran and Lertwongsatien 2005). The resource-based view posits that rare and inimitable resources provide sustainable competitive advantage (Barney 1991). This also explains Carr's (2003) view that IT's ubiquity no longer makes it a strategic factor to a firm. However, Barney (1991) has also emphasized the importance of common but valuable resources. Along with the resource-based view, the process view has also gained popularity. The process view studies IT value at the intermediate level, i.e., business process, as a link between individual or systems and organizational levels of analysis. There is a strong need to continue studying the value of IT in light of the new theoretical perspectives.

1.2.3 Challenges in Operationalization and Measurement

A major research challenge in the area of IT value is to operationalize some of the key concepts and develop reliable measures to build a cumulative tradition (Santhanam and Hartono 2003). Different levels of analysis and models of measurement call for a need to provide a unifying framework and develop appropriate measures in this area (Sugumaran and Arogyaswamy 2004).

Part of the difficulty in measuring the value of IT stems for the fact that it is multidimensional; its value can look different depending on how it is measured (Hitt and Brynjolfsson 1996). For example, IT can provide competitive advantage in several different dimensions such as functionality, preemptiveness, and efficiency (Sethi and King 1994). IT value can be demonstrated in various ways (Kohli and Grover 2008) and hence has to be

examined in a multifaceted manner. The measurement of IT value can also differ depending on the level of analysis (e.g., individual, firm or industry level) as different levels of analysis measure IT value using different variables (Kohli and Devaraj 2003).

A related challenge is how to measure IT impact on firm performance. DeLone and McLean (1992) proposed the Information Systems (IS) Success Model and discussed the difficulty of defining and measuring the dependent variable. There is a need to identify the appropriate class of dependent variable (e.g., productivity or profitability), for the type of investment (e.g., operational or strategic), and the appropriate set of variables that would manifest IT payoff (e.g., IT assets or IT impacts) (Kohli and Sherer 2002). Assessing the impact of IT is a challenge, as meaningful evaluation is often hindered by delayed benefits, unintended uses, business changes, or hidden costs (Ross et al. 1996). One particular difficulty of measuring and quantifying the impact of IT lies in that its value cannot be measured in isolation from other business factors as it works through and with the business processes of an organization (Barua and Mukhopadhyay 2000).

The above discussion indicates that more research is required to measure IT value using appropriate measures, in the appropriate time-frame, for the different levels.

1.2.4 Lack of Research at Individual Level

Initial IT value research focused mainly on the economic and financial value of IT at the organizational level. However, it is important to study IT impact on individual performance too, as individual job performance affects firm performance (Christen et al. 2006). While there were several studies on the impact of IT at the individual level in the 1990s (e.g., Forgionne and Kohli 1996; Todd and Benbasat 1999), there is not much work focusing on individual impact in the recent years (Chau et al. 2007). The multidimensional nature of IT, which has posed challenges to research at the firm level, poses similar challenges when measuring the value of IT at the individual level. Past research studies on the impact of IT on individual performance have also produced inconsistent findings, which could mean that the impact of IT on users is much more complex than commonly assumed (Ang and Pavri 1994). While IS research is rich in studies of technology adoption and use at the individual level, there is less research and understanding on how technology affects individual job performance. In fact, utilization of IT does not necessarily improve individual performance (Goodhue 2007). Hence, it can be seen that the impact of IT on individual work in the organization remains an important but understudied phenomenon.

The above practical and theoretical motivations drive us to study the impact of IT on organizational work.

1.3 Healthcare Domain

The McKinsey and Company productivity reports (2001; 2002) indicate that IT impacts on productivity can be industry specific as productivity gains due to IT were observed in some industries but not others. This prompts us to focus our study on a single industry. One particular industry that is relevant to study is the healthcare sector. The healthcare industry constitutes a large portion of most economies. It is estimated that the U.S. will use 20% of its gross domestic product (GDP) on healthcare by 2015 (Borger et al. 2006). In Singapore, healthcare spending constituted 4% of GDP in 2008 but is expected to increase (Straits Times 2008). The health services sector in Singapore has also shown strong economic growth in recent years (Singapore Department of Statistics 2008).

Despite the growing size of the healthcare industry, healthcare lags behind other industries in IT adoption by as much as 10-15 years (Skinner 2003). Although the use of IT for administrative systems such as billing and patient scheduling systems is more prevalent, the number of physicians and medical professionals incorporating IT for clinical purposes is substantially lower. For example, in a recent survey of healthcare CIOs in the U.S., only 17% of the respondents indicated that electronic medical record (EMR) [1] is fully operational across their respective healthcare groups (HIMSS 2009). Nevertheless, many developed countries, such as the U.S., Australia, Canada and U.K., have embarked on national-level efforts to implement healthcare IS

[1] An EMR is a computer-based health record that substitutes for the traditional paper medical record or "chart".

in their respective countries as they are anticipating that it will save costs and improve the quality of healthcare (Anderson et al. 2006). It is thus important to study the IT value in the healthcare industry to understand the impact of these recent initiatives.

The healthcare industry is different from other industries in ways that concern the use of IT (Menon et al. 2000). The three main differences are: (1) Organization structures in healthcare organizations generally consist of two entities, i.e., medical staff who are largely autonomous (Khoumbati and Themistocleous 2006) and administrators. The two groups may differ in their attitude towards and requirements for IT because of their different job objectives and skills. Medical staff have strong economic bargaining power over administrators of the hospital (Kim and Michelman 1990). Conflicts and negative effects on the relationships between these two parties have resulted in barriers in the use of information systems (Kim and Michelman 1990). (2) Medical staff, especially physicians, have shown resistance to the use of IT for clinical purpose as they perceive that IT systems take away their time and ability to deliver quality patient care (Lapointe and Rivard 2006). Clinical IS are also not well-accepted by physicians if they interfere with the physicians' traditional practice routines or workflow patterns (Anderson 1997). (3) The healthcare industry is generally highly regulated by the government. This affects the healthcare organizations' economic behavior towards cost reduction and revenue maximization, thus affecting their spending and use of IT (Menon et al. 2000). In particular, IT budget in the healthcare industry is often insufficient (Grimson et al. 2000). According the HIMSS Leadership

Survey[2], lack of financial resources has been cited as the most significant barrier to implementing IT (HIMSS 2009). In view of these differences, IT use in healthcare warrants separate study.

Another challenge concerning the use of IT in healthcare that is common to other sectors as well concerns the difficulty in demonstrating the value of healthcare IS. While there are studies that present the clinical benefits of using healthcare IS (e.g., Bates et al. 1998), few studies demonstrate the financial or organization value of healthcare IT (Johnston et al. 2003). Overall, there is a lack of understanding of how IT can impact work in healthcare organizations.

Despite the slow adoption of IT in healthcare, IT has tremendous potential to impact healthcare in areas such as quality, efficiency and cost. For example, healthcare experts and policy makers consider electronic health records to be critical in the transformation of the healthcare industry (Chaudhry et al. 2006). Due to the relative newness, lack of understanding, and the potential impacts arising from the use of IT in healthcare, the healthcare industry is a suitable choice for information systems research (Wilson and Lankton 2004) and even strategic management research (Douglas and Ryman 2003). IS theories and research can be applied to the healthcare industry to understand the socio-technical aspects of IT implementation (e.g., Kohli and Kettinger 2004; Lapointe and Rivard 2005). However, healthcare has received relatively less

[2] The Annual HIMSS Leadership Survey reports the opinions of IT executives from healthcare provider organizations across the U.S. regarding the use of IT in their organizations. It has become the most widely referenced healthcare IT survey and has been conducted annually for 20 years.

attention in IS research in the past (Chiasson and Davidson 2004). Recent IS studies in healthcare focus mainly on technology acceptance and adoption issues (e.g., Angst and Agarwal 2006; Hennington and Janz 2007; Tong and Teo 2009) but there is also a need for studies that focus on the impact of healthcare IS (Johnston et al. 2003). Hence, we chose healthcare as the context for our study.

While IT is being used in both primary (e.g., general practitioners' clinics) and secondary healthcare (e.g., hospitals), the use of IT in secondary healthcare, such as general hospitals, is evolving more rapidly as healthcare information systems are increasingly being developed for wider applications in hospital use (Khoumbati and Themistocleous 2006). Hence, we will focus our study on IT impact in secondary healthcare organizations, i.e., use of healthcare IS in hospitals. Our focus is on IT for clinical purposes rather than administrative purposes as this is a newer and less understood area in the healthcare industry.

1.4 Research Questions and Expected Contributions

In response to the need and call to study the impact and contribution of IT to organizations and specific industries (Agarwal and Lucas 2005), we propose a case study on the value and impact of IT in the context of secondary healthcare organizations. We will use the updated IS Success Model (DeLone and McLean 2003) as a research framework to aid us in our study. As discussed in detail in Chapter 2, the updated IS Success Model is suitable as it allows us to study impact or net benefits of IT at both the organizational and individual levels. Our research questions are:

RQ1: How do we assess the net benefits of healthcare IS in terms of organizational impact and individual impact?
RQ2: How do information quality, system quality, service quality, IS use, and user satisfaction interrelate and affect the net benefits?

The two questions will be investigated qualitatively through interviews with organizational stakeholders and data collected from secondary sources. This case study investigates the use of an emerging clinical healthcare IS (the wireless vital signs monitoring system) whose impacts are unclear. Studying the impacts of a single system allows us to analyze impact and value more clearly based on the intended objectives of the system.

We expect the theoretical contributions of this study to be four-fold. First, the study can contribute to IS literature by studying in-depth the impact and value of an IT system to improve organizational work, a relatively less understood phenomenon. Second, it also aims to contribute to our understanding of the factors that makes an IT system effective and valuable. Particularly, the healthcare domain provides a rich context and data to apply and test IS theories. Third, it contributes to healthcare IS research, a relatively new area of IS research, by studying the value of using IT in healthcare. Last, it can contribute to healthcare literature by using IS theories as a reference foundation to investigate the use of IT in healthcare organizations. The use of IS theories applied in the healthcare area can advance the status of IS as a reference discipline (Baskerville and Myers 2002). Practically the study can

offer insights into how IT systems can be deployed to positively impact organizational work particularly in healthcare organizations.

1.5 Structure of the Essay

Chapter 2 provides a literature review on the value and impact of IT. Chapter 3 presents our research framework and propositions. Chapter 4 describes an explanatory case study to investigate the impact of clinical IS in secondary healthcare. Chapter 5 presents the findings. Chapter 6 discusses the findings, the implications, and contributions of the study. Chapter 7 concludes this essay.

2 LITERATURE REVIEW

The focus of this essay is on net benefits and its antecedents. To shed light on these concepts, related concepts of IT value and impacts for organizations are also reviewed. The terms IT value and IT variable are explained first, followed by the levels of analysis. Theoretical approaches (process versus variance models) of studying IT impact are discussed, followed by theoretical perspectives and major findings at the firm level and the individual level. Finally, the chapter concludes with a review of healthcare as the context of study.

2.1 IT Value and Impact

As this study concerns IT value and impact, we begin with the definition and explanation of the terms *IT impact* and *IT value*. IT impact refers to effects caused by IT, whether positive or negative. It can be specific, e.g. impact of IT on the number of middle managers (Pinsonneault and Kraemer 1993) or broad, e.g. impact of IT on organizations and markets (Gurbaxani and Whang 1991).

IT value refers to "the value provided as a consequence of IT use" (Chau et al. 2007, p.197), i.e., deals with positive impacts. The contribution of IT to firm value is commonly referred as *IT business value*. Traditionally, IT business value refers to IT's ability to add economic value to a firm by reducing the firm's costs and/or differentiating its products or services (e.g., McFarlan 1984; Porter and Millar 1985). However, more recent definitions of IT business value look at how IT contributes to a firm's long-term competitiveness (Ross

et al. 1996), and how IT can be a source of sustainable competitive advantage (Mata et al. 1995). A more complete definition of the term is "the organizational performance impacts of information technology at both the intermediate process level and the organizational-wide level, and comprising both efficiency impacts and competitive impacts" (Melville et al. 2004, p. 287). *Efficiency* applies to internal processes such as productivity enhancement, cost reduction, or inventory reduction. In other words, it is about "doing things right" (Drucker 1966). *Competitive impact* manifests itself in the external environment and usually refers to uniqueness of a particular firm's products and/or services, relative to its competitors, involving the creation of a valuable strategic position (Porter 1996). Hence, IT business value has both *internal* and *external* dimensions.

In this essay, we will discuss IT value and impact in a broader way (not just IT business value) that includes non-economic impacts (e.g., impact to organizational work) and other levels lower than firm level (e.g., individual level). We refer to these impacts as *net benefits*, which refers to impacts of IS at various levels, such as individual and organizational level. This is consistent with the concept of net benefits from the updated IS Success Model (DeLone and McLean 2003).

Literature that discusses IT value usually refers to the total or overall IT used in the organization. However, it is also possible to discuss the value and impact of a particular IT system used in the organization. Performance of an IT system can also be categorized into internal and external performance

(Alter 1999). *Internal performance* is similar to efficiency and typically measured through business process measures such as productivity and cycle time. In the case where external parties are impacted by the system, *external performance* is measured in terms of how the system's output meets the expectations of the system's customers, and typical measures include quality and responsiveness. This is related to the concept of competitive impact as described earlier.

2.2 IT Variable

The IT variable used in IT value studies mostly refer to an IT system. Though it may seem obvious, it is appropriate at this point to define what an IT system may refer to. As listed by Seddon et al. (1999), this could be any of the following:

(1) An aspect of IT use (such as user interface)

(2) A single IT application (such as word processor or a personal computer)

(3) A type of IT or IT application (such as a network protocol, a management support system, or an inventory system)

(4) All IT applications used by an organization or part of the organization

(5) An aspect of a system development methodology

(6) The IT function of an organization or sub-organization (such as the IS department)

IT value research may also study the impact of an IT variable such as business-IT alignment or IT capability (Kohli and Grover 2008). What the IT is referring to usually also depends on the level of analysis, which we will

discuss in the next subsection. For example, studies at firm level usually refer to all IT used by the organization, or other firm-level IT-related variables such as organizational IT-based capabilities. For our study, we will focus mainly on a single IT application as this allows us to study the impact of IT at both organizational and individual levels, as explained in the next section (Section 2.3). It also allows us to analyze impact according to the intended objectives of the system.

2.3 Level of Analysis

Chau et al. (2007) proposed a taxonomy in which there are four major dimensions of IT value, i.e., user satisfaction, individual impact, organizational impact, and societal impact. These dimensions correspond to different levels of analysis. Other studies proposed five levels at which IT value and impact can be studied (Bakos 1987):

(1) *An individual performing a task.* Such studies typically look at the impact of IT on individual performance. An example is how decision support systems impact decision behavior and performance of individuals by guiding users to employ different decision strategies (Todd and Benbasat 1999).

(2) *A work group consisting of individuals.* An example is the impact of an integrated material requirement planning system on team decision-making (Barua and Whinston 1991). Another example is a study that investigates the impact of fit of collaboration technology on team performance (Fuller and Dennis 2004).

(3) *A firm consisting of several work groups.* This is probably the most common level of analysis. Most research studies focus on the organizational

level to measure IT value and its contribution to firm performance (Barua and Mukhopadhyay 2000).

(4) *An industry or network consisting of several firms.* An example is an empirical study of net-enabled business value, investigating how the coordination of value activities with customers, suppliers and business partners improve firm performance (Barua et al. 2004). Another example is the impact of digital supply chains on networked organizational performance, which is the aggregate performance of digital supply network partners (Straub et al. 2004).

(5) *An entire economy or society as a whole*, such as the impact of the Internet on society. As this level of analysis is difficult to define and operationalize, most studies tend to be speculative or anecdotal with tentative conclusions (Ang and Pavri 1994). A recent study at this level looks at the impact of IT trading across borders on national productivity using advanced econometric methods (Park et al. 2007).

Increasingly, researchers propose measuring the impact of IT at a lower level, such as the *individual level*, rather than firm level. This is because it is difficult to establish causality between IT and firm-level performance (Im et al. 2001). A firm level analysis would nullify the positive impacts of effective IT applications with the negative impacts of ineffective IT applications (Kauffman and Weill 1989). Santhanam and Hartono (2003) identified four problems on why it is difficult to link IT capability and firm performance: (1) the impact of prior financial performance and possible halo effects (2) the choice of benchmark firms (3) the existing binary measurements of IT leaders

and (4) the difficulty of conducting longitudinal studies. In short, the presence of confounding factors and measurement problems makes it difficult to ascertain the impact of IT at firm level. Devaraj and Kohli (2003) argued that the impact of technology is more likely to be detected if the level of analysis is more detailed.

Another possible level of analysis is the *process* level, which may involve one or more individuals or workgroups working on related activities. Hence, another way of understanding of IT impact is to examine individual applications at the process level. For example, Mukhopadhyay et al. (1997) studied the impact of technology in the mail-sorting process at the U.S. Postal Service, using a set of productivity factors to model the output and quality of mail sorting. In a recent study, Ray et al. (2005) examined the extent to which IT impacts the customer service process and found that shared knowledge between IT and customer service units was a key IT capability that affected the performance of the customer service process. Measuring the impact of IT on a single process allows us to trace its effect on specific tasks. However, measuring IT value at the process level also has its disadvantages. For example, this method does not work well for interdependent processes, and the results from one process may not be generalizable to other processes (Barua and Mukhopadhyay 2000).

Finally, it is also possible to conduct a *multilevel* study, which spans across two or more levels of analysis. For example, Burton-Jones and Gallivan (2007) conducted a multilevel (individual level and group level) investigation of the

relationship between system usage and task performance, examining three elements of this multilevel relationship – the context, structure, and the presence of cross-level relationships. However, multilevel studies in organizations must be handled with care, as activities and outcomes at one level (e.g. group level) do not always affect outcomes at another level (e.g. organizational level) (Goodman 2000). Nevertheless, a combination of organizational-level and individual-level studies have potential to contribute to our knowledge and discussion of IT value as it gives a fuller understanding compared to using a "black-box" approach in which only macro-level inputs and outputs are analyzed (Chan 2000).

Thus, our study will focus on the impact of an IT application at the individual and organizational level. Studying impacts at organizational level allows us to understand how a single IT system contributes to firm value, i.e., at the external dimension. Studying impacts at the individual level is a much-needed area of research (as explained in Section 1.2.4) and helps us understand how the use of IT impacts individual work, thus opening up the "black box". By studying both organizational and individual impacts of a single IT system, any positive impact of this system will not be nullified by any negative impacts of other IT applications (Kauffman and Weill 1989). While Essay 1 examines IT impact at organizational and individual levels, Essay 2 will focus on IT impact at individual level. Hence, the subsequent sections of this literature review will focus on the firm level and the individual level only.

We will first discuss briefly the possible theoretical approaches. As the dependent variable and the theoretical perspectives vary with the level of analysis, the subsequent sections of this literature review will be divided according to levels of interest here (firm and individual). For each level, we will describe the dependent variable, the major theoretical perspectives and findings.

2.4 Theoretical Approaches: Process versus Variance

Theoretical approach refers to "the type of concepts (e.g., things, properties, events) and the types of relationships (e.g., deterministic, probabilistic, recursive) that researchers use, whether explicitly or implicitly, to construct a theory" (Burton-Jones et al. 2004, p. 3). Past research has used two well-accepted forms of theoretical approaches: process and variance models (Markus and Robey 1988; Burton-Jones et al. 2004). In variance models, research constructs are properties of phenomena, whereas in process models, research constructs refer to events or conditions (Burton-Jones et al. 2004). Variance models are concerned with predicting levels of outcome based on levels of predictor variables, whereas process models are concerned with explaining how outcomes develop over time. The variance approach assumes necessary and sufficient causality, whereas the process approach is defined by necessary but not sufficient causation (Burton-Jones et al. 2004). While the variance approach is commonly used in IT value research, another significant theoretical approach in IT business value research is the use of process models. Here, we discuss three process models that are relevant to IT impact in

organizations (Benbasat and Zmud 2003; Soh and Markus 1995; Ross et al. 1996).

One of the simplest assertions to accept is that IT impacts can only occur if the systems are used. In Benbasat and Zmud's (2003) paper on defining and communicating the core properties of the IS discipline, the IT artifact and its nomological net demonstrate a simple process model of how the IT artifact leads to *usage*, which in turn leads to *impact*.

In their highly-cited paper, Soh and Markus (1995) propose a process model to understand and explain how IT creates business value. The ultimate outcome is improved *organizational performance* due to IT investment, which may be demonstrated through financial measures, stakeholder satisfaction, or productivity of outputs. For the outcome to take place, the first necessary condition is *IT impacts*, which refers to organizational impact due to IT investment, such as new products and services, and redesigned business processes. A necessary condition of the organization to experience IT impacts is *IT assets*, which refer to IT applications, infrastructure and user skill, and there must be appropriate *IT use*. IT assets result from *IT expenditure*, through the *IT conversion process*, which converts IT dollars to IT assets. Hence, this process model describes how IT investment can be transformed into organizational performance, and suggests possible research areas in each of the intermediate outcomes and processes.

Another similar process model describes how business value can be delivered from IT. Based on the responses of top IT executives at leading firms, Ross et al. (1996) argue about the importance of building an IT capability for competitive advantage based on three IT assets – *human asset* which refers to IT staff that solve business problems and address business opportunities through IT, *technology asset* which consists of technology architecture and data and platform standards, and *relationship asset* where IT and business unit management share the risk and responsibility for effective application of IT in the firm. These assets impact a firm's planning, delivery, operations and support processes, strategically aligning these processes to make them fast and cost- effective, thus resulting in competitive IT-enabled business processes.

For this study, we will use the IS Success Model (DeLone and McLean 1992; DeLone and McLean 2003), which is a combination of variance and process approaches, to study the impact of IT at organizational and individual level. It is also a unique model that can be applied at both individual and firm levels. We will describe this model in detail in the section on individual and firm level literature (Section 2.7).

2.5 IT Impact at the Firm Level

This section reviews studies on IT impact at the firm level.

2.5.1 Dependent Variable

For research studies at the firm level, the dependent variable is usually *firm performance*. Since the early years and even till now, such studies tend to measure firm performance by using standard financial ratios such as return on investment (ROI), return on sales (Ravichandran and Lertwongsatien 2005) or return on assets (Bharadwaj 2000). Some studies used metrics that reflect market value, such as Tobin's Q (Bharadwaj et al. 1999). These measures are high in validity, but the presence of confounding factors makes it difficult to measure the impact due to IT (Bakos 1987). While most studies use objective measures, it is also possible to use perceptual measures obtained through surveys or interviews, such as *perceived firm performance* (e.g., Ravichandran and Lertwongsatien 2005). Research has found that subjective and objective measures of firm performance are typically positively associated (Wall et al. 2004).

Not forgetting the internal dimension of IT business value, it is also possible to measure organizational impact using efficiency or internal measures. Examples include improvement in management of the company and increase in productivity (Teo and Wong 1998). *Productivity* measures are especially common in economics-based studies that measure productivity gains from the IT investments and/or usage (e.g., Francalanci and Galal 1998).

Hitt and Brynjolfsson (1996) argue that empirical results on IT value depend on what is measured. For example, productivity, consumer value, and business profitability are related, but they are three different measures of IT value.

Hence, the choice of dependent variable is critical, especially for comparison of results across studies.

Most of the above studies investigate the value of all IT in the firm, or total IT spending in the firm. However, as our study focuses on the value and impact of a single IT application, the above measures may not be appropriate in isolating its effect. A possible way of measuring the impact of an IT application at organizational level is through qualitative methods such as case studies. For example, one of the classic case studies focuses on the development and application of a new system architecture, and how it impacts managerial effectiveness and productivity of the firm (Edelman 1981). Also, case studies of three firms in different industries were conducted to propose a theoretical framework for measuring IT impact on the organization (Kohli and Hoadley 2006). Qualitative methods can aid in providing a rich understanding and meaningful analysis of IT value (Chan 2000). Hence, we will assess the organizational benefits of an IT system through qualitative means.

2.5.2 Theoretical Perspectives

For firm-level analysis, past research has studied the impact and value of IT using different theoretical perspectives, including microeconomics, industrial organization, strategic management theories such as the resource-based view, and the IS Success Model (DeLone and McLean 1992).

Microeconomics focuses on the production process and economic impact of IT (e.g., Barua et al. 1995; Mukhopadhyay et al. 1997). A popular theoretical

approach is the use of a microeconomic production function (e.g., Barua et al. 1995; Mukhopadhyay and Cooper 1992). Such studies are based on the premise that IT investment is an input to a firm's production function and this is combined with other inputs in a specific functional form to form the firm's outputs. A related research stream focuses on information economics and the value of information (Barua and Mukhopadhyay 2000). The information economics perspective is concerned with the value of information attributes (such as accuracy and update frequency) and how it contributes to the decision-making process (e.g., Barua and Whinston 1991). It usually involves a payoff function that determines IT value by comparing IT-assisted decisions with unassisted decisions (Mukhopadhyay 1993).

The microeconomics approach, though common and rigorous in methodology, suffers from a few drawbacks. For example, it is difficult to distinguish between different types of IT investments and how they impact specific areas of business because of the aggregate level of analysis used in a production function approach. Also, the conventional productivity measurement techniques are unable to measure the intangible benefits of IT, such as user satisfaction (Barua and Mukhopadhyay 2000; Im et al. 2001).

The *industrial organization* literature studies the interaction between firms in IT investment decisions and how the resulting benefits are divided (Melville et al. 2004). Examples of such theories are transaction cost economics and agency theory. For example, Gurbaxani and Whang (1991) examined the impact of IT on two firm attributes, firm size and the allocation of decision

rights, by building on agency theory and transaction cost economics. In a study of the impact of IT on the productivity of life insurance companies, hypotheses are developed based on transaction cost economics and agency theory (Francalanci and Galal 1998). A recent study uses transaction cost economics to investigate the value created and retained by suppliers that use supply chain management systems (Subramani 2004).

A more recent stream of research employs the *resource-based view*. The resource-based view of the firm, a dominant theoretical perspective in strategic management literature, attributes superior firm performance to organizational resources that are firm-specific, valuable, rare and difficult to imitate or substitute (Barney 1991). Hence, some of the IT related resources that are potential sources of competitive advantage include the capital needed to develop and apply IT, proprietary technology, technical IT skills and managerial IT skills (Mata et al. 1995).

An extension of this research stream pertains to the *complementarity* between IT and other resources. This stream of research is related to the resource-based view and its extensions, such as competencies and capabilities. For example, studies show that if firms can combine IT-related resources to create unique IT capabilities, it can result in superior firm performance (Bharadwaj 2000). IT does not work in isolation, i.e., it alone does not provide sustainable competitive advantage (Brown and Hagel III 2003). The business value of IT comes from business changes and innovations and hence organizational performance is derived from business operations, not directly from IT

(Peppard and Ward 2004). If a firm does not complement investments in IT with appropriate changes in business processes, strategies or organizational design, the value and payoff is likely to be limited. Related to this is the *contingency-based perspective*, which studies other organizational factors such as contingency variables for IT value (Saunders and Jones 1992). For example, a recent study looks at the importance of a good fit between business strategy and IT strategy, and states that the role of IT is to support a firm's main strategic objectives (Oh and Pinsonneault 2007). Furthermore, the complementarity view also suggests that IT investments are more related to intermediate performance measures such as time to market and customer service response time, rather than firm-level performance measures such as profitability (Barua and Mukhopadhyay 2000).

Another possible theoretical perspective is the *IS Success Model* (DeLone and McLean 1992). The IS Success Model can be applied at both firm level and individual level. Hence, we will elaborate on this model in the section on firm and individual level research.

A *combination* of these theoretical perspectives is also possible. For example, Wagner and Weitzel (2005) developed a model to study the impact of IT by using the resource-based view, and augmented it with a microeconomic production function.

2.5.3 Major Findings

While some studies in the *industrial organization and microeconomics* streams of research found a positive relationship between IT investment and firm performance (e.g., Francalanci and Galal 1998; Hitt and Brynjolfsson 1996), there are also studies that find a nil relationship (e.g., Prasad and Harker 1997) or even negative relationship (e.g., Jain 2003). In response to Carr's (2003) assertion that IT has become a commodity input, some research studies attempt to answer the question "How does IT matter when it is a commodity input?" (Thatcher and Pingry 2004a; Thatcher and Pingry 2004b). Thatcher and Pingry (2007) suggested that the impact of IT investments depends on three factors: (1) The type of product development that IT supports (digital products versus traditional products); (2) The market structure in which the firm competes (monopoly versus competition); and (3) The type of IT in which the firm invests (design tools versus production/distribution tools). Findings indicate that the impact of IT investments depends on the combination of the three factors. For example, IT investments in design tools in the case of a monopoly should increase firm profits but decrease firm productivity under both digital and traditional product categories (Thatcher and Pingry 2007).

Studies based on the *resource-based view* generally aim to identify IT-related resources that lead to sustainable competitive advantage (e.g., Bharadwaj 2000). A recent study that draws on the resource-based and resource complementarity views uncovers the IS-related resources required to build IS capabilities that would impact firm performance (Ravichandran and

Lertwongsatien 2005). A conceptual study, using the theory of complementarities, offers a possible reason for the ambiguity of findings on IT value, i.e., that risk is an important aspect of firm performance but has been ignored in past studies (Tanriverdi and Ruefli 2004).

Other studies focus on the *contingency perspective*, to uncover the various IT-related factors that must be present in order to positively impact firm performance. A comparison study between the resource-based perspective and the contingency perspective found that the contingency perspective has a stronger explanatory power for the strategic value of IT (Oh and Pinsonneault 2007). Another study in this stream (Sabherwal and Chan 2001) examines the impact of alignment of business strategy and IS strategy on perceived business performance using Miles and Snow's (1978) typology of Defender, Analyzer and Prospector business strategies. It finds that alignment seems to influence overall business success in Prospectors and Analyzers though not for Defenders. IT alone does not create value, but it must work with other IS and organizational-related factors to create value (Melville et al. 2004; Wade and Hulland 2004; Kohli and Grover 2008)

A relatively less common way of answering the question of IT value is to use an event study methodology to study how stock prices react to announcements of IT investments of a firm (Im et al. 2001). Findings show that there is no price reaction for larger firms, and a positive price reaction for smaller firms; however, there is an increase in both price and volume reaction over time, showing that IT spending is of value to the firm.

To summarize, IT value studies at the firm level employ various theoretical perspectives and dependent variables. Findings tend to be of two different types: (1) whether IT makes a difference to firm performance (2) the conditions, resources or factors that must be present to positively impact firm performance. Most of these studies use quantitative methods. There appears to be a lack of studies employing qualitative methods to study the impact of IT at organizational level. Qualitative method has its benefits, as it allows one to understand the context and have a richer understanding of how IT may impact an organization in different ways. Hence, we will use qualitative methods to study the impact of IT at organizational and individual levels. A suitable theoretical perspective would be the IS Success Model as it can be applied at both firm and individual levels. We will elaborate on the IS Success Model in a later section.

2.6 IT Impact at the Individual Level

This section reviews studies on IT impact at the individual level.

2.6.1 Dependent Variable

At the individual level, one of the clearest ways for IT to demonstrate value is in the improvement of individual task performance. Task performance consists of behaviors carried out to complete a job and can be assessed in two ways: through assessments of *behavior* or assessments of *outcomes* (Beal et al. 2003; Campbell 1990; Sonnentag and Frese 2002).

Outcomes of individual task performance can be assessed in terms of efficiency and/or effectiveness (Beal et al. 2003; Campbell 1990). Outcome measures could be objective (e.g., productivity measures or number of errors), or perceptual. An example of a perceptual outcome measure is perceived task performance obtained through a survey on the use of PDA among insurance agents (Lee et al. 2007). A common approach for investigating outcomes is to measure its antecedents, by studying IT impact on individual's user satisfaction, job satisfaction, work attitudes or user expectations (Ang and Pavri 1994). Another antecedent of individual or task performance is system usage, as it is evident that a system must be used for it to improve individual task performance (DeLone and McLean 1992; Burton-Jones and Straub 2006).

Assessments of *behavior* generally focus on evaluating actions or behaviors relevant to the goals of the study, as well as indices of unobservable cognitive behaviors (Beal et al. 2003). This is a broad approach that studies the effect of IT and information on the behavior of the recipient. This may also include measuring variables such as change in user behavior (DeLone and McLean 1992).

2.6.2 Theoretical Perspectives

There are two well-known IS theories that relate IT to individual performance, i.e., the Task-Technology Fit model (Goodhue and Thompson 1995) and the IS Success Model (DeLone and McLean 1992). We will discuss the Task-Technology Fit model in this section, and the IS Success Model in the next section on firm and individual level.

The *Task-Technology Fit (TTF)* model is part of the Technology-to-Performance Chain (Goodhue and Thompson 1995). The Technology-to-Performance Chain asserts that the technology must be utilized, and it must be a good fit with the tasks it supports, in order for it to have a positive impact on individual performance. This model is consistent with the IS Success Model (DeLone and McLean 1992) as both models propose that utilization and user attitudes about the technology lead to impacts on individual performance (Goodhue and Thompson 1995). Figure 1 shows a subset of the Technology-to-Performance Chain, which includes the TTF.

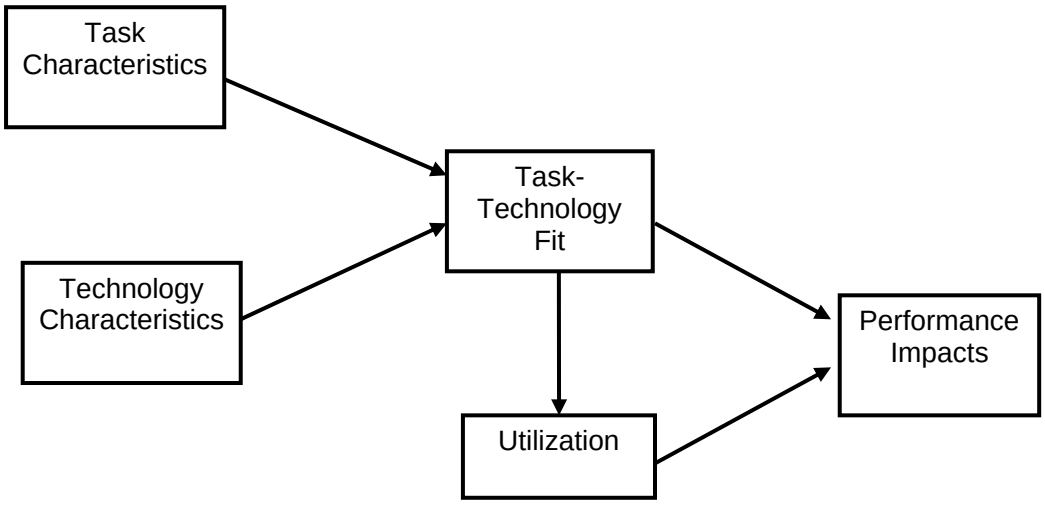


Figure 1: Technology-to-Performance Chain, including TTF (from Goodhue and Thompson 1995)

The Technology-to-Performance Chain hence includes two different streams of research, i.e., utilization research and TTF research. Although Goodhue and Thompson (1995) argue that both are necessary for technology to create impact on individual performance and models that focus on fit or utilization

alone are not sufficient to study the impact of IT on performance, most empirical studies focus on either fit or utilization. Researchers have often taken utilization or user evaluation as a surrogate for performance impact of IS or IS success (Goodhue and Thompson 1995).

TTF refers to the degree to which a technology assists an individual in performing his task (Goodhue and Thompson 1995). Goodhue (1995) proposed user evaluations as a surrogate for TTF and developed twelve dimensions of user evaluations of TTF. Subsequently, this list was reduced to eight TTF factors, i.e., quality (of data), locatability (of data), authorization (for access to data), compatibility (of data), ease of use/training, production timeliness, systems reliability, and relationship with users (Goodhue and Thompson 1995). Performance impact refers to the accomplishment of tasks by an individual, and improved performance implies better efficiency, effectiveness, and/or quality (Goodhue and Thompson 1995). The antecedents of TTF are task and technology characteristics.

The other important construct in the Technology-to-Performance Chain model is system utilization, which is conceptualized as "the extent to which the information systems have been integrated into each individual's work routine, whether by individual choice or by organizational mandate" (Goodhue and Thompson 1995, p.223). This construct is related to the research stream on IT usage and post-adoptive behavior. While IS literature is rich in studies on technology adoption, there is relatively less research work on IT utilization and post-adoptive behavior. In fact, evidence suggests that organizations are

underutilizing the full potential and features of their installed IT applications, thus leading to considerably less benefits (Jasperson et al. 2005).

2.6.3 Major Findings

Studies at the individual level of analysis generally allow greater understanding of the usage of IT and how it impacts individual work. In this subsection, we review studies based on TTF. Other individual-level studies based on the IS Success Model are reviewed in the next section.

There are several empirical studies that apply the TTF to understand how the use of technology may impact individual performance. An example of such a study is the investigation of how the nature of the task and the type of decision support provided influence decision performance (Todd and Benbasat 1999). A recent study uses the TTF instrument to measure the impact of environmental uncertainty on task characteristics and user satisfaction with data (Karimi et al. 2004). However, few studies test the Technology-to-Performance Chain in its entirety. A study was conducted (Staples and Seddon 2004), finding support for the predictive power of this model, but the relationships in the model vary under two usage situations, i.e., voluntary and mandatory. When users do not have a choice about system use, their beliefs and attitude about the system are not significant in predicting utilization, and utilization is also not associated with performance impact.

A recent case study applies the TTF to the use of a mobile electronic procurement system in an organization (Gebauer and Shaw 2004). This is an

unusual case study that applies an individual-level model to the firm level. The relationships between the characteristics of technology and task, usage and organization impacts were analyzed. There are two dimensions of organizational impacts, i.e., operation impacts which improve productivity and efficiency, and organizational flexibility and emergency handling.

The TTF model was replicated in different empirical contexts, such as the use of personal digital assistant technology in the insurance industry (Lee et al. 2007). The TTF model was also extended in different ways. Examples including adding individual characteristics of experience (Dishaw and Strong 2003), adding constructs from the technology acceptance model (Dishaw and Strong 1999) and extending with the computer self-efficacy construct (Strong et al. 2006). However, these extended models are tested with technology utilization as the dependent variable, rather than individual performance or impact.

To summarize, the TTF model is well-tested in different empirical contexts, and applied and extended in different ways. However, the construct of interest is the TTF and the dependent variable is usually utilization, rather than individual performance or impact. In a later paper, Goodhue (2007) remarked that technology use does not necessarily lead to performance. More research is needed to better understand the relationship between IT use and individual impact, which is what we aim to do in Essay 2.

2.7 IT Impact at the Individual and Firm Level

In this section, we review the IS Success Model, which is a unique theoretical perspective that takes into account both firm-level and individual-level impacts.

2.7.1 IS Success Model

The IS Success Model (DeLone and McLean 1992) was first proposed to improve our understanding of how to measure the success or effectiveness of information systems. It attempts to reflect the interdependent process nature of IS success. Figure 2 shows the original IS Success Model (DeLone and McLean 1992). *System quality* refers to measures of the information system or the performance of the IS, in terms of reliability, response time, functionality, ease of use and other system metrics (Petter and McLean 2009). *Information quality* refers to measures of information system output, such as the accuracy, usability and completeness of the information. *Use* refers to the consumption of the information system output by the recipient or user, described in terms of actual or self-reported usage (Petter and McLean 2009). *User satisfaction* reflects the user's response to the use of the information system output (DeLone and McLean 1992). It usually refers to the approval or likeability of an IS and its output (Petter and McLean 2009). This is frequently used as a dependent variable in empirical studies of IS success. *Individual impact* refers to the effect of information on the behavior of the user. This is one of the most difficult terms to define and is closely related to performance, as improvement in performance should be evident for positive impact of IS (DeLone and McLean 1992). This could include measures such as decision effectiveness or

user productivity. *Organizational impact* refers to the effect of information on organizational performance. However, most empirical studies based on the IS Success Model do not include organizational impact in their studies (DeLone and McLean 2003), i.e., this model has been mainly applied at the individual level of analysis (e.g., Rai et al. 2002; Iivari 2005).

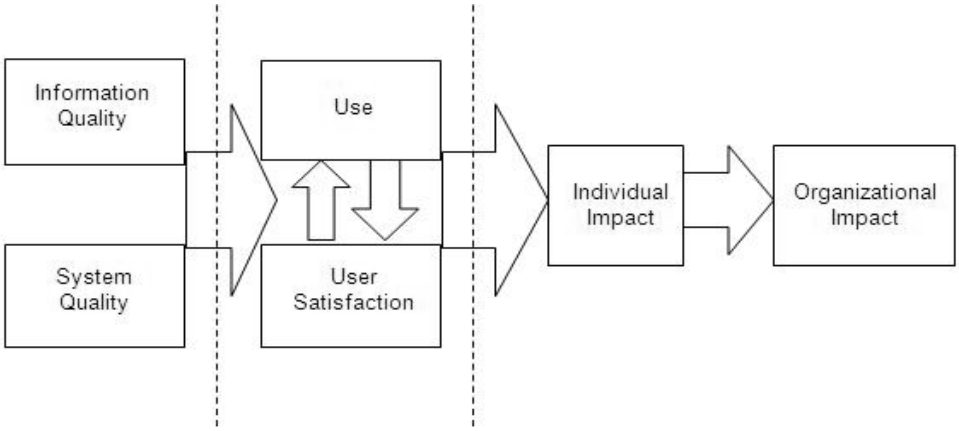


Figure 2: IS Success Model (from DeLone and McLean 1992)

The IS Success model uses a combination of theoretical approaches, i.e., variance and process. However, the hybrid approach is not without criticism. Seddon (1997) argues that the combination of process and causal approaches has led to much confusion making it difficult to interpret and use, and thus proposed an alternative model. It is similar to the IS Success Model except for the definition and placement of IS use, as Seddon (1997) argues that use must precede impact, but does not necessarily cause impact (Rai et al. 2002). Seddon's (1997) proposed model also separated the process and variance components.

Acknowledging various potential improvements and adaptations of the model (e.g., Seddon 1997; Jennex et al. 1998), DeLone and McLean (2003) proposed extensions to the IS Success Model, which is known as the *updated D&M IS Success Model* (see Figure 3). First, they added *service quality*, and second, they grouped all "impact" measures into a single category called *net benefits*. *Service quality* refers to the effectiveness of the services of the IS function to provide support to the users and include measures such as responsiveness and assurance. It was first suggested by Pitt et al. (1995), that the basis of the IS Success Model is product-oriented and ignores the intangible measure of IS success, i.e., service quality which affects both use and user satisfaction. *Net benefits* refer to the impacts of IS at various levels, such as individual, work group, organizational, interorganizational, industry, consumer and societal impacts. Examples of measures used in past studies include organizational performance, perceived usefulness or affect on work practices (Petter and McLean 2009). Lastly, another enhancement to the IS Success Model was the clarification of the *use* construct and the proposal of measuring *intention to use*. DeLone and McLean (2003) explained that increased *user satisfaction* would lead to a higher *intention to use*, which in turn increases *use*.

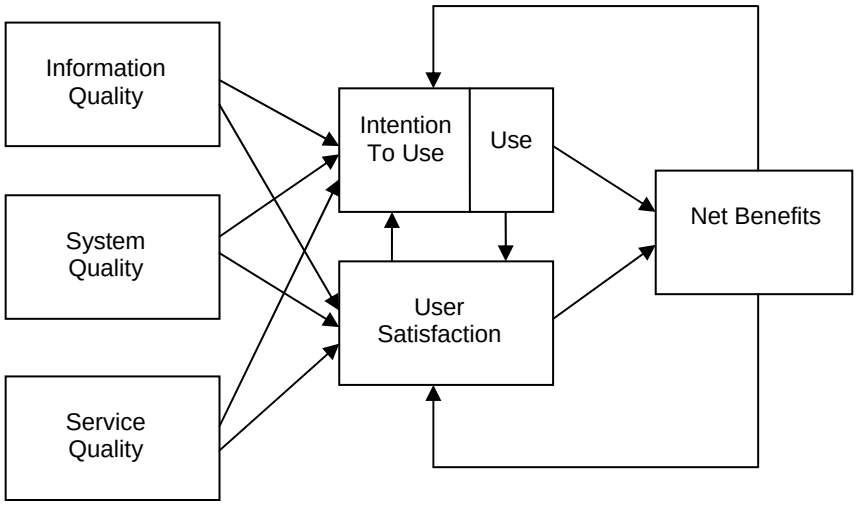


Figure 3: Updated D&M IS Success Model (from DeLone and McLean 2003)

The Net Benefits construct requires three issues to be addressed, i.e., what qualifies as a "benefit", the benefits for whom, and the level of analysis (DeLone and McLean 2004). This is demonstrated in DeLone and McLean's (2004) example of applying the updated model to e-commerce success. An e-commerce system can benefit single users (customers), a group of users, an organization or even an industry and hence the net benefits success measures can be similarly organized by level, with their respective benefits. For example, individual benefits include improved customer experience and reduced shopping cost, whereas organizational benefits include global reach and customer retention. In the context of IT healthcare, net benefits may include impacts to IT users (e.g., doctors and nurses) and patients, and it may be measured at individual level (e.g., net benefits to individual users) or organizational level (e.g., net benefits experienced by the hospital in terms of efficiency and/or effectiveness).

2.7.2 Major Findings of Studies based on the IS Success Model

The original IS Success Model has been applied and tested in various studies. However, few studies test the model in its entirety (Petter and McLean 2009). We analyzed how frequently the links have been tested. Few studies test the relationship with organizational impact. Examples of such studies include Teo and Wong's (1998) empirical study based on firms in the retail industry, and another study in the user-developed application domain in which data was collected through a business policy simulation game, but findings there indicate that individual impact is not associated with organizational impact (McGill et al. 2003). A recent study tests the IS Success Model in the context of different corporate cultural types, and operationalizes organizational impact by measuring three dimensions: impact of strategic use, impact of tactical use, and impact of operational use (Bradley et al. 2006).

Some studies have *individual impact* or *user satisfaction* as the dependent variable. For example, one recent study tested the model using a longitudinal field study of a mandatory information system (Iivari 2005). In this study, although most part of the model is supported by the data, only user satisfaction, and not actual use, is found to predict individual impact. Studies that focus on user satisfaction include Doll et al. (2004), which developed an end-user computing satisfaction instrument consisting of the following dimensions: content, accuracy, format, timeliness and ease of use. Au et al. (2002) proposed a conceptual model of end-user information system satisfaction but the model was not tested.

In addition, some studies extend the IS Success Model by studying the *antecedents of system quality and information quality*. For example, a study conducted by Bradley et al. (2006) examines the inclusion of IT plan quality as an antecedent of system quality and information quality. Another recent study develops a model consisting of nine fundamental determinants of quality, i.e., antecedents of system quality and information quality (Nelson et al. 2005).

There are few studies that test the *updated IS Success Model*. DeLone and McLean (2004) used the model to illustrate e-commerce success but there was no empirical data. Another study applies the updated model in an empirical investigation of website quality (Cao et al. 2005) but considers individual impacts (intention to revisit website) that are not directly related to work impact. The updated IS Success Model was respecified to measure the success of knowledge management system but service quality was not included (Wu and Wang 2006). Nevertheless, there are some recent studies that test part of the updated IS Success Model. For example, the technology acceptance model was extended with information quality, system quality and service quality to understand the intention to continue e-learning (Roca et al. 2006).

A meta-analytic assessment that combines studies based on the original and updated IS Success Model was conducted (Petter and McLean 2009). This was based on 52 studies that applied the IS Success Model (or part of the model) at the individual level. All relationships in the model was supported, except the relationship Service Quality → Intention to Use (not studied due to insufficient data) and the relationships Service Quality → Use and Service

Quality → User Satisfaction (these two hypotheses were found to be insignificant). The relationship Use → User Satisfaction was also found to be weak, but the other relationships were moderate to strong.

Table 2 summarizes a sample of empirical studies from major IS journals based on the IS Success Model applied at the firm level. This sample was derived from the studies reviewed by DeLone and McLean (2003) with the addition of recent studies from 2003 onwards. Studies which investigate the impact of a single IT application in an organization are highlighted by italics in the table.

Table 2: Sample Firm-level Empirical Studies based on the IS Success Model

Authors	**Description of Study**	**Model/Framework**	**IT Variable**
Bradley et al. 2006	Survey conducted with CIOs to test the IS Success Model in different corporate cultural contexts and to examine the role of IT plan quality as an antecedent	IV: Plan Quality DV: Impact of strategic, tactical and operational IS use	All IT used in firm
Devaraj and Kohli 2003	*Longitudinal study of eight hospitals to investigate the relationship between hospital performance and technology usage*	*IV: Technology usage* *DV: Hospital performance*	*Decision support system used by eight hospitals in a healthcare network*
Gelderman 1998	Survey among 212 Dutch managers to study the relationship between usage, user satisfaction and performance	IV: Usage, user satisfaction DV: Organizational performance	Any information system used by the respondents

Jurison 1996	*Three-year evaluation of user productivity and organizational effectiveness following the installation of an IS*	*IV: Individual impact* *DV: Organizational impact*	*Integrated office IS used by an organization*
McGill et al. 2003	Business simulations to test the IS Success Model in the user-developed application domain. Although the relationship between individual impact and organization impact is tested, it is not significant.	IV: System quality, information quality DV: Individual impact, organizational impact	Spreadsheet application[3]
Teo and Wong 1998	Empirical study of the relationships between intensity of IT investment and organizational impact based on firms in the retail industry	IV: Intensity of IT investment DV: Managerial satisfaction, organizational impact MV: Information quality, improvement in work environment	IT investment
Wixom and Watson 2001	Survey conducted with 111 firms to investigate a model of data warehousing success	IV: Management support, user participation, development technology DV: Perceived net benefits MV: Implementation success, data quality, system quality	Data warehouse used by different warehousing companies

Note: IV = Independent variable, DV = Dependent variable, MV = Mediating variable.
Studies based on the individual impact of single IT system in an organization are in italics.

Table 3 summarizes a sample of empirical studies from major IS journals based on the IS Success Model applied at the individual level. The sample was derived using the same approach as for Table 2. Although the IS Success

[3] As the study uses business simulations, it does not study the impact of an actual system in an organization.

Model is widely researched, only studies which investigate individual impact or performance are included. Studies which investigate the impact of a single IT application in an organization are highlighted by italics in the table. From Table 2 and Table 3, it is clear that there is a lack of studies evaluating the impact of a single IT application on organizational work, which is the focus of our study.

Table 3: Sample Individual-level Empirical Studies based on the IS Success Model

Authors	Description of Study	Model/Framework	IT Variable
Cao et al. 2005	Survey to verify measures of web site quality	IV: System quality, information quality, service quality, attractiveness DV: Intention to revisit a website	Three websites
Etezadi-Amoli and Farhoomand 1996	Survey conducted with 341 end users to validate an instrument for measurement of end user computing satisfaction	IV: Dimensions of end user computing satisfaction DV: User performance	Users' chosen primary application software[4]
Guimaraes and Igbaria 1997	Survey conducted with IS managers and their end-user department managers to study the human aspects of client/server systems	IV: Management support, end-user involvement and characteristics, developers' skills DV: Individual impact MV: User satisfaction and system usage	IS manager to select most recently implemented client/server system[5]
Igbaria and Tan 1997	Survey conducted in a Singapore government agency to examine the relationship between IT acceptance and its impact on individuals	IV: User satisfaction DV: Individual impact MV: System usage	16 types of end-user applications

[4] This study investigates different IT applications depending on the survey respondents' choice.
[5] This study investigates different IT systems depending on the respondents' choice.

Iivari 2005	*Longitudinal field study of the use and impact of a mandatory information system*	*IV: System quality, information quality DV: Individual impact*	*A financial system in an organization*
McGill et al. 2003	Business simulations to test the IS Success Model in the user-developed application domain. Although the relationship between individual impact and organization impact is tested, it is not significant. Hence, this can be classified as an individual-level study too.	IV: System quality, information quality DV: Individual impact, organizational impact	Spreadsheet application[6]
Rai et al. 2002	*Field study survey to assess two competing models of IS success in a quasi-voluntary IS use context*	*IV: Ease of use, information quality DV: System dependence*	*Student information system in a university*
Roca et al. 2006	Survey to test decomposed technology acceptance model extended with the IS Success Model to understand e-learning continuance intention	IV: Information quality, service quality, system quality, confirmation, perceived usability, subjective norm, perceived control, satisfaction DV: E-learning continuance intention	E-learning courses offered by two different organizations
Teng and Calhoun 1996	Survey that measures the computing and communication dimensions of IT use and their perceived effects on operational and managerial decisions	IV: Information usage DV: Decision efficiency, organizational decision process, overall effects	Computer-based communica-tions software[7]

[6] As the study uses business simulations, it does not study the impact of an actual system in an organization.

[7] This refers to any computer-based communications software and hence it is not regarded as a single IT application in an organization.

Torkzadeh and Doll 1999	Development of a tool to measure the perceived impact of IT on work	IV: User involvement, satisfaction, usage pattern DV: Four dimensions of work impact, i.e., task productivity, task innovation, customer satisfaction and management control	139 different applications
Weill and Vitale 1999	Development of a model of the IS applications portfolio and assessing the health of this portfolio based on survey of executives from a process manufacturing firm	IV: Importance, investment, technical quality, use DV: Management value	Systems in different functional areas of a company
Wu and Wang 2006	Survey that tests a proposed knowledge management system (KMS) success	IV: System quality, information quality, user satisfaction, KMS use DV: Perceived KMS benefits	KMS used in 50 firms
Yoon et al. 1998	Survey conducted with project leaders and end users of expert systems (ES) to study ES implementation success factors in the context of business process reengineering (BPR)	IV: Managerial support, problem difficulty, user characteristics, user involvement, developer's skills, shell characteristics, problem importance DV: BPR benefits experienced by end-users MV: User satisfaction	150 expert systems in an organization
Yuthas and Young 1998	Laboratory experiment to study the relationships between user satisfaction, system usage and performance in the context of materials management. Subjects are undergraduate students.	IV: User satisfaction, IS usage DV: Materials management performance	Computerized inventory system[8]

Note: IV = Independent variable, DV = Dependent variable, MV = Mediating variable.
Studies based on the individual impact of single IT system in an organization are in italics.

[8] As this study is a laboratory experiment, the computerized inventory system is not regarded as a single IT application in an organization.

As the IS Success Model can be applied at both individual and organizational level, it is thus suitable to apply the updated IS Success Model as a research framework and theoretical lens to study net benefits at individual and organizational level (RQ1). We will also use the updated IS Success Model as a framework to study the antecedents of the net benefits of IT (RQ2). This will aid us in understanding whether information quality, system quality, and service quality influence use, user satisfaction and net benefits in a healthcare IT context. In addition, we will analyze the net benefits of the IT system in detail. Our goal is to use this model as a theoretical lens to better understand the impact of an IT system in a healthcare organizational context.

2.8 Healthcare IS

Healthcare is currently a large and growing industry undergoing major transformation enabled by IT (Wilson and Lankton 2004), making it relevant for IS research. It has been proposed that the design and implementation of IS, aided by knowledge on people and organizational aspects, can lead to improved medical and organizational outcomes (Lorenzi et al. 1997). There are significant opportunities for healthcare organizations to benefit through the use of IT.

2.8.1 Measuring the Impact of IS in Healthcare

Despite the potential of IT in healthcare, it is challenging to measure the impact and net benefits of IT. To measure IT value in healthcare organizations require us to effectively measure performance at organizational level.

However, it is difficult to measure firm performance for healthcare organizations. In addition, it is difficult to isolate and measure the impact of IT in healthcare.

Defining and measuring *firm performance* is particularly challenging for healthcare organizations. Some of the reasons include the following (Shortell and Kaluzny 1994): (1) It is difficult to define and measure the product of healthcare organizations. In particular, a service is delivered rather than a product. In addition, not-for-profit hospitals or public organizations dominate the healthcare industry (Douglas and Ryman 2003). While the performance of private organizations are typically measured through profitability and financial measures, the performance measures of public organizations are less profit-driven and tend to be more complicated, multifaceted, and even subjective (Hull and Lio 2006). This is because public organizations have to evaluate their performance based on the original mandate of the organization and the needs of a diverse group of stakeholders, and are typically more concerned with societal change than financial gain. (2) Many of the activities that influence the performance of healthcare organizations are under the control of physicians and caregivers rather than managers. Yet physicians are viewed more as customers than employees of the healthcare organizations. Although patients are the key customers of hospitals, the physician's influence on the hospital financial performance make them co-customers (Kohli et al. 2001). Physicians are known to have strong economic bargaining power over administrators of the hospital (Kim and Michelman 1990).

The impacts of IT in healthcare are challenging to quantify as it is difficult to provide quantifiable benefits and demonstrate return on investment (Kuhn and Giuse 2001). Consequently, it is difficult to justify for IT investment in healthcare organizations. Lack of financial resources has been cited as the most significant barrier to implementing IT in healthcare (HIMSS 2009). In fact, the slow adoption rate of IT in the healthcare industry may be due to insufficient IT budgets in the healthcare industry (Grimson et al. 2000).

Nevertheless, there have been attempts to measure the impact of IT on healthcare using different measures. For example, a study on the impact of computerized inpatient order entry system measured differences in physician time spent on the task (Overhage et al. 2001). This measures the efficiency aspect of individual job performance. Another study on the impact of computerized surveillance and identification of high-risk patients showed an improvement in the health status of hospitalized patients (Kucher et al. 2005). This measures the effectiveness dimension of organizational performance. In a study of the relationship between IT investment and organizational performance, hospital performance is measured by the hospital's mortality level, revenue per admission and revenue per day (Devaraj and Kohli 2003). This is a measure of organizational effectiveness. Other possible measures include improvement in quality and efficiency of healthcare, and reduction of costs (Chaudhry et al. 2006). Indeed, some of the objectives of using IT in healthcare are to reduce medical errors and improve clinical outcomes (HIMSS 2009). Thus, the net benefits of using IT in healthcare should not be constrained to financial measures. Neither can randomized controlled trials

(popularly used in healthcare to evaluate effectiveness of drugs) sufficiently study the benefits of using IT in healthcare. Instead, past research insights highlighted the need to examine user and organizational factors in healthcare IS (Heathfield et al. 1998).

We aim to study the net benefits of an emerging healthcare IT system. Instead of using financial measures, we will focus on net benefits to patients and organizational work. While there are a number of studies focusing on quality- and efficiency-related benefits, a recent systemic review pointed out the need for future studies focusing on impact on organizational work and human factors (Chaudry et al. 2006). Our goal here is to use the updated IS Success model as a theoretical lens to better understand a new technology and its impact in a healthcare organizational context. Our focus is on a single IT application and its impact, set in the healthcare context. The next section describes the types of healthcare IS.

2.8.2 Types of Healthcare IS

There are two main types of healthcare IS used in hospitals – administrative information systems (IS) and clinical IS (McHaney 2008). Administrative IS are used to manage information used in the daily operations of an organization not directly linked to hands-on patient care, such as financial systems and human resource systems. In healthcare organizations, administrative IS may include systems such as patient registration and billing systems. Clinical IS are information systems used in patient care. Examples are Computerized

Physician Order Entry systems (CPOE), electronic medication administration systems (EMAS), and radiology systems.

While administrative IS have been developed since the 1970s, increased use of clinical IS only happened in the 1990s. Despite its potential in improving quality of care and outcomes, clinical IS has seen a slow diffusion and low acceptance among physicians (Lapointe and Rivard 2006). There is thus a strong need to study the social and organizational factors in introducing and using clinical IS. It is also important to "identify specific benefits that the information system provides to individuals and organizational groups" (Anderson 1997, p. 90).

Further, the most recent HIMSS Leadership survey indicates that clinical IS will be a key focus for healthcare organizations for the next two years (HIMSS 2009). Hence, we will focus on clinical IS. We aim to study the impact of a new emerging clinical healthcare IT system at both organizational and individual levels. Such an analysis can be beneficial to other healthcare organizations considering the adoption and implementation of similar healthcare IS. The next section describes the clinical IS that we will study.

2.8.3 Vital Signs Monitoring System

Vital signs monitoring is a salient activity conducted by nurses to monitor patient's progress and any irregularities (Evans et al. 2001). Nurses typically go to each patient and manually take vital signs readings such as blood pressure, temperature, respiratory rate and pulse rate. However, this process is

prone to errors. Based on a survey done by Balas et al. (2004), 12% of errors in hospitals were attributed to mistakes in manual charting. In a work sampling experiment (Bosman et al. 2003), it was found that manual documentation time, which includes manual recording and charting of patients' vital signs, took up to 20.5% of nurses' total time. Hence, there is a strong need to adopt techniques to improve patient safety and reduce the workload of nurses to improve patient care. A wireless vital signs monitoring system uses wireless technologies and monitoring devices to measure the vital signs of patients at regular intervals, thus automating and transforming the vital signs monitoring process.

The application of pervasive computing towards vital signs monitoring is a possible approach (Varshney 2003), which can also reduce contact between healthcare professionals and patients to prevent spread of contagious diseases. Pervasive healthcare is defined as "healthcare to anyone, anytime, and anywhere by removing locational, time and other restraints while increasing both its coverage and quality" (Varshney 2005, p. 4). Pervasive healthcare involves the wide-scale deployment of wireless networks to improve communication among healthcare professionals and patients (Varshney 2003). Examples of pervasive healthcare applications include mobile telemedicine and wireless patient monitoring.

Pervasive healthcare has the potential to reduce long-term costs and improve patient care and safety (Varshney 2003). Particularly, with the recent concerns about H1N1 influenza, healthcare organizations are making strategic

investments in technology to combat the pandemic. Pervasive healthcare may be invaluable in reducing the spread of communicable diseases such as SARS[9] and H1N1 influenza since it allows remote monitoring and communication between healthcare professionals and patients, as can be seen from the vital signs monitoring system which is the focus of this study. While previous studies have looked at the conceptual model and architecture of vital signs monitoring systems (see Table 4 for examples), research and understanding of its impacts is lacking, motivating us to focus on such systems.

Table 4: Sample Studies on the Vital Signs Monitoring System

Authors	Description of Study
Blount et al. 2007	Design, description and pilot tests of a remote healthcare monitoring system
Gao et al. 2005	Design and description of a wireless vital signs monitoring system
Paradiso 2003	Architecture and functions of a vital signs remote monitoring system
Park et al. 1998	Architecture of a vital signs patient monitoring system
Sneha and Varshney 2005	Architectural framework of a wireless ECG monitoring system
Sneha and Varshney 2009	Conceptual model of a wireless patient monitoring system

[9] SARS is an abbreviation for the Severe Acute Respiratory Syndrome. It is an infectious and possibly fatal viral respiratory illness.

3 RESEARCH FRAMEWORK AND PROPOSITIONS

This chapter describes the research framework and the propositions for this study.

3.1 Research Framework

As explained in Section 2.7, we will use the updated IS Success Model (DeLone and McLean 2003) as the theoretical lens and framework to guide the data collection and analysis of our case study. Although the updated IS Success Model introduced an additional construct Intention to Use, we chose to use the construct Use from the original IS Success Model (DeLone and McLean 1992) instead of Intention to Use. This is because at the time of our case study, the users have already started using the healthcare IS, hence it is more meaningful to study use rather than intention to use. Studying the Use construct is also consistent with past studies that chose to measure self-reported or actual use of an IS (Petter and McLean 2009). According to the updated IS Success Model, the antecedents of net benefits are information quality, system quality, service quality, user satisfaction and use. We will study these antecedents to understand how they affect net benefits of the system. Propositions are developed consistent with the updated IS Success Model.

3.2 Propositions

Information quality affects both use and user satisfaction (DeLone and McLean 1992). The quality of the information produced by the system

influences the usage of the system. Past studies have provided support for the positive relationship between information quality and system use (e.g., Bradley et al. 2006; Cao et al. 2005). Specifically for the vital signs monitoring system, information produced by the system are in the form of digital patient charts. The quality of these charts affects the extent that users (both physicians and nurses) use the system. Hence, we propose:

Proposition 1: Information quality is positively related to use.

Similarly, the quality of the information affects user satisfaction. In an earlier study on user-developed applications, there was strong support for the relationship between information quality and user satisfaction (McGill et al. 2003). Another study of web-based customer support systems also indicated that information quality is positively related to user satisfaction (Negash et al. 2003). A more recent study on e-learning systems also indicates that information quality has a positive effect on satisfaction of the system (Roca et al. 2006). In the context of our case, if the quality (e.g., data accuracy) of the digital charts is high, users will also be satisfied with the system. Hence, we propose:

Proposition 2: Information quality is positively related to user satisfaction.

System quality also affects both use and user satisfaction (DeLone and McLean 1992). System quality includes ease of use, response time and system reliability. These aspects are important in influencing users to use the system. Specifically in healthcare, where users such as doctors and nurses have hectic

schedules, system quality is important to ensure work is not affected by system problems. A system that is slow or unreliable will not be usable, especially during critical times of saving lives. Hence, we propose:

Proposition 3: System quality is positively related to use.

Similarly, system quality affects user satisfaction of the system. Strong support for the relationship between system quality and user satisfaction was found in various studies (e.g., Bharati and Chaudhury 2004; McGill et al. 2003; Negash et al. 2003; Roca et al. 2006). While a high quality system is likely to lead to user satisfaction, a system that is problematic, unreliable, or causes delay can lead to frustration and dissatisfaction to users, especially in the hectic pace of healthcare work. Hence, we propose:

Proposition 4: System quality is positively related to user satisfaction.

Service quality is a new construct added to the updated IS Success Model to reflect the emerging role of IS as both information provider and service provider (DeLone and McLean 2003). Service quality can affect the use of IS. In the context of healthcare IS, service quality refers to the quality of the support and service from the technology solutions provider of the healthcare IS. If service quality is lacking, it will affect system use as healthcare professionals are unable to obtain the help and support they need to use the system. Those who receive high-quality service will be able to use the system more (e.g., using more features and using the system more frequently). Hence, we propose:

Proposition 5: Service quality is positively related to use.

Past research has shown that service quality can affect user satisfaction of the IS function (Kettinger and Lee 1995). Similarly, the service quality of the technology solutions provider can affect the user satisfaction of the system. In a study on short-message service, service quality is positively related to user satisfaction (Lai 2004). In the context of our case, we expect that the quality of the service provided by the technology solutions provider (who provided the clinical IS) can affect user satisfaction. Users are likely to be more satisfied with the system if the service quality is high. Hence, we propose:

Proposition 6: Service quality is positively related to user satisfaction.

The extent of use can affect the degree of user satisfaction (DeLone and McLean 1992). It has been proposed that user satisfaction may explain intended use, while actual use (our focus for this study) explains subsequent user satisfaction (McGill et al. 2003). As cautioned by DeLone and McLean (2003), the nature of the causal relationships should be hypothesized in the context of a particular study. For example, a system that is high in quality will be associated with more use, which leads to more user satisfaction. On the other hand, more use of a poor quality system will lead to more dissatisfaction. In the context of our case, we expect that increased use of the clinical IS can increase user satisfaction. Hence, we propose:

Proposition 7: Use is positively related to user satisfaction.

Use and user satisfaction are direct antecedents of individual and organizational impacts (DeLone and McLean 1992). Continuing from the

earlier example, the more an individual uses a high-quality system, the more positive net benefits the user will experience. Similarly, at the organizational level, with the increased use of a high-quality system, there will be more positive net benefits at the organizational level. Previous research has found that system use is positively related to individual impact (e.g., Iivari 2005; Weill and Vitale 1999; Yuthas and Young 1998) and organizational impact (e.g., Gelderman 1998). In our case, we expect that increased use of the clinical IS leads to more net benefits. Hence, we propose:

Proposition 8: Use is positively related to net benefits.

Similarly, more use of a high-quality system leads to more user satisfaction, and this also leads to more net benefits. Past studies have found that user satisfaction is positively related to individual impact (e.g., Iivari 2005; Igbaria and Tan 1997; McGill et al. 2003) and organizational impact (e.g., Gelderman 1998; Yoon et al. 1998). A user who is satisfied with the clinical IS is more likely to experience more positive net benefits. Hence, we propose:

Proposition 9: User satisfaction is positively related to net benefits.

The updated IS Success Model includes a feedback loop, in which positive net benefits reinforces subsequent use and user satisfaction (DeLone and McLean 2003). A user who has experienced positive net benefits is likely to continue using the system. This is because the user perceives the system as useful (given the net benefits) and this leads to further use. In a similar tradition, Seddon (1997) proposed that expectations of net benefits lead to use of IS. Hence, we propose:

Proposition 10: Net benefits is positively related to use.

Similarly, a user who has experienced positive net benefits is likely to be more satisfied with the system. For example, in the healthcare context, users of the healthcare IS who have experienced positive net benefits are likely to be more satisfied with the system as they appreciate the value and usefulness of the system. A study on the use of telemedicine also suggests that experiencing net benefits (e.g., effective patient care) can lead to user satisfaction (LeRouge et al. 2007a). Hence, we propose:

Proposition 11: Net benefits is positively related to user satisfaction.

4 RESEARCH METHODOLOGY

As the use of clinical IS in healthcare is still an emerging field, there are few studies that explore their use in IS research. This prompts us to use the case study method as it allows us to study the impact of IT in a natural setting, and to answer the "how" question (Benbasat et al. 1987), i.e., how do we assess the net benefits of a healthcare IS (RQ1) and how do information quality, system quality, service quality, IS use, and user satisfaction interrelate and affect the net benefits (RQ2). Hence, the case study method is a good fit with our research questions and objectives. Moreover, the IT system that we are studying, i.e., wireless vital signs monitoring system, is an emerging technology which is newly being deployed in hospitals. This makes the case unique and revelatory (Yin 1994) and is therefore a good choice for an in-depth study. A case study is thus conducted to reveal insights concerning the value and impact of a particular IT system in a hospital. The case study method adds to richness of the data and the context of the framework. The findings of the case study are expected to provide a deeper understanding of net benefits of healthcare IS impact and the antecedents of net benefits. The rest of this chapter describes this explanatory positivist case study to test the updated IS Success Model in the context of healthcare IS.

4.1 Background of Hospital

In Singapore, healthcare services are provided by both the government and the private sector[10]. Hence, Singapore's healthcare system comprises of public and private healthcare. Public health services are subsidized through general taxation.

In the primary healthcare sector, private practitioners provide 80% of primary healthcare services while government polyclinics provide the remaining 20%. There are a total of 18 outpatient polyclinics and about 2,000 private medical practitioner's clinics providing primary health care services.

In the secondary healthcare sector, public hospitals provide 80% of the more costly hospital care with the remaining 20% of care provided by private hospitals. There are seven public hospitals which consist of five general hospitals, a women's and children's hospital, and a psychiatry hospital. The general hospitals provide inpatient and specialist outpatient services, and 24-hour emergency departments. The Singapore Government has restructured all its hospitals such that though they are wholly-owned by the government, they have autonomy and flexibility in management so as to respond more promptly to the needs of the patients. The restructured hospitals receive an annual government subvention or subsidy for the provision of subsidised medical services to the patients, making them different from the other private hospitals. Hence, 80% of public hospital beds are heavily subsidised. These restructured

[10] Most of the information in this section is taken from the website of the Ministry of Health (MOH), http://www.moh.gov.sg. Last accessed in January 2010.

hospitals are to be managed like not-for-profit organisations and are subject to broad policy guidance by the Government.

The public healthcare system is delivered by four broad clusters: the Alexandra Health Pte Ltd, National Healthcare Group (NHG), National University Health System (NUHS), and Singapore Health Services (SingHealth). SingHealth is the largest cluster of public healthcare institutions in Singapore, consisting of three hospitals, five national specialty centres and nine primary healthcare polyclinics. NHG is another large cluster consisting of two hospitals, three national specialty centres and nine primary healthcare polyclinics.

First Public Hospital (FPH)[11], one of the public hospitals in Singapore, was selected as the case study site as it is at the leading edge of using IT in healthcare. In addition, FPH is keen to study and document the impact of using IT in healthcare. FPH is one of the largest hospitals in Singapore and accounts for about one quarter of the acute beds in Singapore.

FPH is highly conscious of quality. It is committed in the areas of clinical quality to provide safe and integrated care delivery, and service quality to provide seamless service and personalized care. Its quality is demonstrated in various clinical outcomes, such as rehabilitation outcomes and in vitro fertilization outcomes. FPH's emphasis on service is also demonstrated in the

[11] The name of the hospital has been changed to protect the confidentiality of the case.

number of Excellent Service Awards[12] received in 2007. The total number of awards received by FPH is far more than any other healthcare organization in Singapore.

FPH has been very advanced and innovative in the use of IT. All medical records are fully computerized using its electronic medical record system. Patients are reminded about their appointments through SMS on their mobile phones. Educational reminders and messages such as how to use an inhaler correctly are also sent to patients through their mobile phones. FPH aims to be the "digital healthcare provider of the future". Future plans include point-of-care and bedside computing, to enrich patients' stay experience and to improve communication and counseling between doctor and patient.

4.2 Vital Signs Monitoring System Project

One of FPH's recent IT projects is to develop an integrated wireless vital signs monitoring system. The monitoring of vital signs using existing manual practices is a tedious, time-consuming, and interruptive manual task. Hence, FPH proposed a new integrated IS to ease the work of the clinicians and nurses and to enable them to focus on delivering quality patient care. FPH identified the following as the objectives of the new vital signs monitoring system: (1) To enhance patient safety (2) To enhance patient care; and (3) To improve operational efficiency.

[12] The Excellent Service Award (EXSA) is a national award that recognizes individuals who have delivered outstanding service. It seeks to develop models for service staff to emulate, create service champions and enhance professionalism in service delivery.

The new system is a web-based, integrated software system. It consists of several components – vital signs monitoring devices to be attached to the patients, a web-based graphical user interface used by the nurses and clinicians, a database server and a web server at the backend. It makes use of the wireless infrastructure in the hospital. This system monitors six vital signs (blood pressure, pulse, temperature, electrocardiogram, oxygen saturation[13], and respiration rate) and includes a software module for nurses to manually enter the pain level of the patient. Each patient wears a RFID tag for identification and registration to the system. In addition, the RFID tag allows the system to do location tracking of the patient.

The technology was developed by a local healthcare IT vendor in partnership with FPH. As it is a new technology and clinical results have not been validated, FPH decided to introduce this system as a trial in a selected ward consisting of about 80 beds. The development and trial was carried out for a year, ending in August 2007. The actual trial period was over several weeks from May to August 2007. The trial was implemented by a project team, consisting of the doctor who championed the project, nurses in the selected ward, the IT team from FPH, and the vendor.

4.3 Data Collection and Analysis

To ensure rigor in conducting this case study, we adhered closely to the criteria and practices suggested by Dube and Pare (2003) for a single-case

[13] Oxygen saturation (SpO_2) is a measure of the amount of oxygen attached to the red blood cells in the circulatory system.

study. The list of criteria is established from Benbasat et al. (1987), Yin (1994), Eisenhardt (1989) and Lee (1989), and consists of three areas: (1) Research design (2) Data collection (3) Data analysis. The relevant criteria that we practiced in this study are summarized in Table 5. Criteria for multiple-case study are excluded from the table as our study is a single-case study.

Table 5: Practices for Rigor in Case Research

Criteria	Reference
Area 1: Research Design	
Clear research questions and a priori specification of constructs – Our research questions are as described in Chapter 1. A comprehensive literature review was conducted before the study for prior theorizing. Constructs are described and defined in Table 7.	Dube and Pare 2003; Eisenhardt 1989
Theory of interest and predictions from theory should be presented for explanatory case studies – Our theory of interest is the updated IS Success Model and predictions are based on this model.	Dube and Pare 2003
Nature of single-case design – Our case was selected on the basis that it is unique and revelatory. It is rare to obtain access to a site where a new and emerging healthcare IT system is being implemented.	Dube and Pare 2003
The context and the setting of the case are clearly described – This is described in Section 4.1 and Section 4.2.	Dube and Pare 2003; Yin 1994
Use of multiple investigators, as a team of researchers can capture greater data richness, foster greater confidence in the findings, and maximize reliability – Both the main researcher and a student assistant conducted the data collection and analysis.	Dube and Pare 2003
Area 2: Data Collection	
Elucidation of the data collection process – Our data collection process is clearly described in this section.	Dube and Pare 2003
Multiple data collection methods: (1) Documentation – Secondary data was collected from FPH, which consisted mainly of project reports, presentation slides and quantitative data that was collected by FPH during the trial. Other secondary data came from the Internet, such as the FPH's website and the vendor's website. (2) Archival records – This was not relevant to the case and hence was not collected. (3) Interviews – 16 semi-structured interviews were conducted. All interviews were transcribed and analyzed. Details can be	Dube and Pare 2003; Yin 1994

found in Table 6. (4) Direct observation – Site visits and observations were conducted to study the nurses' work processes. (5) Physical artifacts – We observed the use of the vital signs monitoring system.	
Data from various sources are triangulated to provide strong substantiation of constructs. Our findings were based on data from different sources as listed above.	Dube and Pare 2003
Development of case study protocol and case study database – We developed a case study protocol describing the objectives, schedule and type of access required, a comprehensive literature review (part of which is included in this paper), and a set of questionnaires to guide interviews. Our case study database consisted of the case study protocol, interview transcripts and field notes, secondary data, coded data and coding template.	Dube and Pare 2003; Yin 1994
Area 3: Data Analysis	
Data collection process is clearly described. The data analysis procedures are described in this section to help the reader understand the findings and to judge whether the results are derived from a systematic and rigorous process.	Dube and Pare 2003
Data collection and analysis are conducted in an overlapping manner – This allowed us to maintain flexibility in data collection. For example, the doctors and the assistant project manager were interviewed before the nurses so that initial issues could be analyzed and this was taken into consideration when developing the interview guide for the nurses.	Dube and Pare 2003; Eisenhardt 1989
Coding to observe the logical link between the theoretical model and the codes – Template coding was conducted using qualitative research software to identify key concepts and recurring themes. To ensure reliability of the data analysis, coding was conducted independently by two researchers. Axial coding followed after template coding.	Dube and Pare 2003
Maintaining logical chain of evidence – We categorized the findings according to the coding process and the constructs of the research framework, and drew discussions from there.	Dube and Pare 2003; Yin 1994; Benbasat et al. 1987
Using a data analysis strategy – Our strategy was to test our data against what was proposed by our research framework.	Dube and Pare 2003; Yin 1994
Quotes are used extensively as evidence and to "bring in the voice of participants in the study" – Relevant quotes were included in Chapter 4 which describes our findings.	Dube and Pare 2003; Creswell 1998, p. 170
Soliciting views of research subjects for credibility of interpretations and findings – At the conclusion of the case study, we solicited the project manager's views on the credibility of interpretations and findings.	Dube and Pare 2003; Yin 1994

The primary data collection method was through interviews with participants and other project members, conducted shortly after FPH concluded its trial using the vital signs monitoring systems. We also conducted site visits and field observations to understand how the system was used in the hospital. The field observations also helped in understanding the context so that we could develop appropriate interview questions for project team members and also understand the clinical jargons used.

Table 6 shows the list of interviewees. The interview sessions were semi-structured to allow the interviewers to probe emergent themes and make use of special opportunities which arise during the conversation with interviewees (Eisenhardt 1989). The interview data was analyzed after each session to make adjustments to subsequent data collection (Eisenhardt 1989). Each interview session lasted an average of 60 minutes for the project managers and 45 minutes for the nurses. All interviews were recorded and transcribed. Next, the NVivo 7 software for qualitative analysis was used to code the interview data. The coding allowed us to observe the logical links based on our initial framework and to identify recurring themes (Dube and Pare 2003).

Table 6: List of Interviewees

Interviewees	**Number of Interviews**
Research and Policy Director (Doctor)	1
Project Advisor (from IT department)	1
Project Managers (from IT department)	2
Project Champion (Doctor)	1
Senior Nurses (Users)	8
Junior Nurses (Users)	2
Technology Solutions Provider (Vendor)	1
Total	**16**

As the updated IS Success Model was used as a theoretical lens for this study, constructs were defined a priori according to this theoretical model. We adopted King's (1998) template coding data analysis approach, where codes are specified a priori, but may be modified as the researcher analyzes the data. The template consists of the categories that are relevant to our study on IT impact. Table 7 shows the final template used for this study.

Table 7: Template for Categories and Subcategories

Categories and Subcategories	**Definition and Description**
Information Quality	This refers to measures of information system output, i.e., the quality of the information that the system produces (DeLone and McLean 1992). It includes information accuracy, reliability, timeliness and data accuracy.
System Quality	This refers to measures of the information system itself (DeLone and McLean 1992). It includes system reliability and performance.
Service Quality	This refers to measures of the service provided for end users (DeLone and McLean 2003). This usually measures the support that is provided by the IS department to use the system. *In this case study, it refers to the service provided by the technology solutions provider (the vendor). It includes training and relationship with users (Goodhue and Thompson 1995).*
Training	*This refers to training to learn how to use the system. In this case, training is provided by the technology solutions provider (vendor).*
Relationship with users (vendor service)	*Goodhue and Thompson (1995) intended this to refer to the relationship of the IS function with the business users, but in an outsourced setting, it refers to the relationship between the technology solutions provider (the vendor) and the users of the system. Relationship with users includes areas such as responsiveness and dedication (Goodhue and Thompson 1995).*
Use	Use refers to the consumption of the output of an information system (DeLone and McLean 1992). While use can be actual use or perceived use, this study measures perceived use by questioning users about their use of the system (DeLone 1988). *Use can be measured through regularity of use (Davis 1989), frequency of use (Taylor and Todd 1995), or extent/range of features used (Hartwick and Barki 1994; Burton-Jones and Straub 2006). However, this study finds that the regularity, frequency and extent of use were quite consistent across the*

	nurses due to the nature of the task and system (e.g., all vital signs were to be measured by the system at regular intervals). The updated IS Success Model suggests the possibility of measuring intention to use, instead of actual use. Hence, while we coded based on the usage of the system, we also noted comments concerning the nurses' intention to use the system in the future when the system is to implemented permanently (instead of a trial basis).
User Satisfaction	While DeLone and McLean (1992) defined this as the user's response to the use of the information system *output*, user satisfaction can also refer to user's response to the underlying information system (e.g., Swanson 1974). User satisfaction is also associated with user attitudes towards the information system (Lucas 1978).
Net Benefits – Individual Impact	This refers to the effect of information on the behavior of the user (DeLone and McLean 1992). It is mainly measured through job performance. *Impact generally has two dimensions – efficiency and effectiveness (Beal et al. 2003; Campbell 1990).*
Efficiency (Individual)	*This refers to productivity or improvement of individual work. An example is time savings achieved through the use of the information system.*
Effectiveness (Individual)	*This refers to improvement or change in outcome of individual work. An example is the nurse's delivery of better patient care achieved through the use of the information system.*
Net Benefits – Organization Impact	This refers to the effect of the IT (or output of the system) on the organizational performance. *Impact generally has two dimensions – efficiency and effectiveness.*
Efficiency (Organization)	*This refers to the internal dimension. It applies to internal processes such as productivity enhancement, cost reduction, or inventory reduction. In other words, it is about "doing things right" (Drucker 1966).*
Effectiveness (Organization)	*This refers to the external dimension. It includes outcome measures, which are measured from objects upon which work is performed (Shortell and Kaluzny 1994).An example is patient outcome. It also includes competitive impacts. Competitive impact manifests itself in the external environment and usually refers to uniqueness of a particular firm relative to its competitors, involving the creation of a valuable strategic position (Porter 1996).*

Note: The original categories are in normal font and were derived from the updated IS Success Model. Subcategories are then added, indicated in italics. Modifications to the definition of the categories (based on our data analysis) are also indicated in italics.

Axial coding is conducted after template coding, to gather insights concerning the relationships between the categories in the research model. Chapter 5 describes our findings.

5 FINDINGS

In this chapter, we describe our findings based on template coding and axial coding of interview transcripts. We first describe the antecedents of net benefits, then the net benefits, and lastly the relationships between the constructs (i.e., how the antecedents affect the net benefits), for the wireless vital signs monitoring system under study.

5.1 Antecedents of Net Benefits

Findings concerning the antecedents of net benefits are summarized in Table 8. Net benefits are not discussed in this table as we will provide a more thorough discussion of net benefits in Section 5.2.

Table 8: Findings on Antecedents of Net Benefits

Construct	Findings
Information Quality	▪ Doctors do not deem the *information quality* from the vital signs monitoring system to be significantly better or worse than what that was obtained manually without the system. The system is designed to produce charts that look similar to the manual charts, so that it is transparent to the doctors. Nurses were pleased with the way information is presented in the digital charts. The *format* was clear and consistent. ▪ Using the vital signs monitoring system gives better *data reliability*. There is no variance from the human factor and the system measures the data in a consistent manner each time. ▪ Data is also captured in a *timely* manner. For example, setting the system to take readings four hourly is guaranteed to give readings every four hours, whereas if the nurses were to take the measurements manually, it may not be precise at every four hours, and some of the readings may be missed. ▪ However, there are limitations in the *data accuracy* of the vital signs monitoring system. For example, the technology is not able to measure accurately very low blood pressure. In such cases, the system is able to alert that blood pressure may not be accurate, thus prompting the nurse to take blood pressure measurement

	manually. Some of the nurses were of the opinion that the temperature readings from the vital signs monitoring system were not as accurate as those obtained manually. Nevertheless, tests conducted by FPH showed that data accuracy was acceptable by clinical standards.
System Quality	▪ A few nurses reported issues in *system reliability*, such as the device or the system "hang". However, these could be due to initial teething problems when the system was newly implemented. There were also other nurses who did not encounter any system problems. ▪ It was observed that the *performance of the system* deteriorated when there was too much data input at the same time (e.g., during ECG monitoring). Some of the nurses also commented that it took a long time to "go into the system". However, the slow response time could be caused by the vital signs monitoring system or the network infrastructure used by the system.
Service Quality	▪ The nurses were of the opinion that the service quality from the vendor is good. The *training* provided by the vendor was perceived to be effective, and the vendor provided a good level of *support and availability*. The relationship between the vendor and the nurses was good too, as the nurses noted that the vendor was responsive to user needs. ▪ The nurses did not bring up any issues concerning service quality. They had no complaints concerning the support or training provided by the vendor.
User satisfaction	▪ Most of the nurses were *satisfied with the interface* of the system. This could be partly due to the fact that doctor and nurses were consulted during the development process. They gave their inputs concerning the workflow and the user interface. The involvement from users, i.e., doctors and nurses, probably encouraged usage too, as the system was designed according to their needs. ▪ A few nurses pointed out that the registration of patients (when the devices were first put on the patients and patient data was first entered into the system) was inconvenient. ▪ Most of the nurses had a positive attitude towards the system and felt that the system would be useful.
Use	▪ Most nurses were eager to try using the system when they first heard about it. ▪ All nurses whom we interviewed participated fully in the trial by using the system as part of their job. ▪ As the system was implemented on a trial basis, nurses also expressed their desire to see the system implemented on a permanent basis as they were pleased with their experience during the trial. Most nurses also looked forward to the long-term use

	(rather than trial use) of the system. This meant they intended to use the system in the future when it is rolled out on a permanent basis.

5.2 Net Benefits

The net benefits of the system include how the system impacts organizational and individual performance. We will discuss how the system impacts efficiency and effectiveness at both levels.

5.2.1 Organizational Impact

The system has the following objectives: (1) To enhance patient safety (2) To enhance patient care; and (3) To improve operational efficiency. To aid our analysis, for each objective we classify whether it contributes to efficiency or effectiveness at the organizational level. *Patient safety* is enhanced through continuous and frequent measurement of patient vital signs at all times even when patient is asleep, faster detection of abnormalities, reduction of errors, reduction in number of missing vital signs readings and reduction of infection rate. Continuous automatic measurement leads to time savings and thus increases organizational efficiency. Faster detection of abnormalities, reduction of errors, reduction of missing vital signs readings, and reduction of infection improve patient outcome and thus increase organizational effectiveness. The findings on patient safety are summarized in Table 9.

Table 9: Findings on Benefits concerning Patient Safety

Benefits	Findings	Examples
Organizational Efficiency		
Continuous frequent monitoring	The system measured vital signs automatically on a continuous frequent basis. This automated the nurse's job of measuring vital signs, thus leading to time savings and increasing overall efficiency.	*"Sometimes doctors order half hourly parameters, but we don't have the time. So with this wireless [system] it is actually useful. You can program it to be half hour, and it will just continue [taking measurements] every half hour." – Nurse*
Organizational Effectiveness		
Faster detection of abnormalities	The use of this system enabled faster detection of any abnormalities in vital signs that require immediate attention. This was especially useful during critical times or for situations in which patients are not in an intensive care unit, yet require closer monitoring. As observed by a doctor, the layout of the ward was such that the nurses did not have visibility of the patients when they are at the nurse station. Hence, the use of the monitoring system helped the nurses to be alerted earlier if there was any change in the patients' vital signs or indication that the patient needed attention.	*"[The system allows us] to detect the abnormalities as soon as we can, because now we don't have to wait for one hour to see [whether] the patient has fever or not. The computer screen actually will flash…" – Nurse*
Reduction of errors	The system provided reliability and consistency of measurements. No human error was involved in measuring and recording on patient charts.	*"It's better in the sense that it captures automatically and we are not scared that we make errors like what we did manually... Sometimes we make very small dots, whereas in this system, it's all standard dots." – Nurse*
Reduction in missed readings	Doctors observed that sometimes there were missing readings when vital sign measurements are taken manually. This was because nurses are sometimes reluctant to disturb patients who are resting. However, as the vital signs monitoring system allowed measurements to be taken automatically even when the patient is resting, there was a reduction of	*"And so often times, nurses will 'cut corners'. Because they take pity on the patient, after tossing and turning, they finally fall asleep, then it's time to check the blood pressure, ask them to slip the probe into their ear, so nurses will look and just write patient's details." – Doctor*

	missing readings. This allowed any abnormal readings to be detected on a timely basis.	
Reduction in infection	With the vital signs monitoring system, contact with the nurse was not needed for vital signs measurement. This lowered the probability of infection spreading from patient to nurse. Such benefit is especially important during outbreaks of infectious diseases, such as SARS. The wireless and automatic monitoring of vital signs can minimize contact between nurses and patients, thus reducing chances of infection during pandemics.	*"We find that our device is actually well-suited [during situations such as SARS and bird flu] because it's all wireless…" – Project champion*

Patient care is enhanced through less disruption to patients' rest and more time spent delivering quality patient care. Both of these contribute to organization effectiveness, as they improve patient outcomes. The findings on patient care are summarized in Table 10.

Table 10: Findings on Benefits concerning Patient Care

Benefits	**Findings**	**Examples**
Organizational Effectiveness		
Less disruption to patient's rest	Oftentimes, patients need to be monitored frequently (such as in hourly intervals) for their vital signs. When nurses come around to measure the vital signs, this may disrupt patients' rest. Hence, the use of vital signs monitoring system allowed patients to continue resting even when their vital signs were silently and automatically measured through the monitoring devices that they were wearing.	*"It is quite good for the patients because when you are in hourly parameters, you can at most get 55 minutes of uninterrupted sleep at that point in time, and when patients are in hospitals, they really should be resting... So this [system] probably enhances the quality of [care] for the patients during this period of time." – Doctor*
More time spent delivering quality care	When nurses were freed from the manual task of measuring vital signs, this enabled them to deliver better care to the patients. Patients should be able to experience better patient care and recovery.	*"In future, if all these [vital signs] don't have to be taken by the nurses… the nurses' time can be better spent on other areas like patient care and patient education." – Project advisor*

The third objective of the vital signs monitoring system is to increase operational efficiency in various ways, such as saving cost and manpower, increasing bed capacity, and streamlining communication. These contribute to organizational efficiency. Findings are summarized in Table 11.

Table 11: Findings on Benefits concerning Operational Efficiency

Benefits	**Findings**	**Example/Source**
Organizational Efficiency		
Saving cost and manpower	FPH estimated that through the use of the monitoring system, the time savings achieved per day per patient would be about 8 min. By extrapolating this figure, the potential time savings per year for a ward with 80 beds would be more than 4,000 hours. This leads to a potential annual manpower cost savings of about S$200k. In addition, it is possible to delegate the task of registering devices to administrative assistants as these tasks do not require the medical expertise of nurses. This may free up some nurses, who can then be deployed to other places where they can be more useful or where the nurse-patient ratio may be more critical such as in the ICU.	This finding was provided by FPH through their presentation slides and quantitative data on timings.
Increasing bed capacity	More effective patient care and safety (as discussed in Table 9 and Table 10) should translate to quicker recovery and better outcomes. Early recovery of patient may lead to earlier discharge, thus indirectly increasing the bed capacity of the hospital.	*"If patient is not disturbed during their rest time, they can have more rest, so when they have rested more, they can get well better. So when they get well faster they can recover faster, and can be discharged earlier. So in that sense, when they are discharged early, we can have more beds for other patients to use."* – Nurse
Streamlining communication	Communication between doctors and nurses can be improved by sending the vital sign readings (which is digitized by the system) directly to the doctor's mobile phone or personal digital assistant	*"The communication between the nurse and the doctors can potentially become a lot better. If you could send the trend data to doctor's mobile phone, or PDA or whatever, than you*

	(PDA). The nurse does not have to elaborate on the vital sign readings as the doctor can see the readings directly and make an assessment immediately.	*don't need to explain to the doctor that patient's temperature is going up, or like this is what it was 5 minutes ago."* – Doctor

It is also important to assess the potential of these technologies in providing *competitive advantage*, as this pertains to IT value and the external dimension of IT impacts at the firm level. As one of the doctors commented, the use of such a system, together with the other new technologies used by the hospital, strengthens the positioning of the hospital as one that is at the leading edge of IT. When asked if the use of technologies will improve the competitive positioning of the hospital, the project champion replied:

> *"I think the main thing is the patients, that they will like [the system], and they will benefit from it. And from there, they have a positive experience with this IT…The patient will mention it, they will like it, and have a positive impact on patients coming to our hospitals and so on. Although our main purpose is not to draw patients, but it does have a positive impact on how the patients see our hospital."*

A nurse commented:

> *"If [the patients] have more rest in the hospital, they get better faster, of course word will spread that 'FPH is using this device, that's why they don't have to wake me up and I can fully sleep through the night yet being monitored by the nurses at the counter.'"*

However, there are also nurses who think that it is unlikely a patient would choose a hospital based on its IT adoption and use. A nurse commented:

> *"Nowadays patients choose hospitals…because of the surgeon, not because of the devices. If you interview ten patients, I think eight out of ten patients will tell you they don't choose the place because of the nurses or because of the devices or facilities that we have. They choose because of the doctors that we have."*

5.2.2 Individual Impact

For the vital signs monitoring system under study, the individual impact being assessed is for the users, i.e., nurses. From the interviews, it is clear that the use of the vital signs monitoring system impacts the nurses' work, as it automates part of the nurses' duties. Impact on individual work can be seen in various ways. The most notable impact is the time savings. For example, a nurse explained:

> *"We don't have to do frequent rounds … for example this evening I have four patients going for evening operations, so when they come back, I have to do every hourly rounds for these four patients. But [with this system] I can see all the vital signs on the monitor already. So the other things I can do is to spend more time on the patient's other needs, rather than more time on their vital signs."*

Another nurse described her hectic work as a nurse and was glad that using the vital signs monitoring system could reduce her workload:

> *"Of course it will save a lot of time. We will have more time to do other things…Like we have to give gargle in the morning to the patient… Imagine we have to take temperature, BP and pulse rate and at the same time give gargle. Gargle means wash patient, brush teeth, wash face, so it is actually very time consuming. [With the system], we don't have to take temperature, only do gargle… give IV, and antibiotics…"*

Time savings translates to *efficiency* for the nurses. The more interesting question is whether the time savings also increases job *effectiveness*. While it is expected that the use of such automation technology frees nurses from the manual task of measuring vital signs thus enabling them to deliver better care to patients, findings indicate conflicting views. A few nurses commented that not taking vital signs measurements personally may mean less interaction with patients. One of the nurses commented on the "lack of human touch". Another nurse commented:

> *"If you need to take [vital signs] manually, you need to go to the patient. But if [we are using the system], you can see the reading already so maybe you did not approach the patient and you didn't check the patient."*

However, six out of the ten nurses we interviewed felt that the system would give them more time to deliver quality care to patients. For example, a nurse commented:

"We can spend more time on the bedside care, like talking to the patient on how their condition is, or teaching them more on their condition…rather than busy taking temperature."

Another nurse commented:

"At least you will not get stuck at the patient…you can improve your service, give extra to patients."

One of the nurses observed the following, which aptly summarized our findings concerning the impact of the system on job effectiveness especially patient care:

"It's up to the person how she prioritize or plan her work to do…Depends on the person, depends on how she manage her time."

5.3 Model Relationships

Axial coding is conducted to examine the relationships between key constructs as per the updated IS Success Model. Our findings are described in this section.

Proposition 1: Information quality is positively related to use.

Information quality is an important factor in determining use. If information quality, especially data accuracy, was not satisfactory, nurses would not want to use the wireless system and would have to revert back to the manual system. A nurse commented:

"I don't know if [the data] is accurate ... [If] the results are accurate, it should be ok. If every time [it] shows undetectable, [it] will cause me some trouble. We have to go and look at the patient."

In fact, data accuracy is one of the most important factors determining the hospital's use and adoption of the vital signs monitoring system. One of the main objectives of the trial conducted at FPH is to determine if the vital sign readings measured by the system are acceptable by clinical standards.

Proposition 2: Information quality is positively related to user satisfaction.

We found that information quality increased user satisfaction. Nurses were generally satisfied with the information output from the system, leading to satisfaction with the system. Some nurses also compared the information output (digital charts) from the system with the old manual charts and they expressed satisfaction with the new digital charts. When the digital output of the system is usable, nurses are satisfied with the system. One of the nurses commented that she was not satisfied with the system because there was a situation when the readings from the system were not as accurate as readings obtained manually. While this was a teething problem during the initial deployment of the system which was later resolved, it also indicated how information quality affects user satisfaction.

Proposition 3: System quality is positively related to use.

System quality is also important in affecting use. If the system was problematic or did not work smoothly, nurses would not be able to use the system. We also find evidence in the case which emphasizes the need for a high quality system for the nurses to experience net benefits. For example, one of the nurses commented:

> *"If [the system] works smoothly, if it does not need to wake up the patient, then I will feel it will help me to save time and do my job faster."*

In order for nurses to experience net benefits of a high quality system, they must first use the system. Hence, we see that system quality affects use, which in turn affects usefulness.

Proposition 4: System quality is positively related to user satisfaction.

System quality also increased user satisfaction. Nurses were generally happy with the system interface, leading to user satisfaction. They found the system easy to use, although a few nurses felt that the patient registration process was inconvenient (as described in Table 8). Users are also satisfied when the system is easy to use and thus allows them to save time. For example, a nurse commented:

> *"But [for this new system], you just press the button, it just start automatically. And everything is there so we can save time."*

Proposition 5: Service quality is positively related to use.

Service quality is also found to affect use. Availability of vendor support helped to improve use of the system. Effective training by the vendors also encouraged use. When asked about the training, a nurse answered:

> *"Yes, [the training was effective]. [The nurses] have confidence in using the device, they can help each other. Even though the trainers are not around, they can learn from each other."*

Another nurse commented that more training will help the nurses to be more efficient when using the system.

Proposition 6: Service quality is positively related to user satisfaction.

Service quality was also found to increase user satisfaction. Almost all nurses were pleased with the service provided by the technology solutions provider (vendor). The vendor was responsive to their needs and rendered good support, leading to satisfaction with the system. For example, a nurse commented:

> *"Everything we ask for, [the vendor provided]… the next step is we wish the system can be rolled out [permanently]."*

Proposition 7: Use is positively related to user satisfaction.

This proposition is closely related to net benefits (see Proposition 8). We found it difficult to find supporting evidence to distinguish Proposition 7 and Proposition 8 as they are related. Nurses who used the system were usually satisfied with the system because they experienced the benefits of the system. For example, a nurse commented:

"With the monitoring [system], I finish my job early."

Proposition 8: Use is positively related to net benefits.

Nurses who used the system during the trial were also able to experience the net benefits of the system. Most of the nurses expressed that using the system allows them to save time. For example, one of the nurses described:

"The [biggest] benefit is we save time. For the staff nurses and the juniors, I think it lessens our workload."

Another nurse who used the system commented:

"Can save time then you can spend more time on the patient."

The main net benefit obtained from using the system is efficiency, and some of the nurses further commented that the time savings allow them to deliver better patient care.

Proposition 9: User satisfaction is positively related to net benefits.

While there were no substantial evidence relating user satisfaction as a direct antecedent to net benefits, it is clear that both user satisfaction and net benefits are generally high. This is also related to Proposition 7 and 8. Nurses who used the system are generally highly satisfied as they experienced the net benefits of the system. On closer examination, the case provides more evidence for the causal relationship of Use → Net Benefits → User Satisfaction (Proposition 8 and 11), rather than Use → User Satisfaction → Net Benefits (Proposition 7 and 9)

Proposition 10: Net benefits is positively related to use.

Doctors perceived that nurses will accept and use new technology if they see the *value* of the technology. For example, if the nurses are clear that the technology improves patient care, they are prepared to try it. FPH managed the whole process well by getting nurses to contribute in user requirements, which helped in designing a system that is beneficial to their work. FPH also persuaded the nurses to see the value of the system. This was related to our findings pertaining to user satisfaction (see Table 8). Nurses who were satisfied with the system were more excited to use the system. For example, a nurse commented:

> *"For me, yes, [I want to use this system], because it can help us also to save our time, then we can do other things too."*

Hence we see that nurses who are convinced about the net benefits of the system are more willing to use the system. Nurses who experienced the net benefits of the system during the trial are also eager to see the system implemented on a permanent basis in the hospital, so that they can continue to use the system in the future.

Proposition 11: Net benefits is positively related to user satisfaction.

We also observed that net benefits experienced by the user can influence the user's attitude pertaining to the usefulness of the system. Users who experienced net benefits and value of the system are more satisfied with the system. While the system provided various net benefits at organizational level (as discussed in Section 5.2.1), users relate more to individual net benefits,

especially pertaining to the continuous automatic measurements which give them time savings. This gave nurses the most reason for their satisfaction with the system.

In general, we also noted that most of the net benefits brought up by the nurses pertain to the individual level. Their use of and personal experience with the system helped them to relate to individual impacts. The organizational impacts were described by the project managers and champions who had an overall view of the organization.

From the above findings, we can see that there is generally support for most of the relationships in the updated IS Success Model. Figure 4 summarizes our findings. All propositions are supported, except Proposition 7 and 9 which are partially supported. We will discuss these findings and the implications of the findings in the next chapter.

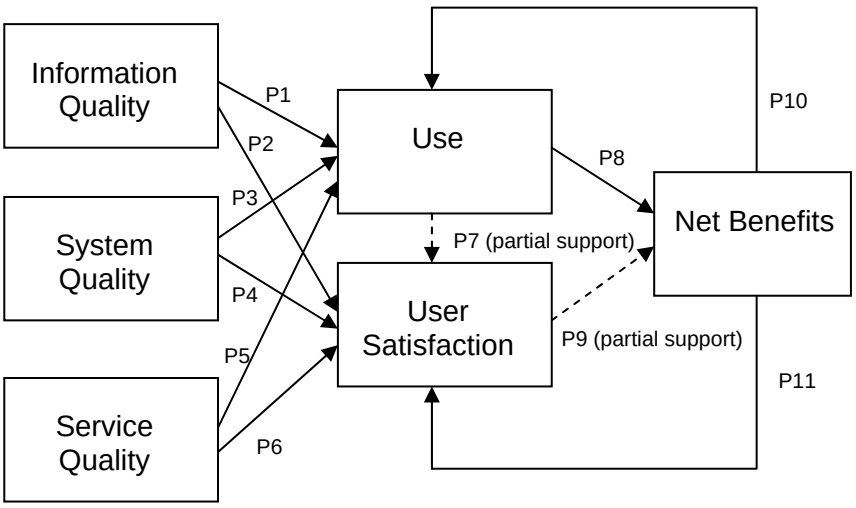


Figure 4: Research Framework and Findings

6 DISCUSSION AND IMPLICATIONS

6.1 Discussion of Findings

We will first discuss the antecedents of net benefits (RQ2) followed by the net benefits of the system (RQ1).

Information Quality and System Quality

From the case findings (as described in Table 8), it appears that nurses are more concerned with information quality and system quality, than service quality. As this system is intended to reduce human errors and improve patient safety, *information quality*, especially the aspect of data accuracy, cannot be compromised. The accuracy and utility of the digital charts from the system is critical for nurses and doctors to experience the benefits of the system. Lack of information quality affects the use and effectiveness of the system, as patient safety is compromised. If the output produced by the system cannot be trusted, nurses will also have to take extra steps to check the vital signs of the patients, thus affecting efficiency. *System quality* is also vital as the system is intended to save time and improve efficiency. Hence, it is important for the system to be reliable and fast to maximize time savings. If the system is slow or unstable, it will be counterproductive.

It appears that system quality is critical in improving efficiency, whereas information quality is critical in improving effectiveness. However, system quality can also affect effectiveness. For example, if the system is slow or

unstable, this may nullify some of the benefits such as faster detection of abnormal readings. Similarly, information quality can also affect efficiency. For example, nurses do not save time if the system output cannot be trusted or is unusable, as they have to manually measure the vital signs.

We also emphasize the importance of information quality, as clinical IS is used for patient safety, and data accuracy therefore cannot be compromised. We see in our case findings that the hospital takes care to ensure that data accuracy is acceptable according to clinical standards and this is a strong determining factor for the adoption and use of the system. In fact, data accuracy is so important, that a prior study on telemedicine system success has proposed an additional antecedent of system use, named input data quality (Hu 2003). Input data quality refers to the degree that the data (e.g. input to a telemedicine system, or inputs to a vital signs monitoring system which comes from biosensors) correspond to the actual source (e.g., accuracy of the vital sign measurements as obtained from the biosensors). In our study, input data quality is analyzed as part of information quality.

Service Quality

Service quality is of less concern to the nurses (compared to information quality and system quality), possibly because the nurses are satisfied with the initial training and service provided by the vendor. The case also reveals training and service provided by the vendor as antecedents of service quality.

While there are definite benefits of looking at the quality of the information system in different dimensions, i.e., information quality, system quality and service quality, nevertheless the updated IS Success Model, seems to differ little in terms of utility when compared to the original IS Success Model. The addition of the service quality construct may add to the completeness of the different dimensions of a system, yet it does not seem to play an equally important role compared to information quality and system quality. After all, an information system is a system that provides information – it is difficult for service quality to be placed on the same weight as information quality and system quality, though the lack of service quality may affect the initial usage of the system. Our finding is consistent with the results of the meta-analytic study which finds the effect of service quality on use and user satisfaction to be insignificant (Petter and McLean 2009).

A possible explanation is that the importance of service quality differs depending on the stage of system implementation, the user, and even the system quality. When a system is initially implemented, there may be teething problems, and users may also require more help in getting started with the system. During this time, service quality is important in influencing use and user satisfaction. After the system is implemented for some time, users may need less help from the IS department or the technology solutions provider and hence service quality seems to be less important. Some users may also require more help than others, and therefore service quality (e.g., support and responsiveness of the IS department) is important in influencing usage and user satisfaction. Any subsequent problem with the system will also require

help and support from the service provider. In such situations, service quality will play an important role in affecting use and user satisfaction. Hence, we see that the role of service quality is contingent on the stage of system implementation, the system quality, and the user.

Use and User Satisfaction

The updated IS Success Model suggests two possible concurrent causal relationships: Use → User Satisfaction → Net Benefits (Proposition 7 and 9), and Use → Net Benefits → User Satisfaction (Proposition 8 and 11). Our case findings give more support for the latter, i.e., net benefits increases user satisfaction, rather than user satisfaction increases net benefits. We searched past studies on healthcare IS to compare our findings. An earlier study on a physician order entry system shows that user satisfaction is highly correlated with perceived effects on productivity (i.e., net benefits) but the study does not assume or hypothesize the causality of the relationship (Lee et al. 1996). The same study also shows that system features that are used most frequently are also rated as most useful, implying that users experience benefits through using the system features more frequently.

Not forgetting the process aspect of the IS Success Model, we believe that initial user satisfaction comes from system quality and information quality. The satisfaction relates to the characteristics of the system and its ouputs, e.g., satisfaction that the system is easy to use and the system outputs are acceptable and usable. Subsequent user satisfaction comes from experiencing the net benefits of the system, rather than from the characteristics of the

system. A user who used the system is more satisfied not because he used the system more, but because he experienced more net benefits of the system. This is consistent with an earlier study on the physicians' use of a clinical IS, which indicates that physicians attributed their satisfaction of the system to the benefits that they experienced (e.g., improved communication and record keeping) (Kaplan and Lundsgaarde 1996).

This suggests that user satisfaction may be multidimensional. User satisfaction depends on the source of the satisfaction (i.e., the system or the net benefits of the system) and the stage it is measured (prior to system use or after system use). Hence, items measuring user satisfaction should be developed with these two factors in mind.

Net Benefits

Next we discuss the net benefits of this IT system at the organizational level. We organized our findings based on the intended objectives of the system and we observe that the system indeed improves organizational efficiency and effectiveness in the targeted areas which the system is designed for. For example, organizational efficiency is improved as the system enables continuous frequent monitoring without manual effort from the nurses. More importantly, from the interviews there is a perception of reduction of measurement errors and missed readings, and faster detection of abnormalities in vital signs. This translates to improvement in patient safety which in turn improves organizational effectiveness. We also see improvement in patient care as there is less disruption to patient's rest and some nurses can find more

time to deliver quality care. As we are studying impact and value of a single IT system, it allows us to analyze its net benefits in a more precise way, i.e., based on the intended objectives of the system.

However, at the individual level, we discover that the use of healthcare technology has different impact on different nurses. Unlike past research which indicates that time saved from documentation through the use of a clinical IS increases time spent on patient care (e.g., Allan and Englebright 2000), our case reveals otherwise. Although nurses welcomed the use of the technology and the time-saving benefits, not all nurses agreed that the use of the system would result in more time or opportunity to deliver quality patient care. While some nurses felt that the time savings would give them more time to deliver quality patient care, there were also some who felt that they would spend less time with the patients as they were not required to "do their rounds" with the patients. Assuming the hospital does not reassign the nurses' responsibilities or duties, what the nurses could do with the time savings from the technology is up to the individual. Of course, it is possible that not all nurses use the time savings for additional patient care.

Our findings also indicate that positive net benefits experienced by the users can reinforce further use of the system. This is consistent with past research in the healthcare literature. In a study on the use of a bedside documentation system, nursing staff who experienced the benefits of the system promoted the use of the system among the other members of their healthcare team (Dennis et al. 1993).

6.2 Research Contributions

This study is one of the few studies that test the entire updated IS Success Model, and also one of the rare studies that uses the IS Success Model as a framework in a qualitative study. This gives us a more comprehensive understanding of the net benefits of the system, and the antecedents of net benefits. It uses data from the healthcare context to test IS theories, specifically the updated IS Success Model. It allows us to better understand the nature of the relationships posited by the IS Success Model in a real context.

What is noteworthy is that information quality, system quality, and service quality may play different roles in influencing use and user satisfaction, as well as net benefits. The updated IS Success Model provides a basic and useful framework but it is not adequate in drawing out the intricate relationships between the different constructs and the dimensions within the constructs. This is where case research adds value, by providing context and richness to the model. Insights from this case study will help us move forward in IT value research, as we uncover areas of possible improvement to better understand the antecedents of IT value. Through this study, we have achieved a better understanding of the relative importance of information quality, system quality and service quality. Insights from the case also suggest that the importance of service quality is contingent on the stage of implementation, and whether users need help or support for the system.

Through this study, we have also achieved a better understanding of the sub-dimensions of the antecedents of IT impact. For example, the sub-dimensions of information quality include data format, data reliability, data accuracy and timeliness of data, and the sub-dimensions of system quality include system reliability and system performance. While these sub-dimensions are not new, this study allows us to identify these sub-dimensions more precisely in the healthcare IS context as discussed in Table 8. This study has also revealed two sub-dimensions of service quality, i.e., training and service provided by the vendor.

This study has also increased our understanding on the causal relationship between use, user satisfaction and net benefits. Our study finds support for the relationship that use leads to net benefits, which in turn leads to user satisfaction arising from the net benefits. This also suggests the multidimensional nature of user satisfaction. User satisfaction can arise from the system itself (e.g., ease of use, reliability of system) and also from the net benefits of the system (i.e., using the system impacts the user in a positive way, leading to user satisfaction). Future studies measuring user satisfaction may need to exercise care in developing appropriate items that correspond to the intended nature of user satisfaction. In addition, this study also allows us to study the feedback loop in the updated IS Success Model, which cannot be easily done using cross-sectional survey methodology. The qualitative nature of this study allows us to understand how initial use leads to net benefits which in turn reinforce subsequent use and user satisfaction. Through the

interviews, we are able to reconstruct the sequence of events and analyze the causal relationships between use, user satisfaction and net benefits.

This study focuses on the dependent variable of IT impact or net benefits. As this is a qualitative study, it allows us to study IT impact at various levels (i.e., individual and organizational levels), using various dimensions (i.e., efficiency and effectiveness measures) and measures specific to the healthcare context (i.e. patient safety and patient care). While we cannot claim that the findings are generalizable, the qualitative findings produce richness and detailed insights which cannot be achieved through quantitative methods alone. The complex nature of IT value is not an easy issue to resolve. The net benefits construct in the updated IS Success Model is multi-dimensional and multi-level, and the onus is left to users of the model to appropriately operationalize and measure this construct. Through this study, we see the importance of using appropriate measures to study IT impacts, relevant to the context.

As we have pointed out earlier, the choice of the dependent variable could make a difference in understanding the impact and value of IT (Hitt and Brynjolfsson 1996). While past studies have used measures such as firm performance and productivity, in this study we were able to better understand the impact of healthcare IT by studying it qualitatively and customizing the measures according to what the system is designed for. By using appropriate measures, we can better evaluate the impact of the system according to its intended objectives. Although this study is based on one particular system, it

provides an example of how IT impact can be analyzed using a combination of qualitative and multilevel measures specifically for the healthcare context.

This study has given us insights into the use of IS in an under-researched sector (i.e., healthcare). It allows us to test and refine IS theories in a largely unexplored context, i.e., healthcare (LeRouge et al. 2007b). It has also contributed to healthcare literature by using IS theories as a reference discipline to investigate the use of IT in healthcare. The use of IT in healthcare is growing, especially in the area of clinical IS. Much research is needed to understand and evaluate the value and impact of IT in healthcare. IS theories can indeed inform the healthcare research community, and this essay has contributed to this much-needed area. Further research work can be done to apply the socio-technical theories to advance healthcare IT research. In-depth studies and field research in a specific context such as healthcare can provide a rich context to test IS theories and advance the status of IS as a reference discipline. This explanatory case study provides impetus for further research in this area.

6.3 Practical Implications

In terms of practical contributions, this case provides a detailed example of how the value of healthcare IS can be measured. One of the barriers in healthcare organizations adopting IT is the challenge of measuring IT value through firm performance measures. Indeed, it may be difficult to measure IT value based on traditional financial measures such as return on investment. This case study has provided alternative measures of measuring IT impact. It

gives examples of how IT adds value and how its value may be assessed beyond using financial measures. For example, IT value can be assessed through qualitative methods, using a combination of measures at both individual and organizational levels. This may help healthcare IT practitioners justify the need to invest in IT, thus overcoming the most significant barrier to the successful implementation of IT in healthcare (HIMSS 2009). This also helps organizations to better appreciate and capture the benefits of using healthcare IS, so that stakeholders and decision makers can be effectively convinced to adopt new IT that can be beneficial to healthcare.

This study also emphasizes the importance of ensuring system quality, information quality and service quality to maximize the value of a healthcare IT system. Use of a high-quality system can lead to positive net benefits, which increases user satisfaction and also leads to further use. This positive feedback loop is critical, and points us back to the importance of ensuring system quality, information quality, and service quality, so as to maximise the usage and net benefits of a healthcare IS. Practitioners have to carefully design and develop a healthcare IT system to ensure system and information quality. Section 5.1 and 5.3, though specific to the vital signs monitoring system, gives us useful tips on what is important particularly to healthcare professionals. For example, system reliability is critical to nurses who usually have a hectic work schedule and are not known to be technology-savvy. Issues such as slow response time or the system "hang" are not well-tolerated by nurses and can affect their use and user satisfaction.

Even as the system is implemented and launched, the importance of service quality cannot be neglected. Effective and well-designed training helps users to get started with a new system. The presence and availability of a competent and supportive helpdesk can greatly increase service quality, which in turn increase use and net benefits of the IT system. This is especially so in the healthcare context. As pointed out in the earlier paragraph, nurses are usually not technology-savvy. Hence, it is important to guide them closely when introducing new technologies for their work. Small group training with hands-on practice, scheduled to fit the nurses' hectic work schedule, can enhance their learning experience and their system use. Responsive service and support from the technology solutions provider can also increase their user satisfaction and use of the system. This case has also demonstrated the importance of involving nurses in the design and development of the system so that their user requirements can be considered and the system can be designed according to their needs.

In addition, this case serves as an example for healthcare organizations considering the adoption and deployment of similar new healthcare IS. The vital signs monitoring system is an emerging pervasive healthcare IT application that has high potential in transforming healthcare and mitigating the risk of global challenges such as infectious diseases and pandemics. This case provides further understanding on the potential benefits of such technologies and the experience of an early adopter. As this is a new innovation that has yet to be commonly implemented in hospitals, practitioners should find the framework and the case findings useful. The

benefits of an emerging technology such as the vital signs monitoring system are exemplified through this case study and should motivate healthcare practitioners and managers to explore how the IT can be exploited to improve patient safety and patient care.

This case also provides practical insights on how individual work of nurses can be improved through the use of technology, and this could in turn improve patient care. Nurses typically have hectic schedules and heavy responsibilities in looking after patients. IT systems that automate part of their work and improve efficiency and effectiveness of the nurse's work can help to improve patient-related outcomes. This translates to better organizational performance. Hence, the study provides some guidance and evidence on how IT can be harnessed to improve healthcare work.

In addition to potential benefits, the case also reveals some issues and potential pitfalls of using the vital signs monitoring system. As the patient charts are stored electronically, there must be supporting IT infrastructure for these charts to be easily accessed whenever needed. IT infrastructure is a necessary resource to complement the use of the vital signs monitoring system. This includes the availability of laptops or computer terminals to access the charts, as well as wireless infrastructure for connectivity. Any problems in accessing the charts can cause frustration or affect the work of healthcare workers. For example, the nurses have observed a shortage of laptops for doctors and nurses during busy periods of the day. One of the nurses commented:

"7am, the doctors have their meeting, and 7.30am, the whole lot of them will come [to do the rounds]…That's the [problem] if we have only one laptop, everybody wants to look at it [at the same time]"

The use of the vital signs monitoring system also introduces changes in the workflow of the healthcare workers. Nurses no longer need to conduct their regular rounds of taking vital signs. On the other hand, they need to ensure that the outputs of the system are monitored regularly so that abnormalities can be prompted discovered and attended to. While time is saved through the automation achieved by the system, there may be additional routine tasks, such as system registration and deregistration of the patients, removal of monitoring devices from the patients before conducting clinical procedures, and reattaching these devices back onto the patient after the clinical procedures. New procedures and duties concerning registration/deregistration, monitoring of abnormal readings, and accountability of the devices, must be developed and put in place. With the introduction of new healthcare IS, changes to workflow and work practices should be expected. This is consistent with past studies in medical informatics. For example, a study on the use of a physician order entry system shows that the introduction of the new system modified established work routines and changed the way healthcare professional relate to each other (Massaro 1993). Hence, healthcare organizations should anticipate that introducing a new IS may cause changes in workflow and therefore manage the changes proactively.

Our findings have revealed that some nurses were of the opinion that not taking vital signs measurements personally may mean less interaction with patients. However, the intention of introducing the vital signs monitoring system is to allow nurses to have more quality time with the patients. As the project manager said:

> *"We are trying to eliminate routine, but increase what we call quality care. That means we still communicate with the patient, but with quality."*

As the objective of the vital signs monitoring system is to deliver better patient care, it is important not to overlook this objective because of workflow changes. One possibility is to leave it to the nurse's imitative to interact more with the patients. Another possibility is to formalize it in the new workflow so that nurses have dedicated time with the patients.

Although the vital signs monitoring system can increase the frequency of measuring vital signs, the possession of patient's vital signs readings increases the hospital's responsibility of detecting and managing patient's condition. One of the doctors explained:

> *"If there is nobody who is tracking [the vital sign readings] real time, and if you only have time to go back and check every hour, then you are no better than hourly parameters. But you have an added medical liability. Because your system did document that this is moving, that you had early warning signs that you did not pay attention to."*

Finally, the value of the vital signs monitoring system may be enhanced if it is integrated with other healthcare IS such as the EMR. Integration with other IS gives more complete and timely information about the patient and also allows the hospital to better use the information for other purposes such as research and trend analysis. Indeed, the integration of isolated systems, together with changes in processes and functions of the organization, is one of the important factors that healthcare organizations should consider in IT use to gain competitive advantage (Kim and Michelman 1990).

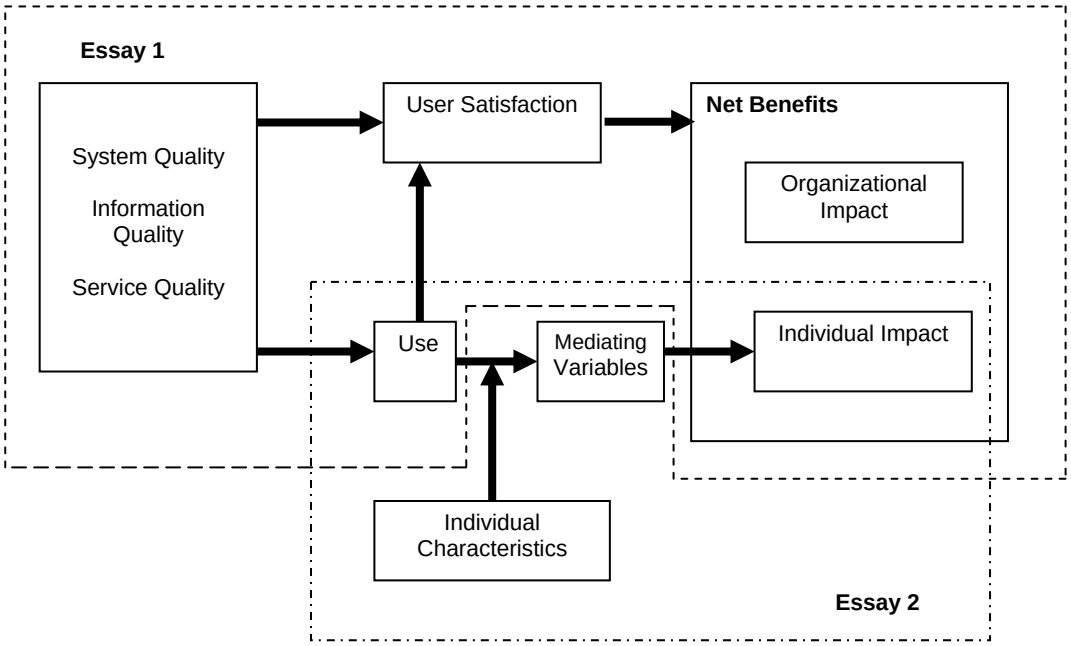
6.4 Limitations and Future Work

There are limitations to be considered when applying the findings of this study. First, the study is based on one hospital and may not represent other organizations in the healthcare context. Although data was collected from a trial which is implemented in one hospital, we were able to analyze how the IT system impacts organizational performance. Nevertheless, the inclusion of a larger sample of hospitals in future studies may provide further insights into the impact of IT in secondary healthcare. Second, the study is based on a particular type of healthcare IT application, i.e., vital signs monitoring system, and thus may not be applicable to all clinical healthcare IS. Nevertheless, the vital signs monitoring system contributes directly to patient safety and patient care, which are common critical aspects of healthcare service. Even so, future research can attempt to increase our understanding of the value and impact of other types of clinical healthcare IS.

Future research can also look into other challenges of deploying the vital signs monitoring system and other forms of pervasive healthcare systems in hospitals. There are various issues pertaining to the deployment of such technologies. One of the issues for consideration is the business model of such technologies – should the hospital or the patients bear the cost? Another issue is that of medical liability, which is a major area of concern in healthcare. For example, while the use of such technology allows continuous monitoring, who should be liable if any abnormalities of patient readings are not detected by staff in a timely manner? Such work will contribute to the under-researched but emerging area of healthcare informatics. It will also advance the use of information systems and technology for clinical purposes in healthcare organizations.

This study also reveals that the use of healthcare IS may impact the individual work in different ways. This may depend on the individual traits of the nurses and their job motivation, which we will explore further in Essay 2. While the use of healthcare IT is expected to translate to improved job effectiveness, such as better patient care, our findings indicate that further research could be done in this area to understand the underlying process linking technology use and individual impact (effectiveness). This is what we aim to investigate in Essay 2, as we study the impacts of healthcare IT on individual work. We will also attempt to open up the "black box" by identifying mediating variables of the relationship between IS use and individual impact (effectiveness) in Essay 2. We will also identify some individual characteristics that may influence the

impact of IS on individual work. Figure 5 shows the research framework that relates both Essay 1 and Essay 2.



Note: Feedback loop (Net Benefits→Use and Net Benefits→User Satisfaction) is not drawn in this framework

Figure 5: Research Framework for Essay 1 and 2

7 Conclusion

Determining the value of IT is indeed a challenging yet critical area of research. Despite its long tradition of research, it is still not a well-understood area, especially in more recent applications of IT such as clinical information systems. It is of great concern to practitioners as it is important to measure and justify the impact of IT on firm performance and work efficiency. This essay has provided a comprehensive literature review and used the updated IS Success Model as a theoretical lens to address identified gaps. The case study of FPH gives us a specific example of how IT impacts the work and performance of a healthcare organization and provides insights into the phenomenon. The question of IT value remains intriguing. Nevertheless, this study has shed some light by exploring the impact of a particular healthcare IT system on organizational work, at both organizational and individual levels. This is especially important given the tremendous potential of using IT in clinical healthcare.

Essay 2

Impact of Healthcare IS on Individual Work

1 Introduction

1.1 Study Motivation

The healthcare industry is expanding even as other industries are shrinking in the economic downturn (Marr 2008). Despite the growing size of the healthcare industry, it is thought to lag behind other industries in information technology (IT) adoption by as much as 10 years (Skinner 2003). In recent years, national governments have recognized that IT has tremendous potential to impact healthcare in many ways. For example, national initiatives on electronic health records are being implemented in many developed countries (Anderson et al. 2006). The U.S. is investing $19 billion in healthcare IT (Mandl and Kohane 2009). Due to the relative newness, lack of understanding, and the potential impacts arising from the use of IT in healthcare, the healthcare industry is a relevant choice for information systems (IS) research (Wilson and Lankton 2004). As described in Essay 1 (Section 1.3), the healthcare industry is unique compared to other industries in its use of IT and warrants separate study concerning the impact of IT. It has been suggested that IS and organizational theories and research can be applied to the healthcare industry to understand the socio-technical aspects of IT implementation (Ash 1997; Meijden et al. 2003) but work in this area has been insufficient.

As explained in Essay 1 (Section 1.3), the focus of our study is on secondary healthcare, in particular, clinical IS used in hospitals. A recent survey among hospital CIOs indicate that clinical IS will be a key focus for hospitals in the next two years (HIMSS 2009). While IT systems such as Computerized Physician Order Entry (CPOE) systems have been around since the 1990s (Sittig and Stead 1994), one of the more recent clinical IT applications is the electronic medication administration system (EMAS). Such systems include electronic prescribing, electronic medication records, and barcode scanning of wrist-tags worn by patients. The main objective of EMAS is to reduce prescribing and medication errors and increase efficiency in medication delivery (Franklin et al. 2007).

Even with their increasing deployment, it is unclear if clinical IS such as EMAS are effective in impacting healthcare as few studies have been conducted on them (Bates 2000). Studies from the medical informatics literature focus mainly on the effect of EMAS on patient safety (Franklin et al. 2007). The impact of such systems on the users (healthcare professionals) is under-researched. It is hence timely to examine if healthcare IS such as EMAS are serving the intended purpose of improving efficiency and effectiveness of healthcare workers. This could be useful in convincing healthcare workers to use healthcare IS, as research has shown that user resistance is one of the main barriers to the adoption of healthcare IS (Anderson 1997; Lapointe and Rivard 2005; Poon et al. 2004).

In addition, the nature of work has changed considerably over the years due to the introduction of new IT, but there have been few recent studies to address the impact of such changes on the nature of job and job performance (Humphrey et al. 2007). Hence, it is timely to work towards addressing this gap by studying the impact of IT on healthcare work.

1.2 Research Question

While IS research is rich in studies of technology adoption, there is little previous work on how the use of IT impacts individual job performance (Chan 2000; Chau et al. 2007), particularly for healthcare IT. While the previous essay explored organizational and individual impacts (net benefits) of IS and their antecedents, this essay aims to understand how IT use and individual characteristics alter job characteristics as a result of the new IS and in turn affect job performance. Motivated by the theoretical gaps and practical implications, our research question is, "How does the use of healthcare IS such as EMAS impact individual work?" We are interested in individual impact, which is defined as impact on job performance.

In this study, we use three theoretical lenses from the organizational behavior literature, i.e., job characteristics, relational job design, and social cognitive theories to develop a model to understand the impact of EMAS on the healthcare professional's work. To test our research model, we carried out a survey of healthcare professionals using the new clinical IS (EMAS). This essay presents the results of a survey evaluating the use and individual impact of EMAS recently implemented in a public hospital. In addition, qualitative

data in the form of interviews and open-ended survey responses are collected to aid in the analysis. The results are expected to contribute theoretical insights as well as practical suggestions on how to improve use of healthcare IS such as EMAS for greater impact.

1.3 Expected Contributions

Through this study, we aim to contribute to IS literature by studying the role of an IS to improve individual work, a relatively less understood phenomenon. The focus is on individual impact arising from the use of a single IT system in an organization. We attempt to understand the link between IS use and individual impact by exploring how IS use may change job characteristics and therefore affect individual work. Further, this study also aims to contribute to healthcare literature by using IS and organizational theories as a basis to investigate the use of IT in healthcare. Practically the study can offer insights into how IT systems can be deployed to positively impact individual work particularly in healthcare organizations.

1.4 Structure of the Essay

Chapter 2 presents the conceptual background of the job characteristics, the relational job design, and social cognitive theories. Chapter 3 describes our research model and the hypotheses. Chapter 4 describes the research methodology. Chapter 5 presents the qualitative data analysis while Chapter 6 presents the results of the quantitative data analysis. Chapter 7 discusses the findings, the implications, and contributions of the study. Chapter 8 concludes this essay.

2 Conceptual Background

As discussed in Essay 1 (Section 2.6.2), there are two well-known IS theories that relate use of IS to individual performance, i.e., the Task-Technology Fit (TTF) model (Goodhue and Thompson 1995) and the IS Success Model (DeLone and McLean 1992; DeLone and McLean 2003). Both TTF and the IS Success Model indicate a direct relationship between use (or utilization) and individual impact (or performance impacts). However, in this essay, our aim is to better understand the relationship between IS use and individual impact and identify mediating variables that may explain the link.

A salient issue pertaining to IT impact on individual work is whether computerization leads to job redesign and enrichment (Millman and Hartwick 1987). Thus, a relevant theoretical background for our research is job design, which is known to impact individual work motivation and performance (Hackman and Oldham 1976). The use of IT may affect job design by changing certain job characteristics (Ryker and Nath 1995). In this study, we propose the use of two theoretical perspectives in job design to understand the phenomenon, i.e., the job characteristics model and the relational job design model. In addition, we will also use a well-known theory from organizational behavior and psychology literature, i.e., the social cognitive theory, to explain the effect of individual differences on IT impact.

2.1 Job Characteristics Model

The job characteristics model (Hackman and Oldham 1976; Morgeson and Campion 2003) is one of the dominant perspectives in explaining how job features are related to individual reactions to work. It proposes the conditions under which employees will be motivated to perform effectively. The model identifies five job characteristics which could affect work outcomes, i.e., skill variety, task identity, task significance, autonomy and feedback. *Skill variety* refers to the extent to which an employee uses different skills to perform his/her job. For example, an owner-manager of a small company who does all tasks himself requires a variety of skills to complete different tasks. *Task identity* refers to the extent to which an employee can complete a whole piece of work. For example, a worker who designs and builds furniture has a job that is higher in task identity compared to one who solely does painting of the furniture. *Task significance* refers to the extent which a job impacts others' lives. For example, nurses or counselors may view their jobs as high in task significance. *Autonomy* refers to the freedom an employee has in carrying out his/her work. For example, a job that allows the employee to plan and schedule his work activities for the day is high in autonomy. *Feedback* refers to the extent to which a job provides information about the employee's performance. For example, a worker who gets to test the equipment he builds receives feedback on the quality of his work.

The five job characteristics are thought to influence three underlying psychological states, namely, experienced meaningfulness of the work, experienced responsibility for the outcomes of the work, and knowledge of the

results of the work activities. These three psychological states in turn lead to positive personal and work outcomes, such as high internal work motivation and high quality work performance. It is important to note that it is the *perceived task characteristics* that influence outcome variables such as work performance, hence studies that apply the job characteristics model measures the employee's perceptions of their tasks (Griffin et al. 1981).

Over the years in organizational behavior research, the job characteristics model has been adapted for specific purposes. For example, Gagne et al. (1997) adapted the job characteristics model to explain psychological empowerment and intrinsic motivation. In this adapted model, task identity and skill variety are excluded, and feedback was expanded to two aspects (feedback from agents and feedback from the job). Another study adapted the job characteristics model to predict career intentions and organizational commitment (Kraimer et al. 1999). In that study, task identity, skill variety and task significance are combined into a construct named job meaningfulness. The job characteristics model was also extended with other work group characteristics to predict work group effectiveness (Campion et al. 1993). Indeed, most models developed in organizational behavior literature to explain job motivation or job performance have their roots in the job characteristics model. As our study focuses on job performance in general, we found it appropriate to use the job characteristics model by Hackman and Oldham (1976).

The job characteristics model has been applied in IS research mainly to study the job design, motivation, and work outcomes of IS professionals (e.g., Ang and Slaughter 2001; Chen 2008; McKnight et al. 2009). However, it has rarely been applied to study impact of IT systems, with a few exceptions. An early study investigated the impact of automated office systems on the work of middle managers by measuring changes in their job characteristics (Millman and Hartwick 1987). Managers from various organizations and industries using different IT systems were surveyed, i.e., not for a particular type of IT. Another study measured changes in job characteristics after the implementation of computer systems but the survey was based on all IT systems used, rather than the impact of a single IT system (Ryker and Nath 1995). Nevertheless, both studies affirm the validity of using the job characteristics model to study IT impact on individual work. In the same tradition, we expect that healthcare IT use will affect certain job characteristics that will in turn impact individual job performance.

Although the job characteristics model has a long history in organizational behavior research, it is still subject to criticisms. A shortcoming of the job characteristics model is in not considering other important work characteristics such as the social environment and work context (Humphrey et al. 2007). Hence, additional theoretical perspectives have emerged, such as the relational job design theory which is described next.

2.2 Relational Job Design Model

Prosocial characteristics that enable employees to benefit other people have important implications for individual job performance (Grant 2008a), especially for jobs that involve serving others e.g., nursing or counseling. The relational job design model describes how the characteristics of such jobs may spur employee's motivation to make a prosocial difference, thereby affecting the employee's job behavior (Grant 2007).

Studies have shown that the motivation to do good is not just an individual trait. Rather, it can be shaped by the context and situation (Nelson and Norton 2005). However, there is little research about how work context can strengthen such motivation to do good (Grant 2008b). The relational job design model explains how motivation to make a prosocial difference can be enhanced by increasing employees' contact with their beneficiaries. The theory posits that relational properties of the job can be designed to increase an employee's opportunity to impact beneficiaries' lives. This increases the perceived impact on their beneficiaries, which in turn increases employee's motivation to make a difference, resulting in extra effort to help their beneficiaries.

A key independent variable of the relational job design model is beneficiary contact. *Beneficiary contact* refers to the degree to which the job provides opportunities to meet and interact with beneficiaries (Grant 2007). For example, in the case of nursing, beneficiaries refer to the patients being served. In the relational job design model, beneficiary contact is hypothesized to affect *perceived impact on beneficiaries*, which refers to the degree which

employees experience their actions as positively affecting beneficiaries. Similarly in the context of our study, we expect IT use to influence beneficiary contact and in turn impact perceived individual job performance. While Grant's (2007) relational job design model measures job opportunities for contact with beneficiaries, our research model aims to assess how the use of IT may enhance the employees' contact with beneficiaries. For example, the use of IT in healthcare is expected to eliminate some of the routine task in a nurse's work in delivering patient care. This is expected to improve the contact with patients, thereby improving patient care, as elaborated below.

Job contact with beneficiaries consists of three dimensions, i.e., frequency, breadth, and depth (Grant 2008a). *Frequency* refers to how often the job provides opportunities for contact with beneficiaries. *Breadth* refers to the degree which the job gives opportunities to interact with a variety of different beneficiaries. *Depth* refers to the extent to which the job provides opportunities for meaningful interactions with beneficiaries.

In a recent conceptualization of work design, it was proposed that worker characteristics have implications on job characteristics (Morgeson and Humphrey 2008). Past research on job design has tended to ignore the characteristics that employees must possess to perform the roles implied by the job characteristics. For service jobs, the relational job design model (Grant 2007) suggests that employees' prosocial characteristics will be important. Thus for healthcare workers such as nurses, we expect their prosocial values can influence perceived job characteristics. *Prosocial values* refer to "the

extent to which individuals regard protecting and promoting the welfare of others as important guiding principles in life" (Grant 2008b, p. 111). Prosocial values have also been described as "the need to be helpful and a desire to build positive relationships with others" (Rioux and Penner 2001, p. 1307). Additionally, employee characteristics related to IT use, e.g., self-efficacy as explained by social cognitive theory, are also likely to affect the impact of IT on job characteristics.

2.3 Social Cognitive Theory

The Social Cognitive Theory is a widely accepted model in which behavior, environmental events and cognitive factors operate as interacting determinants (Bandura 1986). It is one of the most significant theories to influence work motivation research (Latham and Pinder 2005). The social cognitive theory focuses on expectancies for success, particularly efficacy expectations (beliefs whether one can perform the behavior). *Self-efficacy* is a focal determinant of behavior as it influences goals and aspirations, and determines how obstacles and impediments are viewed. It refers to a user's belief in his ability to perform a behavior. This construct has been applied to behavior in different domains such as school, health and IT use (Bandura 1997).

Generalized self-efficacy has been shown to be positively related to job performance (Bono and Judge 2003) and perceived job characteristics (Judge et al. 2000). More specifically, computer self-efficacy, i.e., a user's judgment of his/her capability to use a computer, has been found to affect individual's use and reactions to computer technology (Compeau and Higgins 1995). In the

context of our study, self-efficacy towards healthcare IS is expected to influence use of IS and change in job characteristics as a result of using the system.

2.4 Integrating the Three Perspectives

We can see from the above overviews that both the job characteristics model and the relational job design model share similar underlying themes, namely work motivation and job outcomes. Each theory attempts to explain how certain job characteristics can motivate employees to perform more effectively at work. However, the two theories have a different focus. The job characteristics model emphasizes structural properties whereas the relational job design theory focuses on relational properties of the job that affect job performance. Thus, these two models may offer complementary explanations to the link between IT use, job redesign, and individual performance. In our study, we identified skill variety and task significance as relevant constructs from the job characteristics model, which will be explained in the next chapter. We will also identified beneficiary contact as a relevant characteristic from the relational job design model that can influence individual impact. Further, to aid us in understanding the effect of individual differences on the impact of IT on job characteristics and performance, we also applied the concept of prosocial values, as well as self-efficacy from the social cognitive theory in our model.

3 Research Model and Hypotheses

The research model of this essay is shown in Figure 1. The independent variables are *use of IS* and individual differences (*self-efficacy* and *prosocial values*). The dependent variable is *individual impact*. The impact of independent variables on dependent variables is expected to be mediated by certain job characteristics (*perceived increase in skill variety*, *perceived increase in task significance*, and *perceived increase in beneficiary contact*), as will be discussed next.

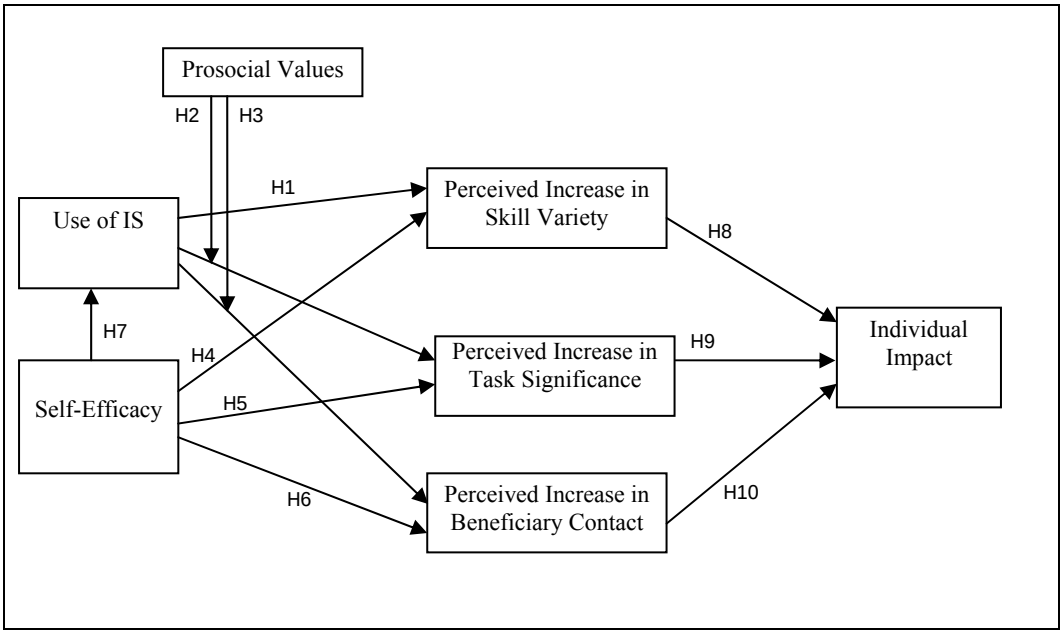


Figure 1: Research Model for the Individual Impact of IT

3.1 Skill Variety

Use of IS is expected to influence one or more of the five job characteristics (Ryker and Nath 1995). In the context of our study, we will examine the impact of IS use on each of the job characteristics below.

Use of IS may increase *skill variety* as the employee is required to learn to use a new IT (e.g., EMAS) to aid in his/her work. To the employee, this may mean an increase in skill variety as he/she has to learn new IT skills in addition to the existing skills required for his/her job. As the healthcare IS replaces paper records and routine checks in medication delivery, it does not necessarily lead to the deskilling of nurses as the medical and healthcare expertise of the nurses are still necessary. Based on the above argument, use of IS is expected to increase perceived skill variety. Hence, we hypothesize:

H1: Use of IS is positively related to perceived increase in skill variety

We expect the use of healthcare IS such as EMAS to affect *task identity*, as the use of EMAS allows users to obtain more information and achieve more coordination through the use of the system, which may increase task identity. However, task identity in this context is closely related to task significance, as nurses who are able to complete more pieces of work for their patients will also perceive this as an increase in task significance. As we will be hypothesizing effects concerning task significance (see Section 3.2), we will not be adding a hypothesis on task identity.

We do not expect the use of healthcare IS such as EMAS to affect the structural job characteristics of feedback and autonomy. Although the EMAS may be able to give *feedback*, it is usually restricted to the function it is designed for, not the entire process or job undertaken by the employee. Neither do we expect the use of healthcare IS such as EMAS to necessarily increase *autonomy* or job freedom. For example, EMAS requires nurses to

administer medicine at regular scheduled time intervals as determined by the physicians (Franklin et al. 2007). Past research has also indicated that autonomy is important only in jobs where work is not routine or predictable, which is not the case for nursing jobs (Latham and Pinder 2005).

For the remaining structural job characteristic (task significance) and relational job characteristic (beneficiary contact), we expect that use of IS may influence them depending on individual traits i.e., prosocial values of users.

3.2 Prosocial Values and Task Significance

Past research has shown that perceptions of work characteristics are related to dispositions (Judge et al. 1998). Among the structural job characteristics, we propose that prosocial values will influence solely the relationship between IT use and the employee's perception of increase in *task significance* since it relates to the job's impact on others lives.

Use of IS may increase *task significance* as the employee is no longer occupied with routine tasks such as keeping paper records or looking for missing paper medication records, but has more opportunity to interact with beneficiaries. By reducing the amount of routine tasks, a nurse may perceive her job to be more significant as she is better able to focus on patient care. However, the effect of IS use is expected to be moderated by prosocial values. A nurse who has higher prosocial values is more likely to perceive an increase in task significance from the use of the IS, as she can focus more on delivering patient care, thus increasing her job impact on others' lives. On the contrary, a

nurse with lower prosocial values may not be as motivated to care more for her patients. She may view the EMAS as a means to computerize a part of her job but that does not necessarily mean that she will proactively put in more effort to care for her patients. Thus, perceived task significance may not increase significantly for nurses with low prosocial values. Hence, we hypothesize a moderating relationship:

H2: Use of IS is positively related to perceived increase in task significance when prosocial values are strong

3.3 Prosocial Values and Beneficiary Contact

The use of IS may provide employees with better quality contact with beneficiaries. IS can automate routine work or manual tasks and allow service employees to have more meaningful and deeper interactions with beneficiaries. For example, it was found that medication administration and documentation accounted for most of nursing practice time (Hendrich et al. 2008) for which EMAS could improve efficiencies and allow more time for quality patient care. This will increase the depth of beneficiary contact, as nurses can interact with patients in a more meaningful manner, instead of being concerned about looking for and keeping paper records. However, the use of EMAS may not increase the breadth of beneficiary contact, as it has little effect over the variety of beneficiaries served by the employee. The use of EMAS also may not increase the frequency of beneficiary contact, as the number of rounds with patients to administer medication remains the same even with the use of EMAS.

As noted previously, certain employee characteristics may influence how they perceive the benefits of using IS. The use of IS may allow prosocial employees to interact more meaningfully with their beneficiaries. For healthcare IS such as EMAS, prosocial nurses may perceive greater increase in beneficiary contact from the system use. Similar to H3, we hypothesize a moderating relationship as prosocial values may allow the employee to perceive greater changes in beneficiary contact from use of the IS.

H3: Use of IS is positively related to perceived increase in beneficiary contact when prosocial values are strong

3.4 Self-Efficacy

Among individual traits, core self-evaluations are positively related to perceived job characteristics (Judge et al. 2000). Core self-evaluations refer to "fundamental assessments that individuals make about themselves and their self-worth" (Judge et al. 2000, p. 237) and include dispositional traits such as generalized self-efficacy and self-esteem. In the context of our study on IT impact, self-efficacy is a self-evaluation that should affect perceived job characteristics. *Self-efficacy* refers to one's beliefs about one's ability to use a technology to accomplish a particular job or task (Venkatesh et al. 2003). In this study, self-efficacy refers to one's confidence in using the healthcare IS. We argue that an individual who is high in self-efficacy is likely to perceive greater changes in job characteristics as a result of using the IS. In particular, we propose that self-efficacy will influence the relevant job characteristics in our model i.e., perceived increase in skill variety, task significance and beneficiary contact.

An employee who is confident in using the IS is more likely to perceive increase in skill variety in his/her as a result of using the system. For example, nurses with high system self-efficacy may perceive that they have learned additional skills (from using EMAS) that are required for his/her job. Employees' confidence in using the new system makes them feel that their job is enriched in the sense that more skills are required of their jobs, thus increasing perceived skill variety. Thus, we hypothesize:

H4: Self-efficacy is positively related to perceived increase in skill variety

Similarly, an employee with high self-efficacy is more likely to conclude that his job is more significant, (i.e., greater impact on others). Previous studies in social psychology have also shown that people who feel more competent are often more willing to help others (Midlarsky 1984). An employee's perceived job competence can increase his or her willingness to be helpful in the workplace (Todd and Kent 2006). This may lead to increased task significance, as a nurse may find significance in helping others. Nurses who are confident in using the EMAS may also perceive that they are able to effectively use the system to improve patient safety, thus increasing task significance. For nurses with higher confidence in using EMAS, the increase in task significance due to introduction of the new IS will appear greater.

H5: Self-efficacy is positively related to perceived increase in task significance

Last, an employee who is confident of using the new IS may view that the system allows him/her to have more meaningful interactions with the beneficiaries. Perceived competence in using the EMAS reduces time and effort spent on finding out how to use the system correctly and allows more time to deliver patient care. For nurses, confidence in using the EMAS empowers them to have deeper and more meaningful contact with their beneficiaries (patients). Hence,

H6: Self-efficacy is positively related to perceived increase in beneficiary contact

Overall, previous studies have shown that computer self-efficacy increases computer use (Compeau and Higgins 1995; Burkhardt and Brass 1990). Individuals who are confident in their use of computers tend to enjoy or prefer the use of computers, thus increasing usage. In the context of EMAS use too, self-efficacy is expected to increase system use. Hence, we hypothesize:

H7: Self-efficacy is positively related to use of IS

3.5 Individual Impact

Previous studies have shown that job characteristics are positively related to individual's work performance (Humphrey et al. 2007). *Individual impact* refers to the influence of IS on the job performance of the individual (Igbaria and Tan 1997). Individual's job performance can be assessed in terms of efficiency and effectiveness (Beal et al. 2003; Campbell 1990; Davis 1989; Gattiker and Goodhue 2005). *Efficiency* refers to how the IS has influenced productivity of individual work such as time taken and resources used

(DeLone and McLean 1992; DeLone and McLean 2003). *Effectiveness* refers to how the IS has affected individual's work outcomes such as quality and accuracy (Gable et al. 2008).

Increased skill variety leads to greater experienced meaningfulness of the work, i.e., the degree of importance and value in the job as felt by the employee. This in turn leads to higher internal work motivation and higher quality work performance (Hackman and Oldham 1976). Employees who perceive the use of technology to be beneficial in enhancing skill variety are likely to feel a greater individual impact from the IT. Added skills should help employees to be more effective, thus increasing their job performance. Hence, we hypothesize:

H8: Perceived increase in skill variety is positively related to individual impact

Similarly, greater task significance increases the experienced meaningfulness of the work and hence increases work performance (Hackman and Oldham 1976). Hence, increased task significance should also lead to more effective job performance. Nurses who feel that their work is more significant and meaningful will also perceive greater impacts in their work in terms of effectiveness. Hence, we hypothesize:

H9: Perceived increase in task significance is positively related to individual impact

Other than structural job characteristics, the relational job property of beneficiary contact should also influence job performance (Grant 2007). When a new IS allows deeper contact with beneficiaries, this is likely to increase the effectiveness of workers. For example, when nurses feel that the EMAS allows greater beneficiary contact they will perceive higher individual impacts from the IS. More quality contact with the beneficiary allows them to appreciate how their work impacts the beneficiary and also motivates them to be more effective in their work (Grant 2008a). Hence, we hypothesize:

H10: Perceived increase in beneficiary contact is positively related to individual impact.

The above three hypotheses pertain to the effectiveness dimension of individual impact. We do not expect perceived increase in job characteristics (skill variety, task significance, and beneficiary contact) to affect the efficiency dimension of individual impact. Increasing experienced meaningfulness of the job does not necessarily increase productivity at work, though it can increase work performance in terms of effectiveness. Similarly, increasing the quality of beneficiary contact does not necessarily increase efficiency, though it can increase perceived impact on beneficiaries and effectiveness at work. While use of IS can possibly lead directly to increased efficiency, our focus is on investigating mediating variables concerning job characteristics that will impact individual work in terms of effectiveness.

4 Research Methodology

The main method used to test the research model is a survey, supplemented by qualitative (interview) data. The quantitative study is expected to provide us statistical relationships between the constructs and more generalizable results (Dooley 2001). The qualitative data aids us in developing and validating the items for the survey instrument, and gives us a richer understanding of the dependent variable (Individual Impact). The combination of qualitative and quantitative measures gives a meaningful analysis of IT impact (Chan 2000). More details of the qualitative data can be found in Chapter 5.

The study was conducted on an EMAS that is implemented hospital-wide, to test the research model. To reduce the likelihood of extraneous factors which might affect the findings, the study was conducted on one healthcare organization based on a particular type of IT system that is implemented at that organization. The use of a single organization acts as a natural control of organizational effects.

Section 4.1 describes the development of the survey instrument and Section 4.2 provides the details of how the constructs are operationalized. Section 4.3 describes the conceptual validation process. The details of the survey administration and context can be found in Section 4.4.

4.1 Instrument Development

The survey instrument was developed following procedures recommended by Churchill (1979). The first step was to specify the domain of the construct. The second step was to generate items that capture the domain as specified. Third, sorting procedures for the conceptual validation of the instrument (Moore and Benbasat 1991) were also conducted. Finally, the reliability and validity of the instrument was assessed. The instrument validation is described in Section 6.1. The rest of this section describes how the instrument was developed.

In the first step of instrument development, the domain of the construct is specified by conducting a thorough literature search. The literature research provides information to draw the boundaries of the construct. In the second step of instrument development, items that capture the domain of the construct are generated. The constructs were operationalized by adapting items from past literature whenever possible. For constructs who do not have appropriate measures from previous studies, items were self-developed from interviews with physicians and nurses (our qualitative data). Pre-tests of the items were conducted with nurses. This helps to ensure content validity. The operationalization of the constructs is further described in the next section.

The next step of instrument development is conceptual validation. This step aims to assess how well the constructs at the operational level reflect the constructs at the conceptual level and it is useful in identifying any ambiguous or confusing items (Moore and Benbasat 1991). Conceptual validity and

reliability are assessed using Kappa scores (Cohen 1960) and item placement ratios (Moore and Benbasat 1991). This will be described further in Section 4.3.

4.2 Operationalization of Constructs

In this section, we describe the items generated for each construct. All questions are anchored on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree).

4.2.1 Use of IS (USE)

Typical ways to measure usage includes regularity of use (Davis 1989), frequency of use (Taylor and Todd 1995), and duration of use (Iivari 2005). However, these may not be meaningful measures of use in a mandated system (Jasperson et al. 2005) such as the one under study. While there may be little variance in usage, the extent of use may vary (Hartwick and Barki 1994). Hence, for this study, items measuring the extent or range of features used were employed. While these items are self-developed, the concept of using range of features to measure usage was adapted from a recent study which reconceptualized system usage (Burton-Jones and Straub 2006). Measuring extent or range of features used is also suggested in healthcare literature (e.g., Hu 2003). Two reflective items were developed to measure range of features used.

4.2.2 Perceived Job Characteristics

Perceived job characteristics constructs consist of Perceived Increase in Skill Variety (PIV) and Perceived Increase in Task Significance (PIS). Job

characteristics constructs were originally measured using the Job Diagnostic Survey (Hackman and Oldham 1974; Hackman and Oldham 1975). Another similar survey, known as the work design questionnaire, was developed by Morgeson and Humphrey (2006). It was designed to be applicable to a wider range of jobs. Hence, items from these two survey questionnaires were chosen to measure job characteristics.

For skill variety, four items from Morgeson and Humphrey's (2006) work design questionnaire were included in our instrument, some of which overlap with Hackman and Oldham's (1975) Job Diagnostic Survey. For task significance, three items were chosen from Morgeson and Humphrey's (2006) work design questionnaire, of which two items were originally from Hackman and Oldham's (1975) Job Diagnostic Survey.

As this study measure perceived increase in job characteristics after the user started using the system, items were re-worded accordingly. For example, one of the items from the work design questionnaire was "The job requires me to use a number of complex or high-level skills." In our instrument, we rephrased the item as "After I started using the system, the number of complex or high-level skills that I require for my job has increased." For each construct, there were four reflective items.

4.2.3 Beneficiary Contact (BEN)

Items were taken from a previously validated instrument that measures relational job characteristics, such as beneficiary contact (Grant 2008a). The

selected items measure the depth of beneficiary contact. As this study measure perceived increase in job characteristics, items were re-worded accordingly. For example, one of the items from the previously validated instrument was "I have meaningful communications with the people who benefit from my work." In our study, the item was rephrased as "After I started using the system, I have more meaningful communications with the people who benefit from my work." This construct is modeled as reflective, as the items reflected the increase in depth of beneficiary contact. There were three items measuring this construct.

4.2.4 Prosocial Values (PRO)

Items for prosocial values were taken from previously validated instruments of various studies (Clary et al. 1998; Grant 2008c; Rioux and Penner 2001). Appropriate items were chosen to suit the healthcare context of this study. Examples of items include "I want to help my beneficiaries in any way I can" and "I am genuinely concerned about the people I am serving". These items are suitable for the nursing profession as well as other jobs of the helping nature (e.g., counseling). This construct is considered reflective and is measured by four items.

4.2.5 Self-efficacy (SEF)

Self-efficacy is a well-established construct in IS literature. Relevant items were taken from previously validated instruments from Taylor and Todd (1995) and Venkatesh et al. (2003). The items are rephrased to refer to the self-efficacy in using EMAS, rather than computer self-efficacy in general

(Compeau and Higgins 1995). The emphasis was on measuring if the user feels confident using the EMAS on his/her own. This construct was measured by four reflective items.

4.2.6 Individual Impact (IMP)

Most previous studies on work design have been conducted such that employees evaluated both the job characteristics and perceptual outcomes since employees are most aware of both (Humphrey et al. 2007). Furthermore, the variable of interest (which is affected by beneficiary contact) in the relational job design model is *perceived impact* rather than actual impact (Grant 2007). Hence, in this study, we measured individual impact through self-reports by nurses. While it is possible that the data may be affected by common-source bias and social desirability, this risk is mitigated by assuring respondents that their responses are anonymous. Furthermore, qualitative data on the dependent variable was collected to have a better understanding of individual impact. Nurses who were not asked to take part in the survey were interviewed to understand how the system has impacted their individual performance (described in Section 5.1).

Our hypotheses pertain to the effectiveness dimension of individual impact. Hence, items are developed to measure effectiveness only. Three items were self-developed to suit the healthcare context and the intended purpose of the healthcare IS. These items were developed through initial interviews with the project champions, to understand the purpose of the system, and subsequently validated through interviews with nurses. In addition, an item from Gable et al.

(2008) was added to capture the overall effectiveness of the system. This construct was considered as reflective.

Table A. 1 in Appendix A lists the items in the initial instrument. The next section describes how the initial instrument is refined and conceptually validated through the sorting process.

4.3 Conceptual Validation

After generating the items, the next step is conceptual validation. The procedure for conceptual validation was taken from Moore and Benbasat (1991). In the first round of sorting, four judges sorted items into self-created categories as they were not told what the underlying constructs were. For each pair of judges, their level of agreement in categorizing items was measured using Cohen's Kappa (Cohen 1960). A second measure of the reliability and validity is the overall placement ratio of items placed within the target construct (Moore and Benbasat 1991).

The Kappa scores from the first round gave an average of 0.96, which is well above the acceptable value of 0.65 (Jarvenpaa 1989). The overall placement ratio of items within the target constructs was 98% (see Table 1). Based on the labels and definitions provided by the judges, Judge 2 split the four IMP items into two constructs. The split placements were resolved after discussion. Hence, we proceeded with the second round of sorting.

For the second round, another four judges were recruited and given the labels and definitions of the constructs. Kappa scores averaged 0.92 while the overall

placement ratio of items within target constructs was 97% (Table 1). Although the Kappa scores and overall placement ratio were slightly lower than Round 1, they were still excellent. Closer examination also indicated that the lower Kappa scores were due to Judge 2's misunderstanding of two constructs, which were subsequently resolved. Thus, we conclude that the instrument development process had resulted in scales that demonstrated high conceptual validity and reliability. The Cohen's Kappa scores and placement ratio summaries for both rounds of sorting can be found in Table 1.

Table 1: Sorting Results

	Round 1	**Round 2**
Type	**Unlabeled**	**Labeled**
Cohen's Kappa		
Judge 1 vs Judge 2	0.91	0.83
Judge 1 vs Judge 3	1	0.96
Judge 1 vs Judge 4	1	0.96
Judge 2 vs Judge 3	0.91	0.87
Judge 2 vs Judge 4	0.91	0.87
Judge 3 vs Judge 4	1	1
Average	**0.96**	**0.92**
Placement Ratio Summary		
USE	1.00	0.88
PIV	1.00	1.00
PIS	1.00	0.92
SEF	1.00	1.00
BEN	1.00	1.00
PRO	1.00	0.94
IMP	0.88	1.00
Overall Placement Ratio	**0.98**	**0.97**

4.4 Survey Administration

4.4.1 Survey Context

Second Public Hospital (SPH)[14] was selected as the study site as it was in the process of implementing a new IT system (EMAS) to aid in delivering quality healthcare. Moreover, SPH granted us access to interview and survey their nurses across different departments. SPH also fits our criteria on conducting the study in a secondary healthcare context as discussed in Essay 1. SPH is a major provider of secondary healthcare, with more than 900 beds and 3000 professional staff.

EMAS is one of SPH's recent IT projects being implemented. SPH decided to implement the EMAS after the management identified inpatient medication errors as a recurrent problem after a review of past hospital incident occurrences records. The system was developed by an IT solutions vendor. After conducting trials in mid-2008, SPH decided to implement the system hospital-wide by 2009.

The hospital-wide EMAS implementation started in late 2008 and the plan was to roll out the system across all wards in a phased manner. After we obtained approval from the hospital to conduct the study, developed the survey instrument and conducted interviews to improve the content validity of the instrument, SPH was more than halfway through their hospital-wide

[14] The name of the hospital has been changed to protect the confidentiality of the case information.

implementation. Due to the limited time, we were unable to conduct a pilot survey to test the instrument. Instead, the instrument was validated through the sorting procedures described in the earlier section and also through interviews with nurses.

Before the use of EMAS, SPH used paper Inpatient Medication Record (IMR). With the introduction of EMAS, all IMR were computerized and they are known as electronic medication administration records (EMAR[15]). Physicians performed electronic prescribing, pharmacists verified the electronic prescriptions, while nurses administered medicine by consulting the EMAR. The main objective of EMAS is to reduce prescribing and medication errors and increase efficiency in medication delivery by moving to the automated and paperless system. In addition to the EMAR, EMAS also included bar-code medication administration (BCMA). BCMA is a system where medication and patients have a bar-coded identification tag each for verification purposes. The main objective is to help nurses adhere to the five Rights – Right patient, Right drug, Right dose, Right time and Right route[16] (Ball et al. 2003).

Nurses are the largest group of users and also have the most contact with the beneficiary. Hence, the study focuses on work impact of the IT system on nurses and the survey and interviews were conducted with them. In addition to interviews with several nurses, interviews with a few doctors and a pharmacist

[15] EMAR replaces the paper medication administration record, which contains the patient's prescription and records of medication that were administered and medications scheduled for the future.
[16] Right route refers to how the medication should be taken, e.g., oral, intravenous or site of injection.

were conducted to aid in the understanding of the system and its impact. More details of the interviews can be found in Chapter 5.

4.4.2 Survey Administration Procedures

Following the development of the instrument, the survey questionnaire was prepared. To reduce measurement error, care was taken in preparing the questionnaire layout, the question format, and the question order (Neuman 2003). The questionnaire was designed to be clear and neat. Colored paper was used to give a professional appearance. Detailed instructions with examples were provided. Identifying information (the name of the university conducting the research and SPH's name) was prominently displayed on the questionnaire to enhance credibility. The cover page also explained that while the study was endorsed by the hospital, the respondents would remain anonymous. Participation was voluntary and would not affect their employment at the hospital.

Numeric labels (1 to 7) were used for each item, but verbal labels (e.g., strongly disagree, slightly disagree) were provided in the examples found in the instructions to help all respondents interpret the scales consistently and to produce more reliable measurement (Schaeffer and Presser 2003). Questions were organized into sections to minimize confusion of respondents and an introductory statement about the section was provided to orient the respondents (Neuman 2003).

The survey was to be administered at the hospital in wards which have implemented EMAS for at least three months. This allowed nurses sufficient time to be familiar with the system and to perceive any changes to their work as a result of using the system. We obtained the list of wards which would fit our criteria in terms of implementation timeframe. We worked with the nurse managers of these wards to obtain the list of nurses who would meet our criteria as regular users of the EMAS, as not all nurses use EMAS as part of their work. We approached some of these nurses directly, while the nurse managers helped us invite the rest of the eligible nurses for the survey. A token cash incentive was given to encourage participation. The nurse managers assisted us by reminding the nurses to complete the survey. A total of 334 forms were distributed and 176 usable responses[17] were obtained.

4.4.3 Demographics

Table 2 gives the detailed demographics information of the sample. Although the overwhelming majority (96.6%) of respondents were female, this reflected the general population of nurses. About half of the nurses (52.5%) were in the age group of 20-29. The majority of the nurses (78.4%) were staff nurses. Most of the nurses (69.3%) considered themselves as regular computer users. The demographics characteristics of the sample are representative of the whole population.

[17] After the surveys were distributed to regular EMAS users, we discovered that some of the respondents do not use EMAS to administer medication but for other purposes such as patient education. As the focus of our study is the impact of EMAS on medicine administration, we made a decision to use only responses from staff nurses and senior staff nurses as they use the EMAS for medicine administration.

Table 2: Demographics Characteristics of Sample (N=176)

Demographic	Category	Percentage	Demographic	Category	Percentage
Age	<20	0.6%	**Job tenure at current organization**	<1 year	29.0%
	20-29	52.5%		1-2 years	15.3%
	30-39	33.2%		3-4 years	19.3%
	40-49	9.7%		5-6 years	12.5%
	>=50	4.0%		7-8 years	8.5%
Gender	Male	3.4%		9-10 years	5.1%
	Female	96.6%		> 10 years	10.2%
Job Title	Staff Nurse	78.4%	**Years of Computer Experience**	<1 year	2.3%
				1-2 years	4.5%
				3-4 years	14.8%
	Senior Staff Nurse	21.6%		5-6 years	17.0%
				7-8 years	19.3%
				9-10 years	11.4%
				> 10 years	30.7%
EMAS Experience	2 months or less[18]	5.1%	**Level of Computer Experience[19]**	Rarely use it	1.1%
	3 months	19.2%		Less than occasional user	2.3%
	4 months	19.9%		Occasional user	10.2%
	5 months	17.0%		Use it sometimes	14.2%
	6 months	13.6%		Regular user	69.3%
	More than 6 months	25.0%		Regular and expert user	2.8%

[18] Although the survey was conducted at wards which have implemented EMAS for at least three months, a few nurses had less than three months of EMAS experience. This could be because they joined the ward after the system was implemented.
[19] This scale was adapted from Lee et al. (1996).

5 Qualitative Data Analysis

This chapter describes the qualitative data used to supplement the quantitative survey data. Qualitative data analysis is an ideal way of exploring initial issues and identifying early findings. This is especially useful when studying an IT system that is newly implemented, as in our case. The primary approach used in qualitative methods is through interviews. Semi-structured interviews were conducted to give a more in-depth and richer understanding of the impact of the IT system (the dependent variable in our research model). The findings pertaining to the individual impact of the EMAS are described in Section 5.3.2. The interviews also helped us to ensure the content validity of our survey items. Examples of interview questions are "What are the benefits achieved from using EMAS?" and "Do you think the system has improved your job performance?"

In addition to the interviews, qualitative data was also obtained through open-ended questions in the survey which solicited the nurses' feedback. The interview findings and the open feedback were compared with our survey findings on job characteristics and this is discussed in Section 7.1. The interviews and feedback responses also helped us obtain views on the negative aspects of the system and improvements suggested. These are discussed in the practical implications section (Section 7.3). The rest of this section describes our qualitative data collection and analysis as well as interview findings.

5.1 Qualitative Data Collection

Interviews were conducted with two wards, i.e., the pediatrics ward and the cardiology ward[20]. These two wards were selected because they were the first two wards to implement EMAS. At the time of the interviews, the paediatrics ward had used EMAS for approximately nine months, while the cardiac ward had used the EMAS for about four months. This was because the EMAS was rolled out at the paediatrics ward before the cardiac ward. The main objectives of the interviews were to better understand the benefits and other impacts of EMAS, and to validate our survey instrument.

A multiple-informants design was followed, involving meetings and interviews with the different personnel (shown in Table 3).

Table 3: List of Interviewees

Department/Ward	**Role**	**Number of Interviewees**
Hospital-wide	Clinician Champion (Doctor) (also the Cardiology Clinician Champion) Nursing Champion	1 1
IT Department	Project Manager	2
Pediatrics Ward	Pediatrics Clinician Champion (Doctor) Registrar (Doctor) Medical Officer (Doctor) House Officer (Doctor) Pharmacist Senior Nurse Manager Nurse Manager Clinical Instructor/Senior Staff Nurse Staff Nurse	1 1 1 3 1 1 3 1 6
Cardiology Ward	Cardiology Clinician Champion (also the hospital-wide Clinician Champion) Nurse Manager	 1

[20] These two wards were excluded from the survey as EMAS was implemented in those two wards much longer than the other wards that we surveyed.

	Senior Staff Nurse Staff Nurse	2 5
Total Number of Interviews:		**30**

The interviews were conducted in a semi-structured manner. Different questions were prepared for the IT personnel, the doctors, the pharmacist, and the nurses as they had different roles to play. The interviews were conducted by the main researcher with the help of an undergraduate research assistant. While both of us were present for the key interviews with the IT department staff, the clinical champions and the pharmacist, some of the interviews with the nurses were conducted by one of us. This was because SPH scheduled multiple interviews for us on the same day, and some of the nurses had to be interviewed concurrently. To ensure we had individual interviews with each nurse, we found it necessary to split up so that we could each interview one nurse at a time.

As requested by SPH, all interviews were preceded with a consent script, informing the interviewees that their participation was voluntary and their identities would be kept anonymous and would not affect their employment at SPH. All interviews were recorded digitally and transcribed. The interviews with the nurses lasted an average of 30 minutes while the interviews with other personnel ranged from 30 minutes to an hour. The total amount of transcribed data was 403 pages for 30 interviews.

Content analysis was conducted using qualitative research software (NVivo 8) to identify key concepts and recurring themes. Secondary data such as

newspaper and magazine articles, publicity materials, project documents, digital pictures/screen shots of the system, and training slides were also collected. The qualitative content analysis was assisted by the same undergraduate research assistant who conducted some of the interviews. The use of multiple investigators improved confidence in and reliability of the findings (Dube and Pare 2003). The interviews enabled the researchers to have a better understanding of the system and its impact.

Section 5.2 describes the qualitative findings regarding background of the system and its usage, while Section 5.3 describes the findings concerning the dependent variable, i.e., individual impact.

5.2 System Background

5.2.1 The Need for EMAS in SPH

The project started with a medication safety working team formed in SPH to explore ways to improve safety standards within the hospital. Various options were evaluated, such as having an additional pharmacist to increase the frequency of medication verifications. The team also explored the use of systems such as CPOE, EMAR, and BCMA. Based on the team's evaluation, the hospital made the decision to implement a CPOE coupled with EMAR and BCMA could reduce medication errors. Collectively, this system was also known as the EMAS. The EMAS had the potential of reducing the amount of work that users had to perform to achieve the same outcome, leading to time

savings and efficiency in medication delivery. The paediatrics clinician champion noted:

> *"There are definitely real advantages with this system ... it reduces human errors by making it safer because a lot of analysis can be done by the computer as opposed to the human mind trying to remember the many different possibilities and then link it up together and make an evaluation."*

The objective of the EMAS was to replace paper IMR as the medium of information transfer among EMAS users. Implementing the EMAS required radical changes to the current infrastructure of SPH. The next section describes the EMAS architecture.

5.2.2 EMAS Description

The EMAS consists of several components. Electronic IMR are stored in a central server with a backup system. The records can be accessed from computers in the hospital. Hence, physicians, pharmacists and nurses are able to access EMAS remotely through their office computers or through Computer-on-Wheels (COW)[21] when they are in the wards. In addition, nurses are also able to access EMAS through handheld personal device assistant (PDA). The PDA is customized such that it is also used to scan patients' wrist tags, as EMAS also includes the BCMA system. The client software on the COW or the PDA communicates with the server through the wireless network

[21] This is a laptop placed on a trolley with wheels, to allow clinicians to move the computer easily within the wards.

in SPH. Figure 2 shows the general architecture of EMAS. Next, we describe the usage scenarios.

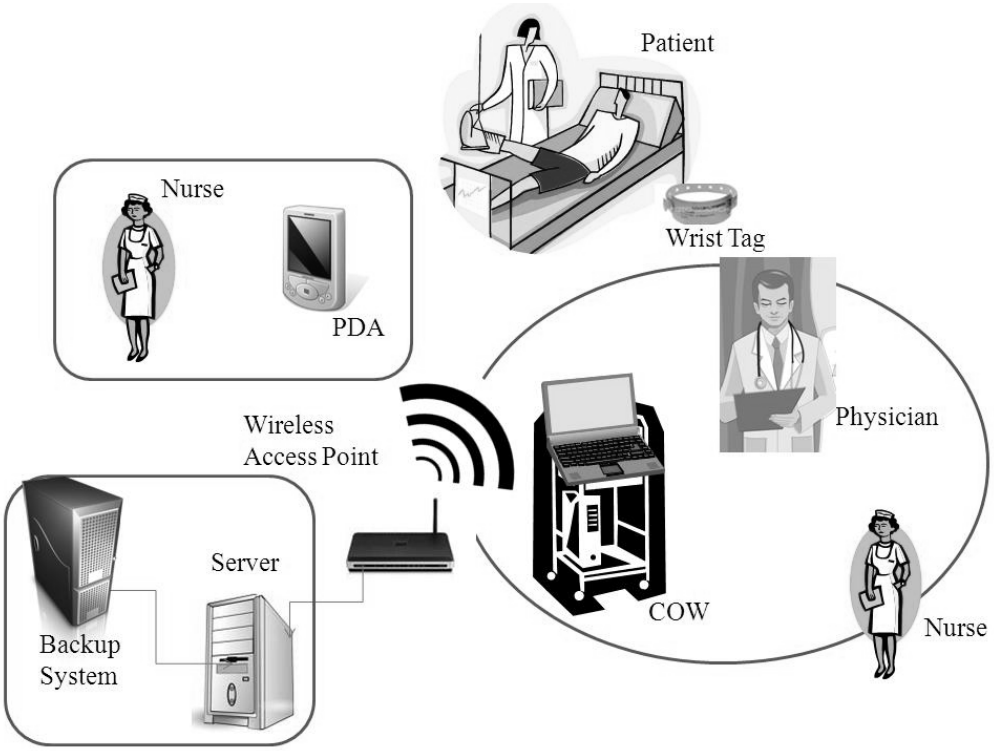


Figure 2: EMAS Architecture

5.2.3 Usage by Physicians

When a patient is admitted, a new record, i.e., EMAR, is created on EMAS for inpatient medication orders usage. The EMAR replaces the paper IMR which was used before the EMAS was introduced. A physician can access the EMAR directly from a COW within the wards or remotely from his office computer. With the EMAS, he can review past medication and order new medication. The system assists physicians in the filling up of medication orders and alerts the physicians if there are any possible allergies. As physicians type in the first few letters of a medication name, the system will

display a drop-down menu that suggests a list of medicines for selection, along with the recommended dosage and suggested serving intervals. The physician completes the online medication order form and logs out of the system when he is done.

5.2.4 Usage by Pharmacists

Pharmacists are able to log in to EMAS remotely from their pharmacy office or through a COW and access patients' EMAR. This allows the pharmacists to verify the medication orders remotely and also use the EMAS to alert the physicians and nurses if the medication orders need to be reviewed or changed. If the pharmacists sets any alerts concerning medication orders, a physician will be required to enter the system to make the appropriate changes before the nurse can serve the medication.

5.2.5 Usage by Nurses

The nurse accesses the patients' EMAR during medication administration. The EMAR displays the medication ordered by the physician, as well as the dose, time and route. The nurse verifies if it is the right patient by scanning the patient's wrist tag. If a nurse scans a wrong patient, an alert will be shown on the PDA, stopping the nurse from serving the medication. Nurses can select and view medication that needs to be served within the next few hours, helping them to plan their medication serving rounds and serve medication at the right time. In addition, omitted medication, i.e., medications that are past due but have not been served, will also be highlighted to seek urgent attention

from nurses. The EMAS records the time that medication is administered to the patient.

5.2.6 Closed Loop Medication

The long-term objective of EMAS is to achieve "closed loop" medication administration. A "closed-loop" medication administration system includes electronic prescribing, automated dispensing of medicine, barcode scanning to confirm patient identity, and the use of electronic inpatient medication records (Franklin et al. 2007). The purpose of electronic prescribing is to reduce prescribing errors, whereas the purpose of automated dispensing and barcode scanning is to reduce medication administration errors (Bates 2000). The use of IT in these processes has been shown to increase patient safety (Mekhjian et al. 2002). It may also increase efficiency and patient care, which we seek to explore in our study.

Figure 3 shows the complete closed loop medication process. At the time of the study, only EMAS was implemented, which provides for electronic prescription (by doctors), medication order verification (by pharmacists) and bedside verification (by nurses). SPH had planned to implement automated dispensing of drug for the preparation of medication trolley but the dispensing system was not ready at the time of our study. Hence, the nurses had to manually obtain medications from the medication supplies cabinet or the pharmacy. Our qualitative data collection and analysis is based on electronic prescribing (by doctors), prescription verification (by pharmacists) and bedside verification (by nurses), whereas the survey is based on the impact of EMAS (bedside verification) on nurses.

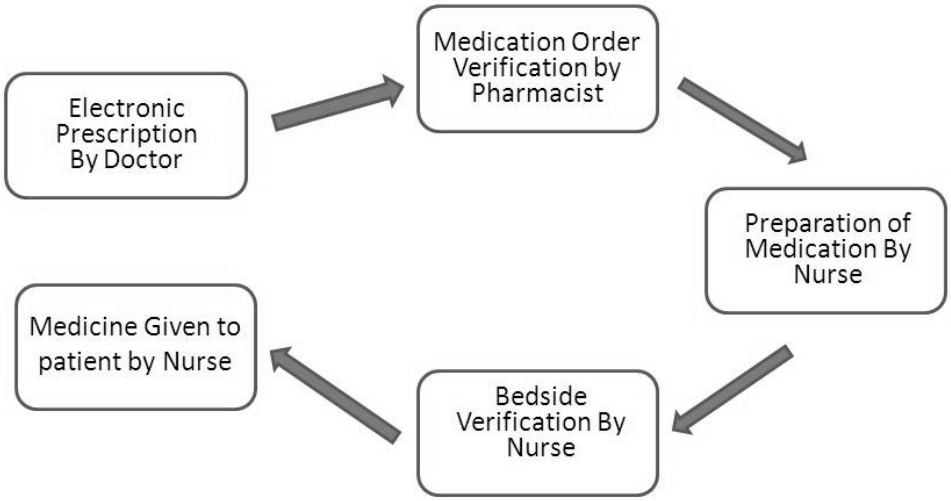


Figure 3: Closed Loop Medication Process

5.3 Findings from Interviews

To better understand the individual impact of EMAS, we had to first understand the issues faced mainly by the nurses before the EMAS was introduced, i.e., the use of paper IMR. This gave us a more comprehensive understanding of the benefits brought about by the EMAS and how it impacted the individual work of the nurses after it replaced paper IMR. This method is also consistent with past research in which the value of a healthcare IS is measured against the old paper-based system (Meijden et al. 2003). Hence, we classify our findings as follows: (1) Issues of paper IMR (2) Benefits of EMAS. While our research model investigates only the effectiveness dimension of individual impact, we found it useful to study the impact on both efficiency and effectiveness in our qualitative data analysis. Our qualitative findings reveal that use of EMAS influences job efficiency, even though efficiency is not necessarily mediated by job characteristics. Hence, the

benefits of EMAS are further classified as efficiency and effectiveness-related benefits.

5.3.1 Issues of Paper IMR

The issues faced by users with the paper IMR system are described in Table 4. These issues are indexed (e.g., I1) for easy reference.

Table 4: Issues of Paper IMR

Index	Issue	Description	Quote
I1	Missing paper IMR	Paper IMR can be easily misplaced because there are many users of the document, i.e., doctors, pharmacists and nurses. 13 out of 19 nurses interviewed had encountered incidents in which paper IMR was missing. Without the paper IMR, nurses were unable to serve medication to the patients. Time was wasted searching for the paper IMR and this also led to a delay in medication serving.	*"Sometimes we cannot find the paper IMR. Somebody might have taken it and gone somewhere else. We had this problem where the physician took the paper IMR to another ward and she didn't realize it." – Nurse*
I2	Difficulty reading the paper IMR	Doctors would write their prescriptions on the paper IMR, but it was often difficult to read. 14 out of 19 nurses expressed difficulties in understanding medication orders due to the doctor's illegible handwriting. Mis-reading the written medication orders may lead to medication errors. As patients are often managed by a team of doctors, doctors may also find it difficult to understand medication orders written by another doctor. Pharmacists may be unable to accurately verify orders for interactions or allergies if they cannot interpret the handwriting.	*"For the old IMR it depends on the handwriting of the person. Some of [the handwriting] are very illegible, so that's where medication errors occur. It happened to me once. The date was not written properly and I understood it wrongly, and I administered [medication] a few times before realizing the error." – Nurse*
		As physicians and nurses use the paper IMR, they may highlight, modify or cancel medication orders on the paper IMR. This	*"At times we can overlook because the columns are small ... some write and sign*

		resulted in messy markings on the paper IMR which can confuse nurses. Nurses may not notice a particular medication order and thus fail to serve the medication at the right time.	*beyond the columns and we can misunderstand that particular action had been performed though it hasn't." – Nurse*
I3	Incorrect reporting of medication administration timing	Nurses are required to adhere to the prescribed medication serving timings closely to avoid any late medication serving. According to SPH's policy, medication served beyond one hour before or after the prescribed time of serving is considered a medication error. If this occurs, the nurse will have to submit an incident occurrence report. To avoid trouble, nurses sometimes did not report the actual medication administration time on the paper IMR when they were late in serving medication. If a patient was given medication late but this was not reflected correctly on the paper IMR, the timing of the next dose would not be adjusted accordingly.	*"One thing is that nurses can cheat on the timings. They can give medication later than the supposed timing for example, giving at 3pm instead of 1pm." – Nurse Manager*
I4	Missed or late stat dose[22]	Stat doses should be served immediately after the physician ordered it. However, the physician may write it on the paper IMR but forget to inform the nurse. As a result, nurses may only notice the stat dose order on the paper IMR at a much later time.	*"For paper IMR, medication errors are quite common because sometimes the doctor doesn't remind you that he ordered a stat medicine. Without notifying us, we wouldn't know about it and that would cause a medication error." – Nurse*

[22] Stat dose refers to medication given immediately as a single dose.

I5	Failure to verify the correct patient	It is mandatory for the nurses to ensure the 5 Rights before serving medication to patients. However, lapses do occur. If a nurse fails to verify the 5 Rights such as the patient's name, medication errors can occur. Nurses also have to ensure that they are using the correct paper IMR. If patients are transferred to another ward or discharged, nurses have to remember to update the paper IMR. If the wrong paper IMR is used, medication will be served to the wrong patient.	*"When you go to bedside, sometimes when patient is sleepy and when you call them, 'are you so and so?', they just say yes even though they are not and if we fail to check the wrist tag, we will give them the wrong medication." – Nurse* *"If I'm in charge of bed 23, then I administer medicine to bed 23 patient but he has already been discharged and I got a new patient, I can serve that medicine and give to the wrong [patient] if I never double check with my colleague and the patient's name." – Nurse*
I6	Transcribing of paper IMR	When the paper IMR is full, a new paper IMR has to be created. The past records on the old paper IMR has to be transcribed to the new paper IMR. This process is time-consuming. It is also prone to error as mistakes could be made while copying the medication information to the new paper IMR. The illegible handwriting [I2] can also cause errors when transcribing the medication orders.	*"If any section of the paper IMR is full, we need to transcribe the entire booklet otherwise it will be very messy. So we need to transfer all ongoing medicine to the new booklet and it is a very laborious process." – Doctor*

5.3.2 Benefits of EMAS

EMAS was developed to address some issues of the paper IMR system. The benefits experienced by the nurses are described in Table 5. The benefits

describe how the EMAS impacted nurses' individual work. All benefits are indexed (e.g. B1) for easy reference.

Table 5: Benefits of EMAS

Index	Benefit	Description	Quote
B1	Reduction of medication errors • Elimination of illegible handwriting on paper IMR	EMAS eliminates the issue of illegible handwriting as it is much clearer to read from a computer or PDA screen. This eliminates a possible source of medication errors. [Refer to I2]	*"Patient safety is improved because EMAS takes away the need for handwriting...half the time the nurses will be like, 'Can you help me check this handwriting?' then we will have to stand there and decipher." – Doctor*
	• Ability to verify medications more frequently	Pharmacists are able to verify medication remotely using the EMAS and thus they are able to verify medications more frequently. For example, the pharmacist we interviewed used to verify medication once a day when paper IMR was used, as she had to personally visit each ward to access the paper IMR. After EMAS was introduced, she could verify medication orders twice a day from her office using the computer.	*"I can actually review as and when the order comes in but because I take over a few wards so currently I can check the order twice a day." – Pharmacist*
	• No need to transcribe paper IMR	Physicians no longer have to transcribe paper IMR to a new copy when it is full. Thus it eliminates a possible source of medication errors. [Refer to I6]	*"Very often what we had to do is to transcribe the entire IMR but this is no longer done because with the EMAS, there is no need to transcribe anymore." – Doctor*

	• Assistance in entering of medication orders	EMAS could assist physicians in ordering the correct drug and the correct dosage for the drug. The system provides a list of options for the doctor to select the correct medication and also suggests dosage and intervals.	*"You feel more safe with EMAS, you know what you are ordering because there is this [function] that is if you key in something that is not in the system you know it is wrong and [the system will] come out with the dosage that is already pre-determined so you kind of know that this is the range you need to give" – Doctor*
	• Ability to serve stat dose in a more timely manner	After the doctor orders a stat dose, it will appear in the list of medication due in the EMAS. Although the nurse in charge may not notice the stat dose until she logs into EMAS, other nurses could help to inform her as they are able to view the same list of medication due. This helps the nurse to serve the stat dose in a more timely manner. [Refer to I4]	*"If there is a due medicine, your colleague will tell you if there is an omission medicine, can you please go through the EMAS because you have a stat medicine." – Nurse*
	• Ability to verify patient's identity	EMAS allows nurses to scan the wrist-tag worn by patients so that the identity of the patient is instantly verified. This eliminates the possibility of giving the medication to the wrong patient. [Refer to I5]	*"You can scan and you can verify the patient's wrist tag and the patient's name" – Nurse*
B2	Improved Accountability • For nurses	Accountability is improved with the use of EMAS because as the details of every transaction are logged. For example, the system records the	*"EMAS can really record [the timing] down then we cannot cheat so it shows your integrity... [Before EMAS] the nurses want to cover for one another they will*

		identity of the doctor who prescribed the medication, and the identity of the nurse serving the medication. The time of medication administration is also logged automatically when the nurse scans the patient's wrist tag and serves medication. This prevents nurses from altering timing of servings [Refer to I3]. Instead, nurses would be more motivated to serve medication in a timely manner.	*change the timing..." – Nurse*
	• For doctors	Doctors would also have to be accountable for the medication orders that are prescribed using their account.	*"I think it's more clearly defined, you know for sure that this medication or this dosage is ordered so you have no uncertainty about it. The EMAS has a record of who started it and who discontinued it, which makes it easier for us to trace as well." – Doctor*
B3	Time savings • No missing paper IMR	As there is no more paper IMR, it resolves the issue of missing paper IMR [Refer to I1]. Time is no longer wasted looking for the paper IMR. Users who need to review the patient's medication record can easily access it through EMAS.	*"Save time. Sometimes we have to spend time searching for the paper IMR. For EMAS we can just use the computer" – Nurse*
	• No need to spend time deciphering handwriting	Nurses no longer have to contact physicians to clarify on illegible orders or attempt to decipher the handwriting as there is	*"We won't need to call other people to ask, "Do you think these words...." and won't need to call the doctor [to ask] what they write, what they*

		no difficulty reading the EMAR, unlike the paper IMR. [Refer to I2]	*want." – Nurse*
	• Easy transfer of patient	Transfers could be performed seamlessly without physical transfer of paper IMR, thus saving time for nurses.	*"It shortens our time because with EMAS we can access [the patient's medication record] anywhere. After we transfer the patient the other side can show the administration so it also shortens the time for medication." – Nurse*
	• Ability to order and verify medication remotely	Physicians can view medication orders of patients and enter, modify or cancel orders remotely. This saves time for the physicians. Nurses can also easily call the physicians to request medication orders. In addition, nurses can also review medication orders remotely without looking for the paper IMR.	*"With EMAS, if a patient requests for a simple medicine, we can call the doctor and he can order it though EMAS without coming down or give a phone order." – Nurse* *"Yes there are time savings. We do not have to go after every paper IMR in the ward and we can check medications from our system." – Nurse*
	• Ability to review past medications easily	Doctors and nurses can also easily review past medications as all the information are available in the patient's EMAR. There is also no need to transcribe the paper IMR.	*"You can see quite clearly the past medications that have been given and stopped because sometimes in paper IMR when you transcribe then the old one is gone, you can't find them easily…" – Doctor*
B4	Overall increase in job performance • Better patient safety	Several nurses have reported an increase in job performance from using the EMAS. An important aspect of the nurse's job is to ensure patient safety. As the	*"[The EMAS] can help me prevent medication errors. Because this is one of my key performance indicator, if it improves then my job appraisal will improve."*

		EMAS helps to prevent medication errors [Refer to I2, I4, I5, I6 and B1], nurses feel that it improves their job performance. Several nurses have expressed that the EMAS allows them to focus on the more important aspects of their job. As tasks generally became easier to perform or are simplified with the use of EMAS, nurses could better focus on other tasks that improve patient safety. This improves their job performance.	*– Nurse* *"You can actually cut down on a lot of workload. You don't need to communicate so much with the physician on what they are ordering... can better focus on serving medicine and all these can help reduce errors." – Nurse* *"because we save some time so we can use the time on patient" – Nurse*
	• Better planning of work	With EMAS, nurses could plan their work better. Through the system, they can easily obtain a complete list of medications due within the shift and this assists them in planning their work for the day.	*"I think EMAS is more organized. It does planning for you and it lessens your burden" – Nurse*

With reference to the past issues of paper IMR in the previous section, it is apparent that EMAS would be able to mitigate most of the issues that have plagued the old system. This is mainly possible because such work process automation reduces the number of possible mistakes that could occur along the complex medication workflow. Table 6 summarizes these benefits and how they could solve the issues of the past approach.

Table 6: How Benefits of EMAS Resolve Past Issues

Benefits of New System Resolving Past Issues	**Issues of Past Approach (Paper IMR)**
[B1] Reduction of medication errors • Elimination of illegible handwriting on paper IMR • Ability to verify medications more frequently • No need to transcribe paper IMR • Assistance in entering of medication orders • Ability to serve stat dose in a more timely manner • Ability to verify patient's identity	[I2] Difficulty reading the paper IMR [I4] Missed or late stat dose [I5] Failure to verify the correct patient [I6] Transcribing of paper IMR
[B2] Improved Accountability • For nurses • For doctors	[I3] Backdating of late medication servings
[B3] Time savings • No missing paper IMR • No need to spend time deciphering handwriting • Easy transfer of patient • Ability to order and verify medication remotely • Ability to review past medications easily	[I1] Missing paper IMR [I2] Difficulty reading the paper IMR
[B4] Overall increase in job performance • Better patient safety • Better planning of work	[I2] Difficulty reading the paper IMR [I4] Missed or late stat dose [I5] Failure to verify the correct patient [I6] Transcribing of paper IMR

In terms of individual impact for nurses, we see that the EMAS offers the following benefits:

Efficiency

The EMAS helped the nurses to achieve time savings in medication administration. Time spent on looking for the paper IMR [I1], deciphering

doctor's handwriting [I2], waiting for the doctor to order medication or the pharmacist to verify medication orders [B3] was significantly reduced. Nurses could review past medications with ease [B3]. The EMAS also automatically recorded the timings when medication was served [B2]. The procedure to transfer a patient from one ward to another is also simplified [B3]. While these can lead to time savings and job efficiency, we also found that there are other issues when the system is new that may negate the time-saving benefits. After the EMAS was implemented, nurses and doctors encountered problems using the system. Slowness of the system and network caused them to spend more time using the system. Some of the nurses and doctors were also not familiar with the system despite having attended training sessions, so more time was taken to figure out how to use the system and to obtain technical support. There were also other system reliability problems which were discovered during the initial deployment, thus slowing down the nurses' work. While the EMAS was designed to improve job efficiency, we see that the initial problems faced by the users may affect the time savings. Hence, the time savings may be more apparent later when the system is stable and users are familiar with it.

Effectiveness

The EMAS helped to reduce medication errors, thus improving the outcome of the medication administration process [B1]. By eliminating illegible handwriting and the need to transcribe paper IMR, as well as enabling users to verify medication orders more frequently and helping doctors to order the correct medications, the possibility of medication errors is greatly reduced.

This is probably the most important benefit of the EMAS as the main objective of the EMAS is to reduce medication errors. Improved accountability also increased patient safety, as doctors and nurses would be more careful performing their jobs, knowing that they would be held accountable for the medication orders and administration [B2]. In addition, with the use of EMAS, the nurses were also able to focus on other aspects of patient safety and patient care [B4]. Nurses also felt that the use of EMAS improved their planning and organization of work, as they have more information and control of the medication process [B4].

6 Measurement Model and Hypotheses Tests

In this chapter, we describe the instrument validation and hypothesis testing results for our research model. The survey data was analyzed using Partial Least Square (PLS). PLS is a structural equation modeling technique that concurrently tests the psychometric properties of the measurement model and analyzes the strength and direction of relationships in the structural model (Chin et al. 2003). It has minimal restrictions on sample size and residual distributions. It is also widely used in IS research (Petter et al. 2007). PLS has the ability to handle moderating effects. Interaction variables were computed by cross-multiplying the standardized items of each construct (Chin et al. 2003). PLS is also able to analyze multi-stage models. Hence, we chose to use PLS for the above reasons. SmartPLS 2.0 (Ringle et al. 2005) is used to analyze our data.

6.1 Instrument Validation

It is important to first establish that the constructs and measures of these constructs are reliable and valid. All constructs in our research model are reflective.

For reflective constructs, measures should covary with one another for internal consistency or reliability (Jarvis et al. 2003). Reliability and convergent validity of the reflective constructs were assessed using Cronbach Alpha, composite reliability, and average variance extracted (AVE) scores. Cronbach Alpha is used to statistically test the reliability of the scale questions

(Cronbach 1951). We examined the alpha value with item deleted diagnostic (see Table B. 1 in Appendix B) to check if reliability could be improved by dropping items. All items were kept as improvement of reliability would not be achieved by dropping any items.

Table 7 shows the Cronbach Alpha values, composite reliability scores and AVE. All Cronbach Alpha values exceeded the required 0.707 for internal consistency. In addition, all composite reliability scores exceeded 0.707 and all AVE scores exceeded 0.50 indicating adequate reliability (Nunnally 1978).

Table 7: Reliability of Reflective Constructs

Construct	Cronbach Alpha	Composite Reliability	AVE
Use of IS (USE)	0.82	0.92	0.85
Perceived Increase in Skill Variety (PIV)	0.94	0.95	0.83
Perceived Increase in Task Significance (PIS)	0.89	0.93	0.83
Prosocial Values (PRO)	0.86	0.91	0.72
Perceived Increase in Beneficiary Contact (BEN)	0.96	0.97	0.92
Self-Efficacy (SEF)	0.87	0.91	0.71
Individual Impact (IMP)	0.94	0.96	0.85

Confirmatory factor analysis (CFA) was performed using PLS. Convergent validity for reflective constructs is shown when each of the items loads on its latent construct with a significant t-value at the 0.05 level (Gefen and Straub 2005). Loadings for the reflective constructs are shown in Table 8. As can be seen from the table, all loadings are significant at $p < 0.001$.

Table 8: Item Loadings for Reflective Constructs

Item	Loading	T Statistics
USE1	0.92***	34.01
USE2	0.92***	40.78
PIV1	0.91***	48.05
PIV2	0.95***	28.38
PIV3	0.89***	15.44
PIV4	0.90***	16.23
PIS1	0.88***	26.45
PIS2	0.92***	37.44
PIS3	0.93***	53.05
PRO1	0.83***	11.98
PRO2	0.88***	13.57
PRO3	0.85***	5.90
PRO4	0.84***	5.46
BEN1	0.96***	51.34
BEN2	0.97***	109.78
BEN3	0.96***	88.20
SEF1	0.88***	28.36
SEF2	0.78***	10.88
SEF3	0.83***	11.53
SEF4	0.87***	14.31
IMP1	0.91***	49.39
IMP2	0.91***	48.53
IMP3	0.95***	117.92
IMP4	0.91***	59.06

*** *Significant at $p < 0.001$ level*

Note: USE = Use of IS, PIV = Perceived Increase in Skill Variety, PIS = Perceived Increase in Task Significance, PRO = Prosocial Values, BEN = Perceived Increase in Beneficiary Contact, SEF = Self-Efficacy, IMP = Individual Impact

Discriminant validity is established when: (1) Items load highly on their theoretically assigned factor and not as highly on the other factors. (2) The

square root of AVE is larger than the correlation with any other latent construct (Gefen and Straub 2005). A more stringent approach is to compare the AVE, rather than the square root of AVE (Gefen et al. 2000).

We first examine the cross loadings to check if items load highly on their theoretically assigned factor and not as highly on the other factors. While there are no established thresholds, the loadings of the items on their theoretically assigned factor should be "an order of magnitude larger than any other loading" (Gefen and Straub 2005, p. 93). Gefen and Straub (2005) gave an example that if items load with a .70 coefficient on its latent construct, then the loadings of the items on any other latent construct should be below .60. Using this example as a guideline, all our items fulfill the criteria of loading higher on their own factors and not as highly on the other factors. Table 9 shows the loadings and the cross loadings. Although the loadings may seem high, it is common to have much higher loadings in PLS than in a principal component analysis (Gefen and Straub 2005).

The second criteria for discriminant validity is that the square root of AVE should be larger than any correlation among any pair of latent constructs. We use the more stringent criteria of comparing AVE, rather than square root of AVE. Table 10 shows the descriptive statistics and correlation matrix, with AVE values on the diagonals. Based on the two criteria, discriminant validity is established.

Table 9: Loadings and Cross Loadings

	USE	PIV	PIS	PRO	BEN	SEF	IMP
USE1	***0.92***	0.27	0.10	0.21	0.10	0.10	0.11
USE2	***0.92***	0.21	0.14	0.14	0.14	0.16	0.16
PIV1	0.32	***0.91***	0.48	0.15	0.34	0.16	0.22
PIV2	0.18	***0.95***	0.51	0.08	0.37	0.14	0.21
PIV3	0.18	***0.89***	0.53	0.02	0.37	0.07	0.10
PIV4	0.24	***0.90***	0.48	0.11	0.33	0.11	0.13
PIS1	0.19	0.54	***0.88***	0.02	0.64	0.22	0.44
PIS2	0.04	0.43	***0.92***	0.26	0.60	0.18	0.48
PIS3	0.13	0.51	***0.93***	0.15	0.65	0.33	0.45
PRO1	0.15	0.08	0.13	***0.83***	0.15	0.18	0.18
PRO2	0.16	0.15	0.15	***0.88***	0.15	0.20	0.15
PRO3	0.16	0.07	0.13	***0.85***	0.11	0.18	0.16
PRO4	0.16	0.07	0.13	***0.84***	0.10	0.13	0.11
BEN1	0.15	0.36	0.66	0.14	***0.96***	0.29	0.58
BEN2	0.12	0.37	0.69	0.15	***0.97***	0.32	0.59
BEN3	0.19	0.36	0.65	0.15	***0.96***	0.29	0.64
SEF1	0.17	0.19	0.32	0.16	0.39	***0.88***	0.40
SEF2	0.02	0.09	0.16	0.10	0.13	***0.78***	0.21
SEF3	0.08	0.07	0.19	0.23	0.18	***0.83***	0.31
SEF4	0.13	0.06	0.15	0.21	0.19	***0.87***	0.34
IMP1	0.06	0.11	0.37	0.13	0.50	0.31	***0.91***
IMP2	0.15	0.14	0.38	0.18	0.45	0.34	***0.91***
IMP3	0.14	0.18	0.53	0.18	0.64	0.36	***0.95***
IMP4	0.18	0.26	0.54	0.16	0.66	0.43	***0.91***

Note: USE = Use of IS, PIV = Perceived Increase in Skill Variety, PIS = Perceived Increase in Task Significance, PRO = Prosocial Values, BEN = Perceived Increase in Beneficiary Contact, SEF = Self-Efficacy, IMP = Individual Impact

Table 10: Descriptive Statistics, Correlation Matrix and AVE

	Mean(SD)	USE	PIV	PIS	PRO	BEN	SEF	IMP
USE	5.66 (0.82)	*0.85*						
PIV	5.15 (1.20)	0.26	*0.83*					
PIS	4.64 (1.30)	0.13	0.54	*0.83*				
PRO	6.33 (0.67)	0.19	0.11	0.16	*0.72*			
BEN	4.00 (1.50)	0.13	0.38	0.69	0.15	*0.92*		
SEF	5.13 (1.23)	0.14	0.14	0.27	0.21	0.31	*0.71*	
IMP	4.76 (1.42)	0.15	0.19	0.50	0.18	0.63	0.40	*0.84*

Note: USE = Use of IS, PIV = Perceived Increase in Skill Variety, PIS = Perceived Increase in Task Significance, PRO = Prosocial Values, BEN = Perceived Increase in Beneficiary Contact, SEF = Self-Efficacy, IMP = Individual Impact

As some correlations are a little high (two are above 0.6), we checked the VIF of the constructs to detect if multicollinearity is present. The VIF values range from 1.11 to 2.43, all well within the criteria of VIF < 3.33 (Diamantopoulous and Siguaw 2006). We conducted tests to check if common method variance is an issue. We used Harman's one-factor test for common method variance (Podsakoff and Organ 1986). This test involves conducting a factor analysis and examining the results of the unrotated solution. The test assumes that if there is substantial common method variance, either a single factor will emerge from the factor analysis, or one "general" factor will account for the majority (>50%) of the covariance in the independent and dependent variables. Our factor analysis results yielded multiple factors, not just one. The first component accounted for 33.56% while the second component accounted for 14.02% respectively. Hence, we conclude that common method variance is not indicated.

After establishing the reliability and validity of the measurement model, we proceed to test the structural model.

6.2 Results of Hypotheses Testing

The structural model results are presented in Table 11. The results indicate that H1, H2, H3, H5, H6, H7, H9, and H10 were supported while H4 and H8 were not. In total, 8 out of 10 hypotheses were supported and 41% of the variance in the outcome variable explained.

Table 11: Structural Model Results

Hypothesized paths	Path coefficient	T value	Hypothesis supported
H1: Use of IS → Perceived increase in skill variety	0.25**	2.82	Yes
H2: Use of IS × Prosocial values → Perceived increase in task significance	0.15**	2.52	Yes
Use of IS → Perceived increase in task significance	0.06	0.91	N.A.
Prosocial values → Perceived increase in task significance	0.11*	1.65	N.A.
H3: Use of IS × Prosocial values → Perceived increase in beneficiary contact	0.23***	4.82	Yes
Use of IS → Perceived increase in beneficiary contact	0.04	0.79	N.A.
Prosocial values → Perceived increase in beneficiary contact	0.10	1.55	N.A.
H4: Self-efficacy → Perceived increase in skill variety	0.11	1.20	No
H5: Self-efficacy → Perceived increase in task significance	0.22**	3.06	Yes
H6: Self-efficacy → Perceived increase in beneficiary contact	0.25***	4.19	Yes
H7: Self-efficacy → Use of IS	0.14*	1.83	Yes
H8: Perceived increase in skill variety → Individual impact	-0.12	1.51	No
H9: Perceived increase in task significance → Individual impact	0.20*	2.13	Yes

H10: Perceived increase in beneficiary contact → Individual impact	0.52***	6.16	Yes

** Significant at p < 0.05 level; ** Significant at p <0.01 level; *** Significant at p < 0.001 level (one-tailed test)*

Figure 4 shows the standardized PLS path coefficients and R square values. The significant effects are shown in solid arrows.

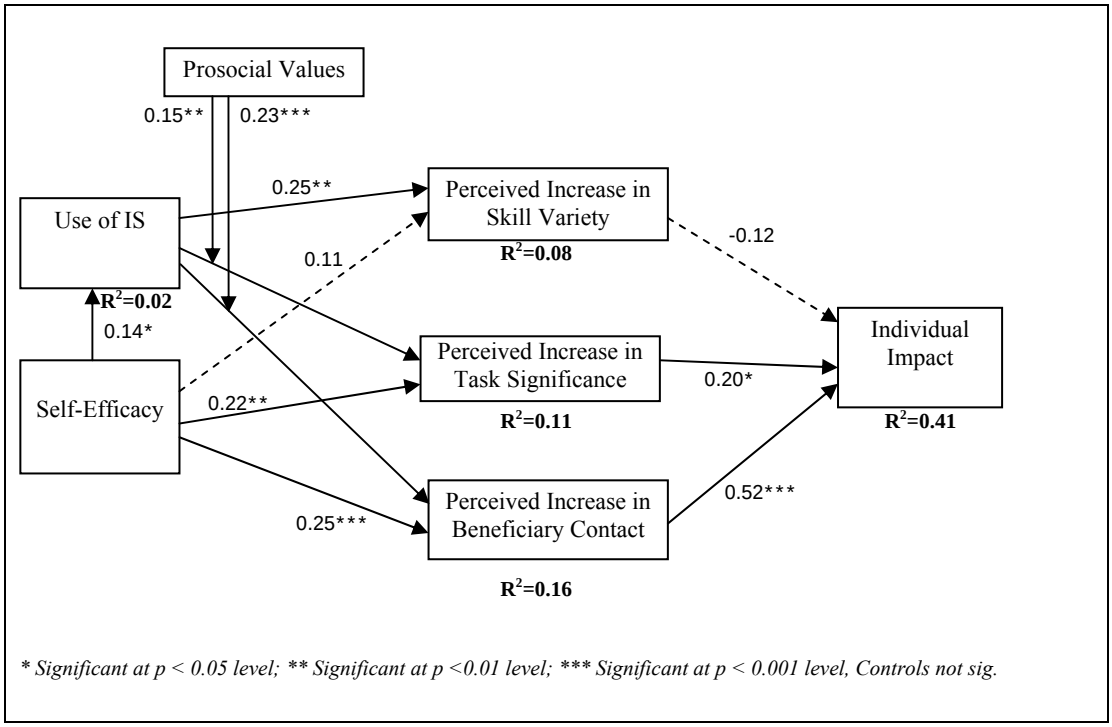


Figure 4: PLS Results for Proposed Research Model

The following control variables were measured and tested in the structural model: years of computer experience, level of computer experience, job tenure at current organization and EMAS experience. All control variables have no significant effect on the dependent variable.

In PLS, good model fit is established with significant path coefficients, high R square for the dependent variable and internal consistency above 0.70 for each

construct (Gefen et al. 2000). In our study, the criteria are largely satisfied. Hence, the model is a good fit.

6.3 Post-hoc Analysis

To assess the mediating effects of the job characteristics (i.e., perceived increase in task significance and perceived increase in beneficiary contact), additional analysis was conducted using Sobel mediation test statistic and its variations, i.e., Aroian's test statistic and Goodman's test statistic (Edwards and Lambert 2007). A mediation is considered significant if two or more of these test statistics are significant. In our research model, one of the independent variables is an interaction term between use and prosocial values. Hence, this is regarded as mediated moderation (Frazier et al. 2004). Our mediated moderation analysis is presented in Table 12. Results indicate that all mediating relationships are significant.

Table 12: Mediated Moderation Analysis

Independent Variable	Mediator	Dependent Variable	Sobel Test Statistic	Aroian Test Statistic	Goodman Test Statistic
Use × Prosocial Values	Perceived Increase in Task Significance	Individual Impact	1.67*	1.60	1.75*
Self-Efficacy	Perceived Increase in Task Significance	Individual Impact	1.78*	1.72*	1.85*
Use × Prosocial Values	Perceived Increase in Beneficiary Contact	Individual Impact	3.83***	3.78***	3.86***
Self-Efficacy	Perceived Increase in Beneficiary Contact	Individual Impact	3.46***	3.43***	3.50***

** Significant at p < 0.05 level; ** Significant at p <0.01 level; *** Significant at p < 0.001 level (one-tailed test)*

7 Discussion and Implications

7.1 Discussion of Findings

The results show that use of IS is positively related to *perceived increase in skill variety*. This is encouraging as it shows that employees view the use of IS as a form of job enrichment in terms of skill variety. For example, one of the nurses wrote in the open feedback section of the survey that through the use of EMAS, she has learned new skills that she never had before. While the use of IS such as EMAS may require users to use additional skills in their job, users perceive it as a positive as they learned new skills so as to perform their job.

The results also indicate that higher *prosocial values* of employees strengthen the positive relationships between IS use and *perceived increase in task significance* as well as *perceived increase in beneficiary contact*. As explained earlier, nurses with higher prosocial values are more likely to perceive and appreciate job enrichment in terms of task significance and increase in beneficiary contact as a result of using the healthcare IS. The use of EMAS allows nurses to focus more on patient care as they no longer have to be concerned with issues such as missing paper IMR and illegible handwriting. In particular, prosocial nurses are more likely to perceive an increase in task significance and beneficiary contact as they are able to focus on interaction with patients, thus improving patient care.

Employee *self-efficacy* with the system was also shown to be a determinant of perceived increase in task significance and beneficiary contact. A nurse who is

confident in using the EMAS will spend less time trying to figure out how to use the system and can instead make good use of the system to provide better patient care, thus increasing task significance and beneficiary contact. Confidence in using the system empowers the nurse to give more to patients. For example, one of the nurses wrote as feedback "When I have a referral to see patients, I am able to view the medication of patient using [EMAS] before I see the patient. This enables me to plan and anticipate for patient's need." Self-efficacy is also a determinant of system use. Confident users use a bigger range of system features which may increase the benefits they experience from using the system.

Perceived increase in task significance is also found to influence *individual impact*. Nurses who consider their jobs as significant in impacting patients are more likely to be more effective in their job performance. Last, perceived increase in beneficiary contact is positively related to individual impact. Increasing the depth and quality of contact with patients through the use of EMAS helps nurses to perceive improved job performance. Nurses consider their work to be more effective when task significance and beneficiary contact increases.

Contrary to our hypothesis, the survey results show that self-efficacy is not significant in increasing perceived skill variety. A possible reason is that nurses who are confident in using EMAS may be confident in using IT in general, and thus do not perceive a significant increase in skill variety. Results also show that perceived increase in skill variety is not significant in affecting

individual impact. On the face of it this seems a surprising finding, as it implies that nurses who perceived that skill variety has increased through the use of IS do not necessarily perceive that they are more effective at work. While nurses may feel that the use of IS increases their skill set, the additional IT skills may not contribute to their effectiveness in serving patients.

In addition to the survey results, our qualitative findings also indicate that reduction of medication errors, improved accountability and time savings are benefits of using the EMAS. Our qualitative findings provide us with a richer and more complete understanding of the benefits of the system.

7.2 Contributions to Research

The findings of this study show that the job characteristics and the relational job design theories can be used to better understand the impact of IT on job performance. Our study is novel in terms of applying the perspective of relational job design and introducing the beneficiary contact construct to IS research, which is appropriate in the healthcare context. This allows researchers to better understand the use and impact of healthcare IT.

Another key research contribution is the understanding of the role of an IS in improving individual work. Previous studies tend to study the direct relationship from use to individual impact, such as using the IS Success Model (DeLone and McLean 1992; DeLone and McLean 2003). In our study, we attempt to open up the "black box" to achieve a better understanding of how use of IS impacts individual work, through change in job characteristics. This

study has identified mediating variables that may explain the link between IS use and individual job impact. In particular, we have identified skill variety, task significance and beneficiary contact as important job characteristics that are influenced by the use of IT and can affect job performance of healthcare workers such as nurses.

In addition, our study has also introduced the construct of prosocial values in healthcare IT and the role it plays in influencing the relationship between the use of IS and perceived increase in task significance and beneficiary contact. This is especially relevant for healthcare jobs such as nursing. It is also likely to be useful for other jobs that are service-related or of a helping nature, such as counseling. Hence, this is a concept to consider when researching IS to be used in healthcare and other service jobs.

Past studies on the impact of computer systems on users (mostly in middle management or supervisory positions) show that computer systems increased task significance but not skill variety (Ryker and Nath 1995). Interestingly, our study shows that nurses perceive an increase in skill variety from the system use which is a new finding valid in the healthcare context of our study. Thus, it is possible that the use of IT affects job characteristics differently depending on the nature of the job.

Previous studies tend to study the relationship between self-efficacy and IT use (e.g., Compeau and Higgins 1995) without considering the additional effects of self-efficacy. In addition to that, this study validates the relationship

between self-efficacy and individual impact, mediated by job characteristics. This introduces an additional explanation which is useful in understanding the impact of IS on individual work. Past studies in the use of healthcare IS have shown that computer self-efficacy impacts end-user job satisfaction and job performance (Henry and Stone 1995; Henry and Stone 1999) but our study gave further insights on the role of self-efficacy influencing job performance through change in job characteristics.

Our qualitative findings also demonstrate how the benefits of a healthcare IT can be measured by studying how the system resolves past issues. A comprehensive understanding of the problems faced by the organization before the system is used is beneficial in analyzing the impacts of the new system. This allows us to evaluate if the system meets its objectives, and if it is successful in improving organization work in specific areas.

Finally, this study also adds to the current limited studies on the impact of healthcare IT and clinical systems such as EMAS, a relatively new healthcare IS. While there are some studies on the impact of EMAS in the medical informatics literature, these studies tend to provide findings concerning patient safety (e.g., Franklin et al. 2007). This study sheds light on how healthcare IS such as EMAS impacts individual work, i.e., the focus is on healthcare workers rather than patients.

7.3 Implications for Practitioners

Findings from this study show that the use of IS in healthcare can indeed improve individual work. This finding is useful in persuading healthcare organizations, such as hospitals, to adopt appropriate IS. This finding is also useful in convincing healthcare workers, such as nurses, to use healthcare IS implemented by their organizations. Past research has shown that user resistance can hinder the adoption and use of healthcare IS (Lapointe and Rivard 2005; Poon et al. 2004). Hospitals can improve the individual acceptance of healthcare IS by explaining to healthcare workers how the use of the system can lead to job enrichment, such as increase in skill variety and task significance. Hospitals can also help healthcare workers see the benefits of using healthcare IS by communicating how the IS use can lead to increased opportunities for quality patient care. This can lead to better job effectiveness and improved job appraisal, as patient safety and patient care are improved. When users are convinced of the benefits of using the system, they are more likely to use the system and experience the positive impacts of the system.

This study also shows that self-efficacy is an important determinant of perceived increase in task significance, and beneficiary contact. This emphasizes the importance of training to boost the skills and confidence of workers in using the system. Systematic group training sessions can be valuable in helping users gain confidence in using the system on their own. Effective training also helps to ensure that users are using the system correctly without any workarounds and unintended methods which may compromise the objectives of the system. This will help to harness the potential benefits of the

IS. Our interviews with the nurses also reinforce the importance of on-the-job training. Through such training, users get to encounter different real-life scenarios and learn how the system should be correctly used in such situations.

Interviews with doctors and nurses also reveal that there were initial teething problems as the users were unfamiliar with the new system. With the introduction of a new system, users have to go through a learning curve to use it proficiently. Therefore, it is unavoidable that users make mistakes when using the system initially. Wrong orders entered by physicians possibly due to lack of training could affect nurses' work as medication administration cannot be performed and nurses have to verify the orders with the doctors. When the system was introduced initially, nurses also spent more time to serve medication as they were unfamiliar with the new system. Incorrect usage of the system has also led to a few near-medication errors. This again emphasizes the importance of training and self-efficacy.

This study also introduces the concepts of relational job design and beneficiary contact in healthcare work. Healthcare organizations should be mindful of the service and helping nature of the nurses' work and use this to enhance the effectiveness of using IT in healthcare. Use of IT should not lead to distancing of healthcare workers from their beneficiaries. Instead, healthcare IT should be designed in such a way that it enhances beneficiary contact and allows healthcare workers to have more meaningful interaction with their patients. Routine work that can be automated by IT is welcome, but it should translate to more quality time and contact with the patients.

Interviews with nurses and doctors have also revealed the importance of adequate technology resources to support the use of the system. Issues relating to connectivity, bandwidth, and software have also contributed greatly to the time required by nurses to perform their tasks. The system relies heavily on the wireless network for transfer of data. However, several areas in a ward may not be covered by a wireless signal possibly due to infrastructure issues. Therefore, users may encounter errors when the COW or PDA is unable to receive or transmit information to the network. This has often frustrated nurses whose aim is to complete their tasks swiftly and efficiently. During peak periods and with the use of systems by physicians, pharmacists and nurses, the system may face a slowdown in accessing information due to bandwidth constraints. The delay caused by this could also slow down and disrupt the work flow of users.

These experiences from our case serve as lessons for other hospitals planning the implementation of healthcare IT such as EMAS. Avoiding these pitfalls can enhance the efficiency and effectiveness gained from using the system.

Lastly, our qualitative findings provide insights on how an EMAS can improve the medication administration process in a hospital. Besides improving medication safety, it offers convenience and time savings for both physicians and nurses. The detailed findings described in Section 5.3 can be useful for hospitals which are considering the adoption of EMAS and also serve as examples for successful implementation of EMAS.

7.4 Limitations and Future Work

The research model is tested with a particular type of clinical healthcare IS (EMAS) in a single hospital. In future, the research model can be tested with other clinical healthcare IS and also in different hospital settings to improve generalizability. The quantitative findings are based on self-reported survey data. Although this limitation is mitigated by the qualitative data we collected, other sources of quantitative data, such as objective performance would be useful in understanding IT impact. Future research could include such data to measure IT impact.

As the EMAS is newly implemented in the hospital, there was insufficient data to measure if there were significant improvements in medication safety. Future studies could follow a longitudinal approach to better understand the impact of healthcare IT, by comparing the number of medication errors before and after the EMAS is implemented. This would be beneficial in demonstrating the value of healthcare IT, thus encouraging healthcare organizations to invest in and benefit from the use of IT.

Last, we noted that the R square values of the mediating job characteristic variables are rather low. This suggests that there may be other variables that can explain these job perceptions. While this is not a concern in our study since our aim is to study their mediating role rather than predict these variables, future studies may investigate other antecedents of these job characteristics.

8 Conclusion

Through this study, we aim to contribute to IS literature by studying in depth the role of a healthcare IS to improve individual work, a relatively less understood phenomenon. We explain the link between IS use and individual impact by exploring how system use may change job characteristics and thereby affect individual work. The results of this study have demonstrated the utility of organizational theories such as the job characteristics model and the relational job design model to understand the use of healthcare IS and its impact on individual work. Further, this study adds to the limited IS research in the healthcare context where IT has the potential to effect substantial benefits. Practically the study offers insights into how IS may be deployed to positively impact individual work in healthcare organizations. Our findings for a relatively new system such as EMAS are also valuable for other healthcare organizations considering the adoption of a similar system.

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APPENDIX A Survey Instrument

Table A. 1: Initial Survey Instrument after Items are Generated

Construct	Item Code	Item	Source
Use of IS (USE)	USE1	I use most of the features of the system.	Self-developed based on Burton-Jones and Straub (2006)
	USE2	I use a range of features of the system.	Self-developed based on Burton-Jones and Straub (2006)
Perceived Increase in Skill Variety (PIV)	PIV1	After I started using the system, the variety of new skills that I require for my job has increased.	Morgeson and Humphrey (2006); Campion and McClelland (1991)
	PIV2	After I started using the system, the number of complex or high-level skills that I require for my job has increased.	Hackman and Oldham (1975); Hackman and Oldham (1974); Morgeson and Humphrey (2006)
	PIV3	After I started using the system, the number of skills that I require for my job has increased.	Morgeson and Humphrey (2006)
	PIV4	After I started using the system, the variety of different skills I require to complete my work has increased.	Morgeson and Humphrey (2006)
Perceived Increase in Task Significance (PIS)	PIS1	After I started using the system, my job is more significant.	Hackman and Oldham (1975); Hackman and Oldham (1974)
	PIS2	After I started using the system, the results of my work are more likely to affect the lives of other people.	Morgeson and Humphrey (2006);

			Hackman and Oldham (1974)
	PIS3	After I started using the system, my job has a larger impact on people outside the organization.	Morgeson and Humphrey (2006)
Prosocial Values (PRO)	PRO1	I feel it is important to help those in need.	Rioux and Penner (2001)
	PRO2	I want to help my beneficiaries in any way I can.	Adapted from Rioux and Penner (2001)
	PRO3	I am genuinely concerned about the people I am serving.	Clary et al. (1998)
	PRO4	It is important for me to respond to the needs of others.	Grant (2008b)
Perceived Increase in Beneficiary Contact (BEN)	BEN1	After I started using the system, I build more close relationships with the people affected by my work (patients).	Grant (2008a)
	BEN2	After I started using the system, I form more emotional connections with the people who benefit from my work (patients).	Grant (2008a)
	BEN3	After I started using the system, I have more meaningful communications with the people who benefit from my work (patients).	Grant (2008a)
Self-Efficacy (SEF)	SEF1	I can complete a job or task using the system even if there was no one around to tell me what to do.	Venkatesh et al. (2003)
	SEF2	I can use the system on my own even if there was nobody around to show me how to use it.	Taylor and Todd (1995)
	SEF3	I feel comfortable using the system on my own.	Taylor and Todd (1995)
	SEF4	I can easily use the system on my own.	Taylor and Todd (1995)
Individual Impact (Effectiveness) (IMP)	IMP1	The system helps me to improve patient safety.	Self-developed
	IMP2	The system helps me to reduce medication errors.	Self-developed
	IMP3	The system helps me to care better for patients.	Self-developed
	IMP4	The system enhances my effectiveness in the job.	Gable et al. (2008); Rai et al. (2002); Iivari (2005)

APPENDIX B ADDITIONAL DATA ANALYSIS

Table B. 1: Cronbach Alpha Values

Construct/Item	Cronbach Alpha	Alpha if Item Deleted
USE	0.822	
USE1		N.A.
USE2		N.A.
PIV	0.936	
PIV1		0.936
PIV2		0.897
PIV3		0.914
PIV4		0.916
PIS	0.894	
PIS1		0.889
PIS2		0.831
PIS3		0.826
PRO	0.861	
PRO1		0.839
PRO2		0.810
PRO3		0.821
PRO4		0.823
BEN	0.958	
BEN1		0.944
BEN2		0.932
BEN3		0.940
SEF	0.869	
SEF1		0.869
SEF2		0.845
SEF3		0.814
SEF4		0.803
IMP	0.941	
IMP1		0.921
IMP2		0.919
IMP3		0.911
IMP4		0.940

Note: USE = Use of IS, PIV = Perceived Increase in Skill Variety, PIS = Perceived Increase in Task Significance, PRO = Prosocial Values, BEN = Perceived Increase in Beneficiary Contact, SEF = Self-Efficacy, IMP = Individual Impact