The Impact of Clinical Information Systems on Patient Outcomes and Organisational Performance

PETER HADDAD, JONATHAN SCHAFFER & NILMINI WICKRAMASINGHE

Abstract We are witnessing significant investments by the healthcare industry globally in information technology (IT) to enhance patient outcomes, safety, efficiency, and financial performance. However, unlike other industries, the complexity of healthcare confounds the evaluation of the business value of these IT solutions and thus to date it has been difficult to clearly articulate the true business value of IT in healthcare contexts. This exploratory study addresses this problem by examining three clinical IT systems in the Australian healthcare context: a nursing documentation (ND) System, a computerized physician order entry (CPOE) solution, and an Incident Reporting System (IRS). The results indicate that these systems have the potential to provide better business value and have direct and indirect impacts on patient outcomes, efficiency, safety, and the overall performance at different levels, depending on a multiplicity of factors all of which need to be considered.

Keywords: • Healthcare • Information Systems • Clinical IT • CPOE • Nursing Documentation •
1 Introduction

Optimal healthcare access, quality and value have become global priorities for healthcare domains to combat the exponentially increasing costs of healthcare services (Huang, Seitz, & Wickramasinghe, 2010; Porter, Pabo, & Lee, 2013). Information systems/information technology (IS/IT) have been promoted as a critical enabler to achieving these priorities (Kenneally et al., 2013; OECD, 2010a, 2010b). Presently, we are witnessing a staggering range of IS/IT applications in healthcare that have promised to deliver higher quality and safety with greater value (Wickramasinghe & Schaffer, 2010). However, the data supporting these claims is often lacking or poorly supported (Melville, Kraemer, & Gurbaxani, 2004; Lemai Nguyen et al., 2015). Advocates, in particular, point to the potential reduction in medication errors as a critical advantage (Radley et al., 2013; Vermeulen et al., 2014). These singular advantages do not reflect the enterprise viewpoint that is so needed (James, 2013). Further, the debate about the difference IS/IT solutions can make to healthcare quality, efficiency, and safety has only intensified (Buntin, Burke, Hoaglin, & Blumenthal, 2011; Jones, Rudin, Perry, & Shekelle, 2014). In the light of these complex circumstances, there is a critical need for a framework to evaluate the business value of IS/IT in healthcare (Haddad, Gregory, & Wickramasinghe, 2014).

Previous research (Haddad, Schaffer, & Wickramasinghe, 2015; Haddad & Wickramasinghe, 2014, 2015) has discussed examining the business value in healthcare IT by leveraging four groups of IS/IT according to their business. These groups classify IS/IT into infrastructural, transactional, informational, and strategic domains (Weill & Broadbent, 1998). Socio-technical aspects (Muhammad, Teoh, & Wickramasinghe, 2013) with healthcare projects are also important to consider. Thus, they are mapped in previous work with the different layers of healthcare delivery including healthcare ecosystem, system structure, delivery operations, and clinical practices (Rouse & Cortese, 2010).

This research evaluates the developed model of The Business Value of IT (BVIT) in Healthcare (Figure 1). This model was designed to help evaluate the business value of IT in healthcare (Haddad et al., 2015; Haddad & Wickramasinghe, 2014, 2015). The model itself takes technical and socio-technical perspectives in mind. The former is presented by the work of Weill and Broadbent (1998), which classifies IT investments into four categories based on their business objectives (infrastructural, transactional, informational, and strategic), while the latter is presented by the work of Rouse and Cortese (2010) which classifies various healthcare delivery activities into four levels, namely healthcare ecosystem, system structure, delivery operations, and clinical practices. Specifically, three clinical IT systems at both private and public healthcare settings in Australia were evaluated. The first system is an American made computerized physician order entry (CPOE) system. The second is an Australian made nursing documentation (ND) system, while the third is an Australian made incident reporting system (IRS). The selection of these systems was based on their characteristics as they address the needs of different stakeholders i.e. the ND system helps streamline the
workflow of nurses, the CPOE helps oncologists (a more specialised clinical group than nurses) to manage cancer medications, and the IRS is meant to be use by all of the hospitals’ staff to report incidents. Testing these systems in two different settings serves two purposes: 1) Data triangulation and findings validation and 2) Impact assessment of two different elements in the Australian healthcare ecosystem (private and public healthcare providers) on generating business value from clinical IT.
Figure 1: The Model of Assessing Business Value of IT in Healthcare
2 Methods and Settings

A multiple case study approach was adopted, as this enables contrasting results for predictable reasons to enhance the generalisation to other case studies (Baxter & Jack, 2008; Yin, 2014). Two case studies were used in this study. The selected cases were chosen based on 1) the volume of IT investments they both made during the last 5 years, 2) their nature (one is public and the other is private) to help identify any differences could result as a result of differences in care delivery models, and 3) having vast ranges of clinical specialties The first is ABC Hospital, a Victorian public hospital established in 2000 and provides care for more than 750,000 people. ABC Hospital has been providing around one million episodes of patient care each year through the efforts of about 10,000 staff. ABC Hospital provides a comprehensive range of clinical services and high-quality acute, sub-acute and palliative care, mental health, drug and alcohol services, and residential care, community health and state-wide specialist services to people and communities that are diverse in culture, age, socio-economic status, population and healthcare needs.

The second case study is XYZ Hospital, which is a private hospital and counted as one of the largest not-for-profit private healthcare groups in Australia. With seven sites and two rehabilitation centres, XYZ Hospital has invested more in IS/IT during the last few years than in the past and hence was one of the reasons they were chosen to be included in this study. According to the Chief Financial Officer (CFO), approximately 30% of the capital budget during the last five year was set aside for IT investments in business, infrastructure and clinical systems.

Three clinical IT systems were examined; the ND, IRS and the CPOE systems. The ND system was studied within ABC and XYZ hospitals, while the IRS and CPOE systems were studied solely within XYZ Hospital.

Prior to conducting the data collection, all ethics approvals had been acquired from both hospitals. For the ND system two sources of data were used; survey\(^1\) data collected from ABC Hospital (two sites A and B), and semi-structured interviews at XYZ Hospital. First, the survey was distributed pre and post implementation of the ND system and consisted of six sections. The survey used the unified theory of technology acceptance and use of technology (UTAUT) as the studied ND system is a new system. The survey consisted of:

- Items related to performance expectancy (PE) (8 questions in this group)
- Effort expectancy (EE), (4 questions)
- Social influence (SI) (5 questions)
- Facilitating conditions (FC) (4 questions)
- Voluntariness (V) (3 questions)
- Behavioural intentions (BI) (5 questions)
UTAUT was used as a technology acceptance model to uncover intentions of users regarding the use of a new system. Inclusion criteria for the survey was: 1) being a nurse, 2) worked for more than 5 years in similar settings, and 3) willingness to participate in the survey. The survey used the lens of UTAUT, and was validated using extensive discussions with academics and experts in the healthcare domain. Required changes were made accordingly. This method is widely used to measure the different aspect of interaction between human resources and health IS/IT, see for example (L. Nguyen et al., 2015; Oshlyansky, Cairns, & Thimbleby, 2007; Taiwo & DOWNE, 2013; Williams, Rana, Dwivedi, & Lal, 2011).

Due to the nature of nurses’ duties, and to our intention to gain instant understanding of how the nurses found the investigated system, a hard copy of the survey was prepared and provided to nurses at the completion of their shift. Those who met the criteria across two sites at ABC Hospital were 39 in site A and 48 in site B with response rates of 60% and 70% respectively.

Due to the complexity of the CPOE and IRS systems, and given they both were new during the data collection phase, 23 semi-structured interviews were conducted for healthcare better understanding of the possible business value of these systems. From these interviews specific themes emerged (Pope & Mays, 2013) with critical information and insights from three major groups of professionals in the healthcare industry: executives, clinicians (physicians), and IT personnel. Selecting the participants was based on their role and/or affiliation with the group, as well as their level of interaction with IS/IT investments and projects. The first protocol for the interviews was reviewed by conducting three pilot interviews with medical and IT experts. This phase resulted in a shorter and more focused protocol. Three questions were deleted as they had been designed to ask about systems that never existed in the case study (Yin, 2014), and two questions were added to explore insights from clinical IT experts, i.e. clinical people who are IT savvy. After modifying the interview protocols, the main interviews took place. All of the interviews were audio recorded with full permissions from interviewees, professionally transcribed, verified, and then qualitatively analysed using QSR Nvivo 10 software (Bazeley & Jackson, 2013). Data collected from these interviews were analysed also to understand the business value of the studied systems. These interviews were also used as a primary source of data about the CPOE and IRS systems (Table 1).
Table 1: Research Design

<table>
<thead>
<tr>
<th>System</th>
<th>Setting</th>
<th>Method</th>
<th>Data Sources</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRS Australian system</td>
<td>Private (XYZ Hospital)</td>
<td>interviews</td>
<td>23 Semi-structured interviews</td>
<td>Physicians, Executives, IT personnel</td>
</tr>
<tr>
<td>ND Australian system</td>
<td>Private (XYZ Hospital)</td>
<td>interviews</td>
<td>23 Semi-structured interviews</td>
<td>Physicians, Executives, IT personnel</td>
</tr>
<tr>
<td></td>
<td>Public (ABC Hospital)</td>
<td>UTAUT based online</td>
<td>UTAUT survey</td>
<td>Nurses</td>
</tr>
<tr>
<td>CPOE American system</td>
<td>Private (XYZ Hospital)</td>
<td>interviews</td>
<td>23 Semi-structured interviews</td>
<td>Physicians, Executives, IT personnel</td>
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3 Results

Data analysis was initiated by mapping the three systems using the Business Value of IT in Healthcare model. Based on their functionalities, the studied systems were classified as informational IT, which provides information for managing and controlling the firm, as well as supporting decision making, communication and control (Weill & Broadbent, 1998). These systems, though, have other components from the IT Portfolio as Table 2 depicts. For example, the CPOE system is informational in nature, as it helps produce and share information on treatment plans and medication scheduling. However, it has a transactional component, which enables data entry/input like identification, progress notes, medication scheduling, discharge checklist, and treatment plans. In addition, it utilises the IT infrastructure like Internet, Intranet, workstations, servers, and databases. Table 2 also shows the different layers of healthcare delivery from a socio-technical perspective.
Table 2: Mapping the Three Studied Systems to the BVIT Model

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Components</th>
<th>ND</th>
<th>CPOE</th>
<th>IRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare Ecosystem</td>
<td>Internet, Intranet, Computers, Servers, Smart devices in wards and at nurse stations, databases</td>
<td>Internet, Intranet, Computers, Servers, Databases</td>
<td>Internet, Intranet, Computers, Servers, Databases</td>
<td></td>
</tr>
<tr>
<td>Transactional</td>
<td>Data entry/ input, like Vital signs Fluid balance charts Pain assessment Identification Progress notes Wound care Medication</td>
<td>Data entry/ input, like Identification Progress notes Medication scheduling Discharge checklist Treatment plans</td>
<td>Data entry/ input, like Incident details Level of reporting Actions required Destination of information</td>
<td></td>
</tr>
<tr>
<td>Informational</td>
<td>Facilitating information sharing within different craft groups rather than using paper records</td>
<td>Producing and sharing information on treatment plans and medication scheduling</td>
<td>Facilitating real time information exchange among different departments and personnel</td>
<td></td>
</tr>
<tr>
<td>Strategic</td>
<td>Smart medication scheduling</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>System Structure</td>
<td>All of the systems work in the Australian healthcare ecosystem. The only difference is one is being implemented in a private hospital (CPOE and IRS) and the other is being trailed and tested in both private and public hospitals.</td>
<td>All of the systems require reengineering healthcare processes to help generate business value. This includes both internal and inter-organizational processes.</td>
<td></td>
<td></td>
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<tr>
<td>Delivery Operations</td>
<td>Detection</td>
<td>Detection</td>
<td>Detection</td>
<td></td>
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<tr>
<td></td>
<td>Diagnosis</td>
<td>Diagnosis</td>
<td>Diagnosis</td>
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<td></td>
<td>Treatment</td>
<td>Treatment</td>
<td>Treatment</td>
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<td></td>
<td>Recovery</td>
<td>Recovery</td>
<td>Recovery</td>
<td></td>
</tr>
<tr>
<td>Clinical Processes</td>
<td>ND</td>
<td>CPOE</td>
<td>IRS</td>
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</table>
3.1 The CPOE System

The CPOE system, specialized in oncology care, has three modules focused on radiation, medical, and surgical oncology care. At XYZ Hospital, the radiation and medical modules have been implemented, while the surgical module has not yet been acquired. The aim of implementing this system is to replace the manual patients scheduling with an electronic means on a quest to improving the integration of the cancer care process and eliminating prescription errors.

The radiation module was implemented in XYZ Hospital two years ago, while the medical module has been recently acquired. Globally, the system has been in use in the market for 10-15 years while in the Australian market, it is been in use for 7 years. Investigating the impact of this system showed that CPOE systems have high potential to optimize both patient outcomes and healthcare efficiency by better aligning with care standards and protocols. Since the introduction of this system, “there’s been a significant reduction in errors because we prescribe according to the protocol. These protocols are quite common and human error in prescribing is common. It has enhanced legibility, all that sort of stuff” as one interviewee described. For the financial performance, a number of interviewees expected that the system would enhance the financial performance by receiving more referrals from independent oncologists (visiting medical officers (VMOs), but this is subject to complex agreements that have to be reached between the hospital and the VMOs and that is beyond the scope of this paper.

3.2 The ND System

The ND system has been envisaged by the developers to replace the paper-based nursing documentation applications in hospital acute wards in both private and public hospitals. The objective of this system is to eliminate time assigned for non-medical duties and allocate more time for patients’ care. This is facilitated by putting smart terminals at patients' bedsides, creating more direct interaction between nurses and patients. Providing these smart terminals directly at the bedside should facilitate higher levels of collaboration between ward nurses and other healthcare professionals according to the system’s designers.

Results revealed from the UTAUT survey at ABC Hospital showed that this system increased the time for patient assessment from 5.2% to 9.1% of the total time spent by a nurse during a regular ward visit. This was achieved by reducing the time consumed for nursing documentation from 15.7% to 6.4%. Not only did the care time increase, but also the level of transparency, as patients could witness more details about their care provision, and an extra 48.1% of nursing activities were performed at the bedside compared to the process before introducing the ND system.

The system helped increase patients safety by having a ‘one-stop-shop’ for patient records as one interviewee described. On the other side, a number of interviewees did not see a
direct translation between ‘longer care time’ and ‘better care’. One interviewee noted that it is “much more complex than just taking some aspects of the role away”, and even with this new system “I think that even with our new technology that we're testing now, nurses find other things to do” as another interviewee explained. The scope of the system is limited to ward and nursing station. This does not allow the system to cover the end-to-end process of healthcare provision as one interviewee noted in their concerns.

In addition, the ND system has demonstrated high potential to increase the healthcare efficiency by reducing the time dedicated for paper records and following patients’ information and records. The nature of the system allows for a “higher number of processes to happen ever than before” as one interviewee noted, which has direct impacts on the efficiency of healthcare delivery through prompts and real time documentation. Also, this system seemed to have some impacts on the clinical decision making process. With all patient data available in the ward in one electronic pool i.e. the ND system, nurses can make clinical decisions or recommendations quicker, and based on more evidence than the paper records as agreed to by the interviewees.

The results show that the system may have indirect impacts on the financial performance of the facilities. This is by enhancing the reputation of the hospital through their use of state-of-the-art systems that are visible to the patients. A number of interviewees noted that this system has what was termed “face value”. As a private hospital, reputation is a “fundamental part of the business” as one interviewee described. Thus “if patients feel that even just on face value, that the nurses are not scribbling on a piece of paper, but actually, they've got an IT system that provides confidence in the organization”. Other aspects of enhancing the financial performance by using this system included better resource allocation. As the time spent by nurses to perform documentation duties is reduced, nurses are expected to capable to provide care to higher number of patients.

### 3.3 The IRS System

This system is used across almost all of Victoria and beyond in large parts of Australia as well for capturing abnormal clinical incidents. It serves two purposes: documentation of an incident at the time it occurs, to support the classification via an inbuilt algorithm into how serious the incident is, and standardizing the information that's being captured through validation fields, distribution of that information to where it needs to be and then to drive it through into a larger data set of all clinical incidents to support more detailed analysis.

This reporting system is web-based and enables all stakeholders to report different levels of incidents irrespective of their criticality. Along with capturing clinical or non-clinical incidents, the IRS enables sharing information with different levels of management and employees without any delay, as one of the closet administrators of this system explains: ”that's about people anywhere in the organization reporting clinical - or incidents of any sort - that a staff or patient. That's dependent upon an IT system having someone locally
doing something that's reasonably easy that makes the information available where it needs to be. Off the back of that incident being reported there are potential triggers or alerts launched to people who need to know. So, if it's a staff incident, O.H.S staff knows about it, as soon as it's entered. If it's a very serious incident, all of the senior management and appropriate clinical risk people know about it straightaway. There are some benefits in terms of information provision”. This system is relatively inexpensive, simple, intuitive, and easy to use, as a majority of the interviewees agreed during our discussions. These features make this system very popular in the Australian Healthcare context.

XYZ Hospital purchased this system a few years ago to address an obvious gap in the information flow regarding incidents across the hospital as a number of interviewees agreed: “... [without IRS] we will have no capacity to know, or no realistic capacity, to know what things are going wrong with our patients, and therefore the ability to monitor them, to improve them and to attract that improvement”.

Using this system has created a 'cultural shift' towards reporting in the group as one interviewee notes: “We’ve got numbers of things that happened at the time we implemented it. We’ve seen the cultural shift towards reporting; so increased numbers of incidents being reported not occurring because we don't know what occurred. Then we’ve seen the severity of those events go down in the time we’ve used it. Then the frequency of things happening goes down, while we have other indicators implying that reporting is still up”. This shift, in turn, has other impacts on the overall performance of the group. A number of the interviewees emphasized that the use of IRS is associated with increased patient safety, healthcare delivery efficiency, as well as reduced cost of healthcare provision: “If we’re not having patients stay longer because something went wrong, then it’s more efficient. If a patient comes to have a heart operation, and then falls over and breaks their leg, then they stay for another week, have another operation; all of which we potentially are not paid for, so there’s a cost imposed. So there are real benefits.”

4 Discussion

This study analyses the business value of IT in three specific healthcare contexts. This was done by using the Business Value of IT in Healthcare Model, which builds upon the IT Portfolio model (Weill & Broadbent, 1998) and the Enterprise of HealthCare Delivery model (Rouse & Cortese, 2010). The results suggest that looking at IS/IT solutions based on their business objectives helps identify which IT systems in the healthcare industry may help create more business value for the studied hospitals. Informational IT was shown to be the most relevant category for the healthcare context. This is consistent with the findings of Weill and Broadbent (1998) that informational IT is important to facilitate seamless information flow between different stakeholders. This is particularly crucial for healthcare providers as clinical decision making is a sophisticated process, and most of the time it requires inputs from different craft groups. Thus, finding an electronic platform that provides dashboard capabilities to nurses and other physicians is prudent for today’s and tomorrow’s healthcare. The results from the interviews showed that information
sharing that is facilitated through the use of the systems evaluated in this study, IRS, ND, and CPOE has positive impacts on patients’ outcomes, efficiency of operations, and the overall performance of the studied hospitals.

The CPOE system shows a potential to increase both patient outcomes and healthcare efficiency by facilitating smoother cancer care delivery and reducing drug prescription errors. The private public nature of hospital did not have any visible impacts on patient outcomes and healthcare efficiency, as the core business is the same between private and public hospitals i.e. patient care. Private hospitals seem to build upon brand and ‘face value’ elements to attract more patients by introducing state-of-the-art systems, the use of these system was not the first factor the patients took into consideration when making the decision on where to receive the care they need. However, the adoption of such systems attracted patients given everything else in the care delivery was the same with the studied hospitals.

On the other side, the results show that embedding IS/IT into various healthcare delivery operations in the studied hospitals has introduced a significant change to both care givers and patients. In addition, given the CPOE is internationally developed, the results from the interviews showed that it still needs some ‘domestication’ to better attend to the uses’ requirements. Similarly, the ND system was still under development during the data collection phase, which resulted in a number of technical problems and thus frustrated the nurses. No downsides were reported with the use of the IRS system.

5 Conclusion

Correctly and completely identifying the business value of IT in healthcare contexts remains a challenging task. To address this, three clinical systems were examined to better understand how information technology can facilitate the generation of business value in healthcare. The BVIT model was constructed to map the studied systems, and to understand what role private/public classification can play in the context of the two tier Australian healthcare system. All of the systems had direct and indirect impacts on generating business value. The BVIT model was found to be helpful to investigate the business value of a vast range of clinical IT systems. The next stage of research will study the CPOE system in Australian public hospitals as the systems are implemented. Given that the Australian healthcare system supports both public and private healthcare delivery models and the model in this study was shown to be as relevant in both spheres, this provides strong support for the applicability of this model in other healthcare contexts; namely UK or US where, as discussed earlier, the healthcare systems tend to be essentially public and private respectively.

In general, investigating the business value of IT in healthcare is a challenging undertaking, due to the complexity and uniqueness of the healthcare industry. Unlike other industries such as finance, retail, and manufacturing, various non-monetized aspects need to be taken into consideration with evaluating the business value of IT in healthcare.
This study has implications for both theory and practice. For theory it significantly describes the development of a systematic and rigorous framework to enable and facilitate the establishment of business value of IT in healthcare and also to value the IT solutions in healthcare irrespective of the public or private nature of healthcare system being studied. For practice it provides a systematic approach that can be applied to any healthcare context irrespective of the underlying healthcare system to facilitate a fuller and deeper identification of the actual business value of IT in a specific healthcare context.

Notes

1 For ethical and commercialisation considerations, the reference is available upon request.

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