Analyzing the Enabling Factors for the Organizational Decision to Adopt Healthcare Information Systems

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ABSTRACT

Technological advancements have accelerated the deployment of healthcare information systems (HIS) with the potential to enhance productivity, lower costs, reduce medication errors, and ease the manpower strain on the healthcare industry. A recent development is the use of wireless vital signs monitoring systems for ubiquitous patient care. Although these systems can provide various benefits to healthcare professionals and patients, there is a high incidence of unsuccessful HIS projects and problems with initiating their adoption. Particularly, the role of pilot studies for initiating adoption and the enabling factors for the decision to adopt HIS are unclear. Motivated thus, this paper applies the technology-organization-environment perspective to obtain a holistic understanding of the phenomenon. A framework of factors leading to an adoption decision for wireless vital signs monitoring systems is developed through a cross-case analysis of pilot trials conducted in two large public hospitals. With differing adoption decisions, findings from the two cases are synthesized to create the framework that identifies the enabling factors and shows their inter-relationships in facilitating the adoption of these HIS.

Keywords: Healthcare IS, vital signs monitoring, pilot trial, adoption enabling factors

1 INTRODUCTION

The deployment of healthcare information systems (HIS) aims to enhance productivity, lower costs, reduce medication errors [1], and ease the strain on the healthcare industry due to the trends of population ageing [34] and shortage of trained healthcare professionals [23]. Facilitated by technological advancements, opportunities have arisen to deploy new HIS, such as wireless vital signs monitoring systems.

In recent times, wireless vital signs monitoring systems have garnered considerable interest from hospitals [33]. By strategically placing sensors at specific places on a patient's body, vital signs such as temperature, blood pressure, and pulse rate can be assessed remotely through such systems.

With the use of a mobile network or Wi-Fi, this information can be transmitted through a trusted network to healthcare professionals responsible for the patient. The potential benefits of implementing a wireless vital signs monitoring system are manifold. The use of wireless biosensors to measure patient vital signs can eliminate the need for nurses to conduct routine rounds for manual vital signs monitoring and the recording of these measurements on paper. Previous studies have found that manual documentation of vital signs measurements can take up to 20% of nurses' work time [5,16]. Introducing a wireless vital signs monitoring system may thus save time that could be used for other nursing tasks such as interactive patient care. In addition, all patients' vital signs measurements can be simultaneously retrieved through a central monitoring PC or wirelessly transmitted to PDAs and Notebooks. Proactive threshold monitoring could then be implemented to remotely alert healthcare professionals should there be any abnormal readings [31].

Although HIS such as the above system have the potential to improve the quality of care, management is concerned about how to implement such systems due to the high incidence of unsuccessful projects [25]. Heeks [15] estimates that up to 85% of HIS projects encounter some form of failure with numerous issues that plague their implementation [21]. However, despite the importance of HIS and the various issues related to their adoption and implementation, the healthcare domain remains underrepresented in the IS literature [14]. With respect to wireless vital signs monitoring systems, there is a lack of research and understanding about the issues involved in their implementation [40]. As a result of these challenges, a careful consideration of the decision for implementation of such IS is needed, such that investments in these systems (which are substantial) may produce the intended benefits and meet the needs of organizations.

For new technologies in general, researchers have suggested that a pilot study can be conducted to evaluate the effectiveness of the technology before adoption [30]. This is particularly true for HIS with considerable resources required for their implementation and the serious consequences of medical errors should they fail to work [38]. Conducting pilot trials provides an opportunity for a preliminary evaluation of a system's usability and usefulness and also highlights and allows rectification of potential issues that might arise if the system is implemented [4]. As a result, the outcome of the pilot study can influence an organization's decision for full implementation of a

HIS. However, although it is recognized that the careful design of a pilot is essential for an effective trial [30], the factors surfacing during a pilot that can initiate and facilitate the system adoption decision remain unclear.

Motivated thus, this paper aims to address the above gap in the HIS literature by proposing a framework to understand the influencing factors from a pilot study that lead to an organization's decision to adopt HIS such as a wireless vital signs monitoring system. With the increasing prevalence and potential benefits of wireless vital signs monitoring systems along with the lack of understanding of the phenomenon, this paper seeks to answer the following research questions: (1) What are the enabling factors from a pilot to initiate adoption of a HIS such as a wireless vital signs monitoring system? ; (2) How do the factors inter-relate and initiate adoption of the HIS?

To examine the research questions, this paper applies the technology-organization-environment (TOE) perspective [37]. The TOE lens is considered suitable since it has been used by IS researchers to comprehensively understand the key contextual elements (i.e., technological, organizational, and environmental) that determine technology adoption at the firm level [27]. Thus, we use this perspective to understand the factors that lead to a HIS adoption decision. Our framework of influencing factors was developed by applying the TOE lens for a cross-case analysis comparing the wireless vital signs monitoring system pilot trials conducted in two large public hospitals. The two hospitals (referred to in this paper as Hospital A and Hospital B) had different adoption decisions after the pilots for the wireless vital signs monitoring systems. Although both system architectures were similar, Hospital A was able to proceed to full-scale adoption while the project stalled after the pilot in the case of Hospital B. Based on the case analyses, we synthesized our findings to develop the framework identifying and showing the inter-relationships of facilitating factors for initiating adoption of wireless vital signs monitoring systems.

2 CONCEPTUAL BACKGROUND

In this section, we first review the research on pilot implementations for IS in general and more specifically for HIS. Subsequently, we discuss the common theories for organizational IT adoption followed by a description of the TOE perspective. Finally, we review the technological, organizational, and environmental factors for HIS adoption as per TOE to guide us in our case analysis and in the development of our framework.

2.1 Research on Pilot Implementations in IS

Organizations have recognized the importance of pilot testing for identifying design flaws and potential implementation issues prior to the full-scale implementation of a new IS [30]. Pilot studies refer to feasibility studies that comprise of small-scale versions or trial runs of planned methods, measures, or systems [38]. Pilot trials allow management to evaluate the effectiveness of the technology on a small scale before committing substantial resources, and have been featured in prominent technology adoption stage models (e.g., [18,26]). For potential adopters, trials provide a "risk-free" way to explore and experiment with the technology, which reduces the uncertainty about the consequences of using the system [22]. For example, Pal et al. [30] highlighted the usefulness of a pilot trial to evaluate the economic viability of an IS through a case study of RFID use in parking operations.

In the HIS context as well, pilot testing is commonly used to evaluate the effectiveness of systems before full deployment [28]. Besides the considerable investments required for such systems, a key reason for conducting pilots is due to the critical nature of the information handled. For HIS dealing with patient information, failure of these systems may lead to serious consequences such as medication errors [14]. Thus, in a literature review of 69 articles on HIS implementations, Orwat et al. [28] noted that at least 84% of the systems examined conducted a pilot study before deciding if full deployment is feasible.

However, although pilot trials are prevalent for HIS, there is a lack of research on the factors from such pilot trials that facilitate the adoption decision, with the limited literature focusing on the challenges when adopting this strategy [4]. Overall, there is a lack of understanding of the enabling factors from a pilot and their inter-relationships leading to organizational adoption decision of HIS such as wireless vital signs monitoring systems. We next review organizational IT adoption theories in general before discussing the TOE perspective used in our study.

2.2 Organizational IT Adoption Theories

IT adoption has largely been studied at two levels, the individual and the organization. However, much of the IT adoption research has focused on the individual by explaining what influences their decision to use a particular technology. For the relatively fewer studies on firm-level adoption, the important theoretical perspectives include the diffusion of innovation (DOI) theory [32], institutional theory [10], and the technology-organization-environment (TOE) perspective [37]. The DOI theory [32] suggests that the predictors of organizational innovativeness (that facilitates new IT adoption) include individual characteristics and characteristics of the organization. In addition, the theory also posits that diffusion of a technology innovation depends on innovation characteristics, such as relative advantage, complexity, compatibility, observability, and trailability.

Another perspective, institutional theory, has been used in IS research (e.g., [35]) to demonstrate that organizational technology adoption can be a result of coercive, mimetic, and normative forces of the institutional environment [10]. Coercive pressures derive from legal mandates or influences that are exerted by structures on which the focal organization is dependent, while normative pressure is brought about by professional groups and associations that define the conditions and methods of an occupation's work. Mimetic pressures appear in a context of uncertainty, where firms model themselves after other organizations in their field that are perceived as more legitimate or successful.

The third prevalent lens is the TOE perspective [37] which proposes that technological innovation decision making is determined by three separate dimensions i.e., technology, organization, and environment. While DOI focuses on individual, organizational, and technological characteristics, and institutional theory focuses on the characteristics of the organizational environment, the TOE perspective is viewed as a more comprehensive lens for the study of adoption of IS innovations at the firm level by encompassing all of these characteristics [42]. In addition to being consistent with the DOI and institutional theories, the TOE perspective suggests an union of the influential factors from the other two theories that can be important drivers for IT adoption decision making [27]. Therefore, we find it suitable to use the TOE perspective to guide us in our case analysis and in the development of our framework.

2.3 TOE Perspective

According to Tornatzky and Fleischer [37], three aspects of an organization's context can influence technological innovation decision making i.e., technological, organizational, and environmental. The *technological* context refers to the technology expertise, technology portfolio, and attributes of the technological innovation, which have been suggested to influence the decision to adopt an innovation. The *organizational* context refers to firm characteristics including strategies, structure, culture, top management championship, and project management capability. The *environmental* context refers to the external arena where the firm conducts its business, its ability to access resources supplied by others, and interactions with the government and other firms. It includes the competitive, legal, and regulatory environment and the market in which the firm operates.

The TOE perspective has been used successfully by IS researchers to understand key contextual elements that determine new IS adoption at the firm level [3]. This is also the case for HIS, where the TOE perspective has been applied to identify the influential factors associated with the adoption of electronic health records [24], hospital electronic signatures [8], and radiology picture archiving and communication systems [7]. However, there is a lack of research that has used the perspective to holistically understand organizational adoption in relation to HIS such as wireless vital signs monitoring systems and the pilot study leading to it. We next elaborate on the technological, organizational, and environmental dimensions previously identified based on our review of HIS adoption studies using this perspective.

2.3.1 Technological Factors

As per TOE, the technological context of an organization is important in influencing the adoption and implementation of a new HIS [39]. Expertise on the use of existing technologies can be leveraged to support the introduction of innovations and knowledge of new technology can highlight the opportunities available for the organization to innovate. Further, researchers have combined aspects of DOI with TOE to increase understanding of organizational IT adoption [27]. Specifically, they suggested that the technological context in TOE includes the knowledge of innovation characteristics from DOI [32]. Table 1 shows a sample of technological factors influencing the adoption decision of HIS from our literature review.

The review indicated that factors such as technology readiness are associated with the adoption decision of new HIS. When organizations have previous experience with initiating and implementing HIS, they can draw on their higher level of technological readiness to support the adoption of new technology. For example, Vest [39] found that hospitals with lower technological readiness had poorer odds of health information exchange systems adoption. Additionally, technology readiness is found to be related to receptivity of the management to novel technology. For example, Hung et al. [20] noted that hospital management's readiness to change influenced their willingness to adopt CRM systems.

Technological factors	**HIS studied**	**Reference**
Technology readiness / receptivity	• Medical records system • Hospital e-learning system • Hospital CRM system • Health information exchange	[24] [19] [20] [39]
Relative advantage	• Radiology picture archiving and communication system • Hospital e-learning system • Hospital CRM system	[7] [19] [20]
Complexity	• Hospital e-learning system	[19]
Compatibility	• Hospital e-learning system	[19]

Table 1: Sample of technological factors influencing HIS adoption decision

In addition, characteristics of the innovation adapted from DOI such as relative advantage, complexity, and compatibility of the system [32] were found to influence technology adoption. Relative advantage is the degree to which the innovation is perceived as being better than the approach it supersedes. Complexity is defined as the extent to which the innovation is perceived as relatively difficult to understand and use. Compatibility of an innovation refers to the degree to which the innovation is perceived as being consistent with the existing values, past experiences, and needs of the potential adopter [2]. For example, Chang et al. [7] noted that the recognition of the benefits of a radiology picture archiving and communication system over previous systems had a positive influence on its adoption. In addition, Hung et al. [19] found that both compatibility and complexity of a hospital e-learning system determined its adoption. Therefore, these studies support the inclusion of innovation characteristics as part of the TOE perspective and identify technological factors that can influence the decision to adopt a HIS such as a wireless vital signs monitoring system.

2.3.2 Organizational factors

The previous HIS literature based on TOE has proposed various organizational factors that are significant determinants of IT adoption. Examples of these factors include hospital type [24], ownership [39], and size [8]. In addition, the internal needs of the organization can serve as project triggers [17]. Further, top management support was found to be crucial for the introduction of a radiology picture archiving and communication system [7].

To improve the chances of project success, researchers have emphasized the important role of organizational resources and capabilities in influencing HIS adoption decisions. For example, Chang et al. [8] noted that having adequate resources (human, financial, and technical) is a significant determinant for hospitals' adoption of electronic signatures. This also includes possessing sufficient technological knowledge [20]. Besides having a pool of resources, organizational capabilities such as knowledge management capability and project team capability may be influential in the adoption decision of HIS [20]. Table 2 shows a sample of organizational factors influencing the adoption decision of HIS based on our review.

Organizational factors	**HIS studied**	**Reference**
Hospital type	• Medical records system	[24]
Hospital ownership	• Health information exchange	[39]
Hospital size	• Hospital electronic signature system • Hospital CRM system • Hospital e-learning system	[8] [20] [19]
Internal needs	• Mobile nursing system	[17]
Resource availability	• Hospital electronic signature system	[8]
Technological knowledge	• Hospital CRM system	[20]
Knowledge management capabilities	• Hospital CRM system	[20]
Project team capability	• Hospital CRM system	[20]
Top management support	• Radiology picture archiving and communication system • Hospital e-learning system	[7] [19]

Table 2: Sample of organizational factors influencing HIS adoption decision

2.3.3 Environmental factors

As per TOE, the external environment also plays an important role in influencing an organization's IT adoption decision. Such adoption drivers that have been identified by prior studies include government involvement [7], vendor partnership [17], business competition pressure [39], and country characteristics [24]. Especially salient for the healthcare sector, government involvement through policies and support can influence the decision to adopt new systems to a large extent [7].

External vendor partnership is also crucial for implementation of healthcare IT innovations, especially when the organization is unfamiliar with the technology [8].

Besides, business competition is also found to stimulate IT innovation adoption as healthcare organizations strive to attract more customers and earn increased revenues by improving efficiency [17]. However, business competition has also been found to negatively influence the adoption decision when the system (e.g., medical records system) involves data sharing among competitors in the industry [39]. Country characteristics such as the wealth of the nation have also been found to increase the likelihood of adoption of medical records system because of the large investments required for these systems [24]. Table 3 shows a sample of environmental factors influencing the adoption decision of HIS based on our review.

Environmental factors	**HIS studied**	**Reference**
Government involvement	• Radiology picture archiving and communication system • Hospital electronic signature system	[7] [8]
Vendor partnership	• Hospital electronic signature system • Mobile nursing system	[8] [17]
Business competition pressure	• Medical records system • Health information exchange • Mobile nursing system	[24] [39] [17]
Country wealth	• Medical records system	[24]

Table 3: Sample of environmental factors influencing HIS adoption decision

In section 2.1, we have reviewed the importance of pilot studies in highlighting potential issues before proceeding with a full-scale HIS implementation. Further, we noted that although pilot studies are prevalent in HIS implementations, there is a lack of understanding of the enabling factors surfaced during a pilot and their interactions that lead to an eventual adoption decision. Therefore, to address this gap, we adopt the TOE perspective to increase our understanding of the factors and their inter-relationships that can determine a wireless vital signs monitoring system adoption decision at the firm level. This lens will guide us in the development of our framework through our case study analyses.

3 RESEARCH METHODOLOGY

3.1 Research Design

As noted above, there is limited knowledge about the enabling factors leading to organization's adoption of HIS such as wireless vital signs monitoring systems, and how the factors inter-relate to influence the decision for full deployment of such systems. This prompted us to use the case study method as it allows the study of the phenomenon in a natural setting and answers the “how” aspect of it [41]. A qualitative case study approach adds to the richness of the data and also enables us to understand the intricacies present within a setting [11] as per our study objective.

Case studies were conducted in two public hospitals, Hospital A and Hospital B, implementing vital signs monitoring systems. These hospitals were selected because both were conducting similar projects to implement wireless technologies to transform the vital signs monitoring process, but had different outcomes. One adoption decision outcome was positive relative to the other. As both hospitals belong to the same healthcare group (StarHealth), “extraneous variations” are reduced [11] and a consistent setting for comparing the IS pre-adoption processes is provided. Through an in-depth analysis, we could study the processes leading to the adoption decision within the two hospitals as the approaches taken during the pilots by both hospitals were different. By using the two cases for comparison, similarities and differences could be derived to allow for a more robust theoretical understanding to be created [13].

3.2 Data Collection and Analysis

In the case study, several data collection methods were used to allow for triangulation of sources and for increasing reliability of the findings [41]. The primary data collection method was through interviews with project members performing various roles, conducted shortly after both hospitals concluded their trials of the vital signs monitoring systems and the decision about full-scale adoption was made. Secondary data collection was based on project documents and presentation slides provided by both hospitals. The project documents included details on the project objectives, schedule, and data collected by the hospitals during the project, such as feedback from nurses and patients, and results of timing studies. Two researchers carried out the data collection and three researchers participated in the data analysis. The use of multiple investigators can improve confidence in and the reliability of the results [11]. Also, the researchers conducted three days of field observations at the hospitals. The field observations aided in providing the context for the interview questions for project team members and in understanding the clinical jargon used.

Table 4 shows the list of interviewees and roles. The number of interviewees for each case was different, as the project team in Hospital B was somewhat smaller. Nevertheless, we ensured that each case was well-represented by individuals with the different roles in the project team to capture the entire sequence of events for both cases. The sessions were semi-structured to allow the interviewers to probe emergent factors and make use of special opportunities which arose during the conversations with interviewees [12]. The interview questions were tailored according to the project role of the interviewee, and included questions to establish the details of pilot initiation, implementation, management, and adoption outcomes (see the Appendix for the interview protocols). The interview data was analyzed after each session to make adjustments for subsequent data collection [11]. Each interview session lasted an average of 60 minutes for the project management and technology solution providers, and 45 minutes for the nurses. All 25 interviews were recorded and transcribed. The NVivo software for qualitative analysis was used to code the interview data based on the factors suggested from our literature review to allow for the identification of recurring factors [11]. Additionally, new factors were allowed to emerge from the analysis along with refinement or elimination of previous factors.

	Project Role	**No. Of Interviewees**
Interviewees from StarHealth	Research and Policy Manager	1
	Total	**1**
Interviewees from Hospital A	Project Advisor	1
	Project Manager	1
	Assistant Project Manager	1
	Project Champion	1
	Senior Nurses	8
	Junior Nurses	2
	Technology Solutions Provider	1
	Total	**15**
Interviewees from Hospital B	Assistant Project Manager	1
	Project Champion	1
	Senior Nurses	3
	Junior Nurses	3
	Technology Solutions Provider	1
	Total	**9**

Table 4: List of Interviewees with Project Roles

Data from each case was first analyzed separately. This “within-case” analysis encouraged the development of insights about each case first [13]. Subsequently, a cross-case analysis was conducted to identify any similarities or differences between the two settings. With the identification of the important differences between the cases that may influence the technology adoption decision, our framework was developed. At the end of the study, we solicited the project managers' views for both cases to assess the credibility of our findings [41].

4 CASE STUDY BACKGROUND

StarHealth (name changed for anonymity), a public healthcare group in Asia, has been innovating with technology through the formation of an Innovation Steering Group (ISG). For example, one of StarHealth's technological initiatives is the InfoWard Initiative. This initiative consists of a broad plan to deploy innovative technologies throughout the patient care process in wards so that clinicians can access necessary information quickly and easily, providing patients with better quality care.

The two hospitals in our study were managed by the StarHealth healthcare group. The ISG and StarHealth's subsidiary, Hospital A, were collaboratively studying the use of wireless biosensors to monitor patients' vital signs to transform the vital signs monitoring process, referred to as the *OneSystem* project in our paper. As hospitals under StarHealth are given autonomy in making their own decisions and managing their projects, Hospital B also embarked on its own study of the wireless monitoring of patients' vital signs. This is referred to as the *TwoSystem* project in our paper.

4.1 Wireless Vital Signs Monitoring System

The wireless vital signs monitoring system is a web-based, integrated software system that consists of several components. When a patient gets admitted into the ward, wireless biosensors are attached on his upper arm as well as on his lower abdomen. These sensors can measure the five vital signs (i.e. temperature, blood pressure, ECG, pulse rate and oxygen saturation) and are run on rechargeable batteries. At pre-set intervals, these sensors measure the body's vital signs and send data wirelessly to WIFI points which are connected to the hospital's network. As the wireless biosensors are portable, patients are allowed to move freely around the hospital while under monitoring. Information is transmitted to a portal and can be viewed through various means such as a PC, Notebook, or PDA. This system also enables clinicians to view the digital charts anytime and anywhere. Figure 1 describes the general architecture of how the wireless vital signs monitoring system worked in both cases. Although the technology solution vendors for both cases were different, both solutions had similar architectures.

5 CASE FINDINGS

The findings from each case are described below in terms of the need for the wireless vital signs monitoring system before implementation and the details of the pilot implementation.

5.1 Case 1 – Hospital A

5.1.1 Need for Vital Signs Monitoring System

With the OneSystem project being a collaboration between StarHealth and Hospital A, both organizations had needs which provided the rationale for the project. StarHealth had to ensure that its

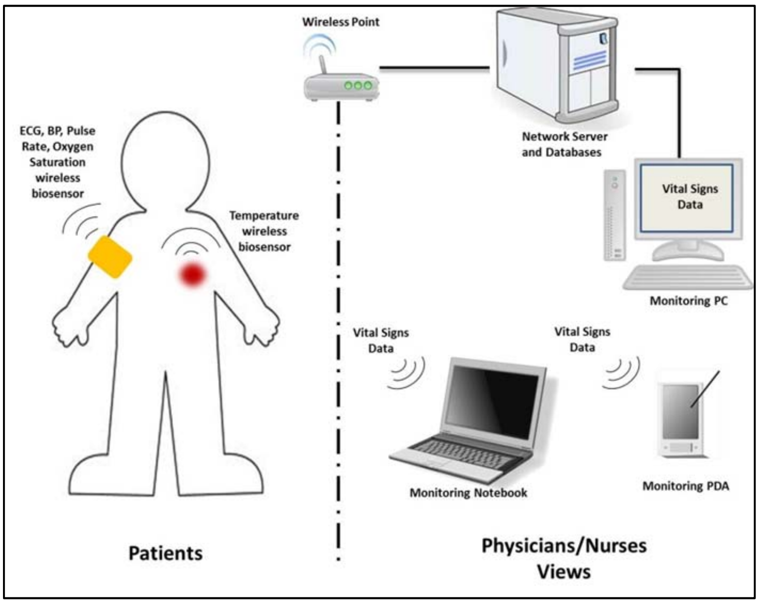

Figure 1: General Architecture of Wireless Vital Signs Monitoring System

hospitals were ready to respond to changes in the environment to remain competitive in the future. For example, as noted by a research and policy manager of StarHealth, due to the short supply of registered nurses, new non-qualified nursing personnel such as enrolled nurses and healthcare attendants were assigned to record vital signs. However, the cost of these new jobs was on the rise as well. A concurrent trend was an increased demand for monitoring vital signs at home from an increasingly ageing population. The research and policy manager of StarHealth explained:

"Because of [the] aging population, there may be [an] increasing number of people who will find it very difficult to come to the hospitals, it may make sense for us to do everything virtually."

Another motivation was due to the possible risk to patient safety from human errors made during manual healthcare tasks. The need to manually record vital signs parameters and plot the charts concurrently with patient care requests could distract nurses from recording accurate readings.

Illegible handwriting also contributed to erroneous records. The project manager of OneSystem explained:

"*…Most of the things are done manually and nurses have to plot vital signs on the chart and write notes, they might not be very legible…With the automated system, things will be captured automatically and the accuracy rate is higher*."

Additionally, as noted by a senior nurse at Hospital A, nurses were burdened with documentation tasks that constrained them from having more interactive time with patients. Freeing up the nurses' time from manual tasks was essential to reduce workload and improve patient care. The nurse revealed:

"… most of the time, I am at the counter because there is a lot of paper work …during patient calls, that's when we attend to the patient. Other than that, we don't have the time to sit down and talk to the patient..."

According to another senior nurse at Hospital A, the risk to nurses' health was also a concern motivating this project. Contagious diseases could place many nurses at risk of infection when they attend to such patients in close proximity. Even though the precaution of wearing medical gowns and gloves reduced the risk, it limited the personal touch in interacting with patients. This highlighted a critical need for a monitoring device that could effectively shield nurses from contagious diseases. The nurse noted:

"We were all very fearful during the SARS epidemic…Every time when we nurse a patient, we have to put on [a] gown and wash our hands... that takes up a long time. [The process is] very meticulous...."

In summary, our interviews indicated that the implementation of the wireless vital signs monitoring technology by StarHealth and Hospital A was motivated by the short supply of healthcare workers, an ageing population, as well as the need to reduce documentation time, avoid medical errors, and to protect healthcare workers from contracting infectious diseases i.e., it was issue driven rather than technology driven.

5.1.2 Pilot Implementation

The proposal of implementing a wireless vital signs monitoring system at Hospital A was mooted after the previous success with developing a wireless temperature monitoring system involving StarHealth, Hospital A, and OneVendor. When the Chief of Medical Board at Hospital A saw the success of this project, he supported the OneSystem project that further explored the inclusion of the other vital signs i.e., the project was triggered by clinical personnel. Together with StarHealth, OneVendor was eventually chosen to develop a complete system to include the other vital signs. The project champion of OneSystem noted:

"…he [the chief of medical board] was looking at it [wireless temperature monitoring] and saying why don't we do all the parameters at one go… And then from there, we expanded into the use of the latest technology [WIFI] for transmission recording [of the other vital signs]."

OneVendor, an external technology solutions provider for OneSystem, provides medical biosensors for healthcare organizations and home patients. As OneVendor was new to wireless health monitoring technology, they hoped to use the clinical inputs from Hospital A to guide them in the development of an integrated solution for monitoring all five vital signs simultaneously with one system. The project team was formed with representatives from StarHealth and Hospital A who held steering roles. In particular, the project advisor was the Head of the ISG in StarHealth who had an interest in generating technology innovation developments across StarHealth organizations i.e., the project was centrally led. In addition, the project champion and nurse representative were the head surgeon and head nurse of a ward in Hospital A respectively. In considering the importance of the project champion, the project manager of OneSystem described:

"If the innovation is related to medical [practice], then we need the clinicians to validate plus be the champion and stick for that innovation."

The project champion was a head surgeon who was familiar with IT and had a keen interest to ensure the success of the project i.e., a clinical champion with a decision making role. Although OneVendor had to develop the system from scratch, the process was facilitated by the champion who drew on his previous experience with technology. The project champion also had access to higher management (i.e., the Chief of Medical Board) to influence important financing and technology decisions in support of the project. In addition to obtaining partial financial subsidies from the government, OneVendor, StarHealth, and Hospital A all contributed resources towards the project i.e., there was a shared contribution of resources. This fostered a mutually beneficial relationship where the vendor's interests were unified in pursuit of the technology adoption. The project champion of OneSystem explained:

“[We] help them out with the funding…We just do it, like a collaboration. …To me, it’s more of a win-win situation because [if] you’re always talking on cost the project will never take off. They won’t be able to meet the budget constraint.”

The project team first went about to gather task requirements and specify how patients’ vital signs could be wirelessly measured. After conducting multiple meetings to understand both task and technology requirements, OneVendor developed the system by producing prototypes that was developed and customized based entirely on the needs of the clinicians. The project champion of OneSystem elaborated:

“…we gave [OneVendor] some inputs, in terms of the requirements…I specify that I want the device to have…open system and WIFI. So they did…change the entire product to suit what we required…”

After the completion of the prototype pilot, trials were performed in an orthopedic ward with approximately 80 beds spread across several rooms. The ward was chosen because the project champion was a consultant who oversaw this ward. Feedback obtained after the trials showed that wireless health monitoring was feasible. Nurses found the technology easy to use i.e., low complexity, and the simultaneous view of multiple patients’ vital signs through a single system was useful for an overall status check on all patients. The system could also limit the amount of contact with patients with contagious diseases and increase time for patient care i.e., highly compatible with nurses’ work. Timings were compared between manual and wireless modes and time savings of 8.5 minutes per patient per day were reported. This translated to annual savings of 4127 hours for an 80-bed ward that could be used for improving patient care. The trial also generated constructive feedback that indicated minor areas of improvement for the wireless vital signs monitoring system.

Due to the benefits of the technology i.e., high relative advantage, which were illustrated during the trials, representatives from Hospital A, OneVendor, and StarHealth decided to recommend full adoption and deployment in more wards within Hospital A and other StarHealth organizations. At the time of the study completion, they had collectively formalized a business case to Hospital A’s top management.

5.2 Case 2 – Hospital B

5.2.1 Need for Vital Signs Monitoring System

The management of Hospital B was enthusiastic about using technology in innovative ways to improve the work processes of its healthcare professionals. The assistant project manager of TwoSystem noted:

"We have been trying wireless RFID, wireless handheld PDA, Intel Tablet, throughout the hospital with different projects. This is one such project… For us we are trying to use IT in a positive way."

This led Hospital B to realize the limitations of their present telemetry system and propose its replacement. The existing telemetry system, used in the Cardiology ICU ward, monitored patients' heart conditions (ECG) alone. Apart from being bulky, the telemetry system could at most monitor 20 patients in a ward at a time. Due to this restriction, only the more acute patients used the system. The data from the telemetry system could only be viewed on one computer that was located in the ICU as this system was not connected to the hospital network. The project champion of TwoSystem revealed:

"…we already have a [telemetry] system that monitors the patients in the ward. We hook the patient into the machine, but…the patient cannot move about…restricted to within the room, and the patient is being monitored in another place, the ICU."

Our interviews indicated that the above issues with the existing technology were the key motivation for the introduction of wireless vital signs monitoring system i.e., the initiative was technology driven. In contrast to the telemetry system, a wireless vital signs monitoring system could allow for the monitoring of all patients' vital signs in addition to ECG. It could also monitor more patients in the hospital as long as the patients were attached with wireless biosensors. This would enable clinicians to access patient's vital signs on any computer connected to the network. A nurse at Hospital B explained :

"With this system, we can visualize all patient's vital signs at one go [from the nurses' computer]. [For example], if any blood pressure readings are not [in the] normal range, we can quickly inform the doctor so that intervention can be [done] early."

In summary, the vital signs monitoring technology implementation in Hospital B was mainly motivated by the need for an integrated system that could monitor all vital signs remotely and extend its coverage to more patients. Based on a comparison between the wireless vital signs monitoring system and the existing technology, it was expected that the new system could help the hospital to monitor more vital signs and more patients.

5.2.2 Pilot Implementation

When Hospital B made known its intention to replace its telemetry system, TwoVendor approached Hospital B for a joint study as they felt they had the ready technology for adoption i.e., the initiative was triggered by the vendor. Subsequently, it was decided by Hospital B that TwoVendor's technology could be appropriate to replace their existing telemetry system and it was worth studying its feasibility.

TwoVendor, a multi-national technology company, is a provider of communication solutions and relies on best of breed third party providers of wireless biosensors to provide the wireless vital signs system. Their aim was to create a communications standard within the healthcare industry that is able to synchronize with any wireless medical device for data interchange. The technology originated from overseas and TwoVendor aimed to use the TwoSystem project to test their system, with a subsequent goal of letting Hospital B adopt their technology at a subsidized cost.

The TwoSystem project team consisted of personnel entirely from the IT department and ICU ward of Hospital B. The project was led by two managers from the IT department i.e., the mandate for the project was department-led, with supporting roles played by the project champion and nurse representative. A nursing administrator, whose role was to manage nurses and coordinate nursing tasks, was appointed to champion the project. As the champion served mainly as a liaison for obtaining clinical inputs from the nurses whenever the project team needed them, his influence was limited i.e., he was an administrator with a supporting role. In considering the type of project champion required for the project, the champion of TwoSystem revealed:

"The IS department, they already identified the person to be the manager of the project, and then they approached us, the nursing. So I am the champion to introduce this to the nursing department… we will select the appropriate ward… and so we gathered a team of people and we started."

In addition to the partial financial subsidies provided by the government, TwoVendor was to provide financial resources for the remaining cost of the project i.e., there was an unilateral contribution of resources. The project champion of TwoSystem noted:

"…the commitment and the amount of money from the vendor itself, not the hospital…because this funding is not done by them [the hospital]. So it is whether the company [is] willing to commit or not."

The project team worked closely with TwoVendor and the project began with the understanding of task and technology requirements through multiple meetings. The ward nurses contributed to provide the requirements for the new system as well as any changes they would like to see in the application from TwoVendor. With the system developed overseas, changes had to be made to customize it to the local context. However, the presence of a ready technology from TwoVendor limited the way in which Hospital B could alter the system to suit its needs, thus TwoSystem was not properly customized to the needs of the users.

After system development, the TwoSystem project trial was carried out in a single cardiology ward with approximately 30 beds spread over several rooms to test the feasibility of the system. The ward was chosen because it was using the old telemetry system, which the wireless vital signs monitoring system was intended to replace. However, the trial stopped for a period because the servers that supported the communication solution application had a lag in transmitting information. These servers, initially located in a foreign country, were relocated to resolve this issue. Subsequently, the trial continued but despite improved system responsiveness, the wireless biosensors continued to receive negative feedback from nurses using the system. Nurses felt that the system functioned poorly because the device was not well-integrated with the workflow and nursing processes. Moreover, due to a hardware limitation, the sensors had short battery life which created inconvenience for the nurses who had to replace the batteries frequently.

A technology assessment of TwoSystem after the pilot trial revealed that contrary to the expected benefits of the new technology as compared to the existing telemetry system, the new system was incompatible with the needs of the ward nurses due to the lack of customization. In addition, ward nurses faced difficulties performing their tasks as they were unfamiliar with the new work processes required by the system. Coupled with the lack of customization and poor usability of the system, nurses thus found the system difficult to use i.e., it had high complexity. Overall, the negative feedback surfaced by the nurses suggests that in its current state, the technology produced more issues than benefits as compared to the existing system i.e., it had low relative advantage.

To ensure that TwoVendor's technology was workable in a larger-scale setting and can provide total care, Hospital B wanted TwoVendor to expand the coverage of the trial and improve the wireless biosensors based on the feedback from nurses. However, TwoVendor was unwilling to commit further resources to conduct another trial. The project stalled and TwoVendor has yet to reply to Hospital B regarding further plans. At the time of our study completion, TwoVendor had not responded for three months. It became apparent that Hospital B’s request for another trial that corrects the poor performance of the wireless biosensors (a third party product) as well as tests the ability of the technology in a larger-scale setting does not align with the goals of TwoVendor i.e., the team had disparate goals. The project champion of TwoSystem noted:

“The vendor wants to test the equipment… But for us, we not only want it to work, we want it to work on the bigger scale and be effective for what we set out to achieve…There is a limit [to what] vendors wanted to do but if [the hospital] wants to introduce the project, [the technology] must meet our need first. So there is a gap there.”

6 FRAMEWORK FOR ORGANIZATIONAL ADOPTION OF WIRELESS VITAL SIGNS MONITORING SYSTEMS

After analyzing the findings of both cases in the previous section, we identified several differences between the two projects that could help us understand why their outcomes differed. From Table 5, it can be seen that all three aspects (technological, organizational, and environmental) influenced the pilot outcome and the adoption decision of a wireless vital signs monitoring system, although some factors that were highlighted in the previous literature did not feature in our two cases.

TOE dimension	**TOE factors from HIS literature (Tables 1-3)**	**Related enabling factors extracted in our study**
Technological	Technology readiness/receptivity	-
	Relative advantage	Pilot Outcome Assessment • Favorable (Hospital A) • Unfavorable (Hospital B)
	Compatibility	
	Complexity	
Organizational	**-**	Champion Type • Clinician with decision making role (Hospital A) • Administrator with supporting role (Hospital B)
	Hospital type	-
	Hospital ownership	-
	Hospital size	-
	Internal need	Awareness Type • Issue-driven (Hospital A) • Tech-driven (Hospital B)
		Trigger Type • Clinically-triggered (Hospital A) • Vendor-triggered (Hospital B)
	Resource availability	Resource Contribution • Shared (Hospital A) • Unilateral (Hospital B)
	Technological knowledge	
	Knowledge management capabilities	-

	Project team capability	Project Team Role • Steering roles (Hospital A) • Supporting roles (Hospital B)
	Top management support	Organizational Mandate • Central-led (Hospital A) • Departmental-led (Hospital B)
Environmental	Government involvement	
	Vendor partnership	Vendor Alignment • Unified (Hospital A) • Disparate (Hospital B)
	Business competition pressure	-
	Country wealth	-

Table 5: Mapping of TOE factors from existing HIS literature to findings

Among the technological factors surfaced in existing HIS studies (see Table 1), our analysis suggests that characteristics of the technology i.e., relative advantage, compatibility, and complexity influenced the pilot outcome. If the users perceive that the system is of low relative advantage, low compatibility, and high complexity, the adoption likelihood of the technology is expected to be low. Besides these three innovation characteristics from DOI theory [5] incorporated in the TOE perspective, the two other characteristics i.e., trialability and observability are also accounted for in our study. However, these were not identified as salient influencers because they did not differ between the two projects. As the two HIS underwent a pilot trial, both hospitals had the opportunity to experiment and experience the system i.e., high trialability. In addition, as users were able to use the system for their daily work tasks in a real-life setting, they could observe the outcome of the new system i.e., high observability. Further, we did not find that technology readiness/receptivity contributed to the difference in pilot outcome. This is because even though both hospitals had high levels of technological readiness, the pilot outcomes differed. Therefore, the *pilot outcome* was likely to be influenced by the three technology characteristics i.e., relative advantage, compatibility, and complexity, adapted from DOI to TOE.

Under the organizational context, we found certain factors that were reported previously (see Table 2) such as internal need, resource availability, technological knowledge, project team capability, and top management support, influenced the wireless vital signs monitoring system adoption decision in our study. However, as the hospitals in our case were both government-owned, there was no basis of comparison for hospital type and ownership. Also, hospital size was not likely to have any bearing on the adoption decision in our study since both pilots were on single wards. In addition, knowledge management capabilities appeared to be less relevant for the wireless vital signs monitoring system as compared to healthcare CRM systems reviewed in Table 2. A possible reason is because a wireless vital signs monitoring system deals with a limited set of data that is collected only for a short period of time during a patient's stay, unlike the vast amount of information and knowledge required to support effective customer relationship management in hospitals [20]. Departing from the previous literature, we found the type of project champion to be an additional factor that may influence the outcome of the pilot. Corresponding to internal need in the previous literature, we divided it into two separate factors depicting the *awareness type* and *trigger type* leading to system initiation in our study. Awareness type indicates the basis for introduction of the system i.e., whether it is issue-driven or technology-driven. Trigger type indicates the source of project initiation i.e., clinically-triggered or vendor-triggered. Corresponding to resource availability and technological knowledge in previous literature, we grouped these factors to signify the *resource contribution* by relevant stakeholders in our study. This is because technological knowledge can be viewed as a form of resource required in the hospital for new IS implementation. Last, project team capability was refined as project team role to highlight the importance of involving the appropriate personnel in an organization to form a project team.

Similar to the environmental factors found in previous HIS literature (see Table 3), government involvement and vendor partnership appeared to influence the adoption decision of a wireless vital signs monitoring system in our study. However, we did not find country wealth to have an influence on the adoption decision. A possible reason is because our study was conducted for a system at the hospital-level rather than a nation-wide initiative such as electronic medical records in [24]. Also, business competition pressure did not feature in our study because the two hospitals were the first ones to implement the wireless vital signs monitoring system in the country. Overall, the organizational factor of top management support was grouped with government involvement under the factor of *organizational mandate*. Both government involvement and top management support led to a strong central-led organizational mandate for the new system adoption in our study. Last, vendor partnership was refined as vendor alignment to reflect a common perspective in IS literature that alignment of interest is essential between a vendor and client organization to meet a project's objectives or overarching goal of the organization (e.g.,[6,36]) .

Thus, eight enabling factors were found to be important in explaining the adoption decision of a wireless vital signs monitoring system in our study: *Awareness Type*, *Trigger Type*, *Organizational Mandate*, *Project Team Role*, *Champion Type*, *Resource Contribution*, *Vendor Alignment*, and *Pilot Outcome Assessment*. As described above and shown in Table 5, several enabling factors surfaced from our two cases are congruent with the TOE factors from previous HIS studies though some factors are not salient here and additional factors are identified in our study. Figure 2 shows the framework linking the eight enabling factors extracted from our analysis.

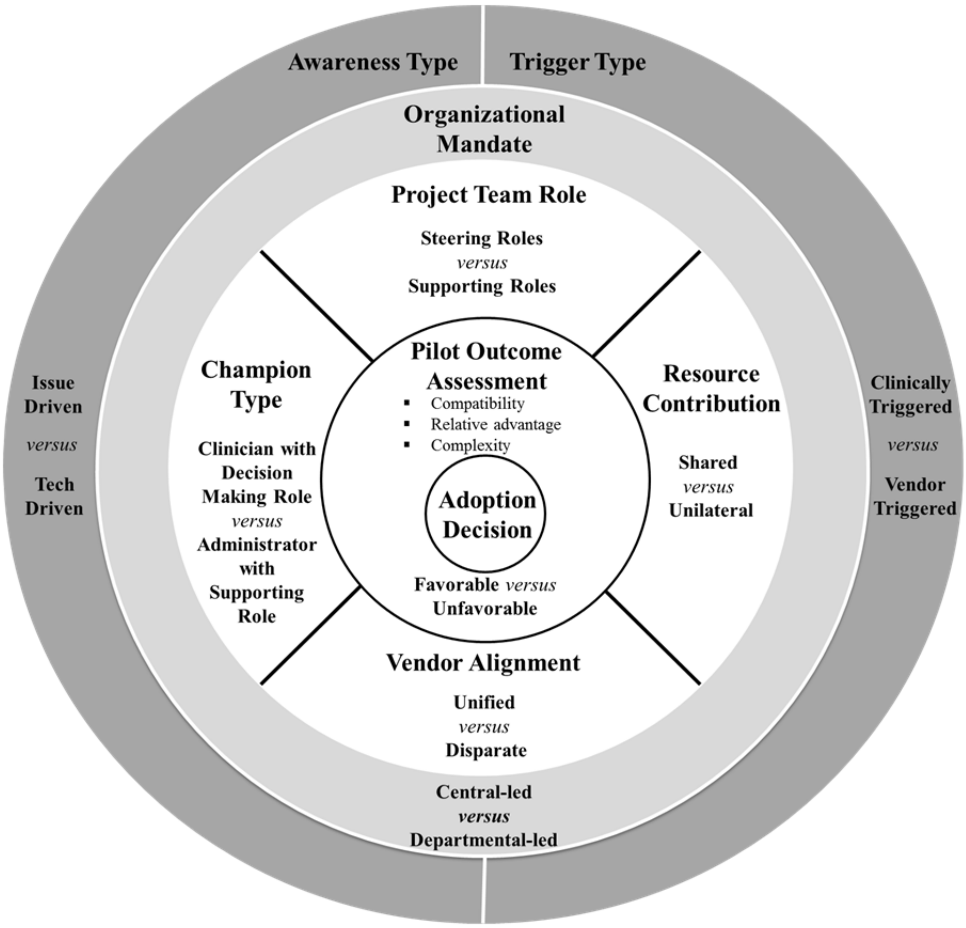

Figure 2: Framework of Factors that Affect Organization Wireless Vital Signs Monitoring System Adoption Decision

Four rings are seen in Figure 2 with the center representing the final result i.e., the decision to adopt the new HIS. The further the ring from the center, the less influence the ring has on the result. Factors in each ring also form lateral relationships to influence the adoption decision. The outermost ring consists of *Awareness Type* and *Trigger Type* that directly influence the ring underneath it which consists of *Organizational Mandate*. These three factors collectively influence the inner ring that consists of the *Project Team Role*, *Champion Type*, *Resource Contribution*, and *Vendor Alignment*. This in turn influences the innermost ring of *Pilot Outcome Assessment* followed by the *Adoption Decision*. The following paragraphs discuss how the relationships among these factors were derived.

The outermost ring, which consists of *Awareness Type* and *Trigger Type* of a HIS project, is able to influence the *Organizational Mandate* for the project. The *Awareness Type* and *Trigger Type* factors relate closely to the concepts of technology-push and need-pull, where innovations can be motivated either by a technological advancement, an internal need, or both [9]. An "issue-driven" initiative strengthens the case for a project as the organization seeks to address its business needs through the project as seen in Hospital A. Together with a healthcare professional i.e., clinically-triggered who realizes the appropriateness of the technology and comes forward to push this project, it reinforces and emphasizes the necessity of the new IS introduction. As a result, an "issue-driven" and "clinically-triggered" project was able to achieve a higher *Organizational Mandate* through a need-pull. This resulted in a "central-led" mandate as in Hospital A that can be further strengthened by external stakeholders such as the government (StarHealth). In contrast, a "technology-driven" approach as seen in Hospital B is opportunistic as technology innovations may or may not be able to meet organizational business needs. The "tech-driven" approach together with a "vendor-triggered" project (technology-push) could result in a lower organizational mandate that is not part of a higher organizational objective. This resulted in a "departmental-led" mandate as we saw in Hospital B.

The *Organizational Mandate* ring can influence the inner ring that consists of four factors: *Project Team Role*, *Champion Type*, *Resource Contribution*, and *Vendor Alignment*. First, the *organizational mandate* for a project can influence the *role of project team members*. A "central-led" mandate is likely to lead to the formation of a project team with members holding "steering roles" who have more organizational influence as compared to members with "supporting roles". For example, as both StarHealth and Hospital A spearheaded OneSystem, the importance of fulfilling the project objectives led to the inclusion of project members with "steering roles". In contrast, a project with a lower *organizational mandate* can result in a project team that consists of members who perform “supporting roles” within the organization, as seen in Hospital B.

Second, our analysis suggested that the *Champion Type* selected for the project is closely related to the *Organizational Mandate*. A “central-led” project requires a project champion who is a clinician with a “decision-making” role and can represent the majority of system users. Apart from being an advocate of the technology, this capacity as a decision maker within the organization allows them to make important financial and strategic decisions, as seen in Hospital A. In contrast, a “departmental-led” project as in Hospital B resulted in a project champion with less decision-making authority on project issues. Another factor that seems to directly influence the *champion type* is the *role of project team members*. The case findings suggest that a project team with “steering roles” will have the clout to choose an appropriate project champion for the project. For example, as the project manager of OneSystem was from StarHealth, it allowed him to choose a head clinician with greater authority as a champion. However, as the project manager of TwoSystem was from the IS department of Hospital B, a nurse administrator who had little influence on the project process was appointed.

Third, the factor on the *Resource Contribution* from different stakeholders suggests the balance of power in controlling the outcomes of the project. A “central-led” project will result in a higher *organizational mandate* that makes the organization more accountable for the outcomes of the project. To achieve this, all parties to the project should contribute their resources to have a stake in the outcomes, thereby fostering a “shared” resource contribution among all stakeholders. For example, the government and Hospital A were able to provide their resources (i.e., financial resources) to OneVendor to supplement its resources to avoid the problem of lack of funds. The *organizational mandate* given to OneSystem by StarHealth could be a facilitator for obtaining these resources. In contrast, the financial resources for TwoSystem were solely provided by TwoVendor, and due to their inability to commit more resources and resolve existing system issues users met with, the project stalled. This could be explained by the “unilateral” *resource contribution* that gave TwoVendor the control to discontinue the project.

Fourth, the cases revealed that the factor of *Vendor Alignment* had a significant impact on project outcomes. A “unified” alignment between the vendor and project team members enables a common goal to be reached and fosters cooperation among the project team. For example, although OneVendor had to develop the system from scratch, they developed prototypes entirely based on the user requirements. In addition, the “decision-making role” of the OneSystem project champion and “shared” resource contribution by all stakeholders also aided in ensuring vendor alignment with all project team members. In contrast, the “departmental-led” approach fosters divergent intentions between the vendor and project team members that may lead to “disparate” goals. The ability to obtain *vendor alignment* is further weakened when the project champion plays a “supporting role” where his influence is limited and incapable of unifying the intention of the vendor with the team members. Moreover, the “unilateral” level of resource contribution could also have led to the vendor pursuing a separate goal from the project team. For example, as TwoVendor was the sole resource contributor for the project, it was able to pursue the goal of testing their existing solution, rather than customizing it to the needs of Hospital B.

As the innermost ring has the most significant influence on the adoption decision, our analysis suggested that a confluence of the factors discussed above can exert an effect on the outcome of the pilot trial by leading to either a favorable or unfavorable result. For example, as TwoSystem was “vendor-triggered” and Hospital B took the “technology-driven” approach, the departmental-led organization mandate resulted in a project team that comprised mainly members with supporting roles. In addition, an administrator with a “supporting role” was appointed as the project champion, and as TwoVendor was the sole resource contributor for the project, it resulted in disparate vendor alignment from the project team. Subsequently, the pilot trial provided management with an unfavorable evaluation of the HIS as the current state of the technology was incompatible to the needs of the users, difficult for the users to understand and use i.e., high complexity, and created more issues than benefits when compared to existing procedures i.e., low relative advantage. This led to a request from Hospital B for a second trial but the project stalled due to non-cooperation from the vendor.

In contrast, Hospital A’s pilot trial had a more favorable outcome and plans to adopt the HIS have been made. As OneSystem was “clinically-triggered” and Hospital A took the “issue-driven” approach, the “central-led” organizational mandate influenced the formation of a project team comprising mainly of members with steering roles. In addition, a clinician with “decision-making role” was appointed as the project champion, and as there was a shared resource contribution among stakeholders, it led to unified vendor alignment with the project team. As a result, the pilot system was shown to be compatible to the needs of users, relatively easy for the users to understand and use i.e., low complexity, and users were able to reap the benefits of the system i.e., high relative advantage.

7 DISCUSSION & IMPLICATIONS

Based on the analysis performed on our two case studies of wireless vital signs monitoring systems, eight enabling factors and their inter-relationships were identified that could influence the organizational adoption decision of the HIS.

7.1 Research Contributions

This study contributes to existing literature in several ways. First, a framework is developed in response to calls for research on the enabling factors from a pilot implementation of a new HIS that could lead to the decision for organization-wide adoption [4]. Our study highlights the technological, organizational, and environmental factors using the TOE perspective leading to the organization adoption of HIS such as a wireless vital signs monitoring system. This results in a more comprehensive understanding of the phenomenon based on all categories of factors.

Second, our framework highlights the inter-relationships among enabling factors that could influence the organizational decision to adopt HIS such as wireless vital signs monitoring systems. At each level of the framework, lateral relationship between enabling factors are uncovered in addition to influences on the next inner ring of factors. Cumulatively, these rings of factors converge and contribute to the pilot outcome and organizational adoption decision of such systems.

Third, although our framework was developed from two cases of wireless vital signs monitoring systems, some factors can be useful in the context of IS in general and HIS, while some may be more specific to wireless vital signs monitoring systems. For example, specific to HIS, a clinically triggered project can attract a higher organizational mandate because it is based on an internal need that needs resolution, instead of a technology-push from a vendor. In addition, a project champion who is a clinician with a decision making role may better represent the majority of the system users (nurses in our case) and interact with top management to make important financial and strategic decisions.

Specific to wireless vital signs monitoring systems, the three technological factors i.e., relative advantage, complexity, and compatibility, are found to be crucial for assessing the pilot trial, which subsequently influenced the adoption decision outcome. Pilot trials of wireless vital signs monitoring systems should demonstrate the relative advantage of the ubiquitous technology such as having an improvement in quality of healthcare and the ability to allow patients to roam around the hospital. The new system should bring convenience to clinicians by not having to routinely take manual measurements of vital signs from patients and being able to access and view all of their patients' vital signs information with ease at any location. In addition, a wireless vital signs monitoring system should be customized to meet the needs of the users. For example, nurses can reduce their contact with patients with contagious diseases by obtaining their patients' vital signs automatically and retrieving them remotely. This could also bring time savings for nurses and improve patient care.

Fourth, our findings have shown the relevance of several existing TOE factors from HIS literature in explaining adoption decision outcomes of wireless vital signs monitoring systems (see Table 5). Further, similar existing factors have been grouped together, broader factors have been subdivided, and relevant existing factors refined for better explanation of the phenomenon in our study. Technological factors such as relative advantage, compatibility, and complexity were grouped into *pilot outcome assessment*, while resource availability and technological knowledge were grouped into *resource contribution*. Moreover, top management support was grouped with government involvement under the factor of *organizational mandate*. Broader factors such as internal need was subdivided into *awareness type* and *trigger type*. Factors such as project team capability and vendor partnership were refined to *project team role* and *vendor alignment* respectively.

Besides, some previously identified factors were not found to facilitate the adoption decision in our study i.e., technology readiness/receptivity, hospital type, hospital ownership, hospital size, knowledge management capabilities, business competition pressure, country wealth. Our analysis also surfaced a new enabling factor of the champion type, which has not been found in previous HIS studies adopting the TOE perspective (see Table 5).

Fifth, previous literature e.g., [29] often assumed HIS implementations to be issue-driven and clinically-triggered and as a result, placed little emphasis on the possible effects of awareness and trigger type on adoption decision outcomes. Our study has demonstrated that awareness and trigger type could be major contributors towards the decision for organizational adoption of wireless vital signs monitoring systems. Sixth, unlike previous suggestions that resource availability is essential for organizational adoption of HIS e.g., [8], our study further highlights the importance of shared resource contribution among stakeholders. We found that when every party has a stake in the system, there will be more support for the HIS project cumulatively as each party strives towards a common goal. If resource contribution is unilateral, even in the presence of high resource availability, the imbalance in power may lead to lack of adoption. Last, although a substantial percentage of HIS projects have conducted a pilot study before deciding about a full-scale implementation [28], previous literature did not discuss the role of pilot trials and the factors surfaced from them in the adoption decision of HIS. Our study highlights the factors and their inter-relationships by analyzing two separate wireless vital signs monitoring system pilot trials conducted in two large public hospitals with differing adoption decisions.

7.2 Practical Implications

Apart from the research contributions, this paper offers several practical implications. First, as healthcare organizations continue to explore the use of emerging technologies as a means to tackle the challenges posed by changing healthcare and socio-demographic trends, our study has demonstrated the usefulness of wireless vital signs monitoring systems in this regard. Healthcare organizations' management could consider the use of a wireless vital signs monitoring system to relieve the workload of their healthcare professionals in order to focus more on patient care. In addition, patients could be assured of their healthcare, knowing that their vital signs are being continuously acquired and monitored to trigger the necessary corrective actions.

Second, this study has conducted a comparison of two distinct outcomes that organizations may achieve when deciding to adopt a new HIS such as wireless vital signs monitoring system. This highlights the complexity in designing and implementing such a system despite its potential to improve the overall quality of healthcare. Findings from the two cases studies were synthesized to derive a framework of enabling factors and their inter-relationships that could influence the adoption decision of such HIS. The framework can guide practitioners responsible for healthcare technology adoption to pinpoint areas within their current processes that require improvements. For example, healthcare organizations would be advised to adopt an “issue-driven” approach in using emerging technology such as wireless vital signs monitoring systems to meet organizational needs. Organizations could also encourage “clinical-triggers” by allowing open communication and feedback so that innovators within the organization can step forward. When introducing new technology into processes, a “central-led” project that is in line with organizational goals will likely receive a higher level of organizational mandate and support from managers. Further, forming a project team with members having steering roles, engaging a champion who is a clinician with a decision making role, implementing a project with shared level of resource contribution, and selecting a vendor which is aligned to the project goals can be important in fostering collective intentions among stakeholders and obtaining required resources for the project. These factors together may increase the likelihood of a positive pilot outcome in terms of relative advantage, complexity, and compatibility that can positively influence the decision to adopt HIS.

Third, our study highlights the importance of a pilot trial in a healthcare setting, and the need for effective pilot implementation and change management. As much as a new HIS can bring benefits to healthcare practice, an effective pilot design is essential for management to verify the merits and identify the shortcomings of the technology. As a pilot trial is usually conducted with a small sample, suitable groups that are representative of the user population will need to be identified to participate in the trial. For example, a ward using a system that is to be replaced by the new HIS and the users are more pro-active is likely to be a suitable candidate for pilot implementation. In addition, as the purpose of a pilot trial is to evaluate system feasibility, organizations are encouraged to establish mechanisms for users to provide frequent feedback about the system during the trial. This will allow the project team to capture and understand issues on-the-ground. Besides, adequate technical support should be provided over the course of the pilot trial for quick issue resolution. Organizations are also recommended to form a project team consisting of members with steering roles, and appoint a champion with a decision making role, so that decisions for system refinements based on feedback can be quickly initiated during the trial. To prepare users for the impending change, management's training efforts are important so that the transition from the old system will be smoother. Last, educating users on the benefits of the system may improve their receptivity to the new implementation and reduce their resistance to change.

7.3 Limitations and Future Work

The findings of this study should be interpreted in view of its limitations. First, while the case study approach allows for in-depth investigation of the phenomenon, it inherently may not present findings that can be generalized to other healthcare organizations. Therefore, the inclusion of a larger sample of hospitals in future studies may provide further insights about important factors related to HIS adoption decisions.

Second, as the factors extracted for our framework were a result of the dichotomy found based on the salient differences between our two cases, the differences found may not be able to fully represent the range of the domain of each factor in general. For example, beside the trigger types identified in our framework i.e., clinical, and vendor, the necessity for a new HIS introduction may be triggered from other sources such as the government [8]. This is because healthcare institutions may be compelled to implement a new HIS to comply with new government regulations. Besides issue-driven and technology-driven awareness types, the basis for introduction of a system may be driven by the awareness of and need to mimic competitors' use of a new technology for a healthcare institution to remain competitive [17]. Moreover, a high level of organizational mandate may be given to HIS projects not necessarily from central or department authority but from government or top management [19]. Therefore, future research can elaborate further by improving construct validity for the factors in our framework.

Third, as this paper has focused on a particular HIS i.e., wireless vital signs monitoring system, the framework may not be readily generalizable to other healthcare IS. Future research can validate and extend the framework through studies involving other types of HIS. Fourth, the current study suggests relationships between enabling factors without testing them statistically. Future work can validate our findings by testing them in a causal model.

8 CONCLUSION

HIS such as wireless vital signs monitoring systems present new opportunities to overcome the challenges facing the healthcare industry. However, in light of the high incidence of unsuccessful projects, it is essential for healthcare organizations to better understand the role of enabling (technological, organizational, and environmental) factors in a pilot trial leading to the adoption decision of HIS. By reviewing prior literature on the factors influencing organizational technology adoption through the TOE perspective and using them to analyze two cases, this paper identifies factors contributing to different pilot outcomes that influence the decision for organization-wide adoption of wireless vital signs monitoring systems. With the synthesis of findings from the two case studies of such systems, a framework of enabling factors that affect the organizational adoption decision was developed. This study thus identifies and inter-relates the salient factors with this framework, and takes a step towards reducing the uncertainties faced by healthcare management in their decision to adopt an emerging HIS.

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APPENDIX – Interview Protocols

The interview protocol is developed for three main groups of stakeholders i.e., management, system users, and technology solutions provider (see Table 4). Management includes the project advisor, managers, and champions who are involved in the wireless vital signs monitoring (VSM) system planning. The user group includes healthcare professionals such as senior and junior nurses who will be using the system for their daily routines. The last group includes the vendor personnel.

Management

1. What are the motivations behind the implementation of the VSM system?
2. How was the project initiated?
3. How was the project team formed?
4. What is the importance of the project champion for this project?
5. What is your role and responsibilities in the project?
6. Can you describe how the project was funded?
7. How was the vendor selected for the development of the VSM system?
8. How was the project team's relationship with the vendor over the course of the development?
9. What were the issues encountered during the pilot test?
10. What do you think contributed to the outcome of the pilot test?
11. How do you see the use of the VSM system changes the nurses' work?
12. What do you think are the benefits of the VSM system?
13. Now that the VSM system trial has ended, do you hope to see more use of the system in the future?

System Users

1. Can you describe how did you take patients' temperature and BP readings before the VSM system?
2. When you first heard that your hospital will be using the VSM system to monitor temperature and BP for you, how did you feel about this?
3. With the use of the VSM system, can you describe how your job processes have changed?
4. What do you think are the benefits and drawbacks from using the VSM system?

a. Do you think the use of the VSM system has made your job easier? Was the system helpful? If not, what issues did you face?
b. With the VSM system, do you save more time now?
c. Do you think patient care has improved with the use of the VSM system?
d. Do you think the use of the VSM system will make a better workplace for nurses since you need not do mundane monitoring anymore? Does it improve the quality of the work environment?
e. Do you think these devices have improved your job performance?

5. What do you think of the look and feel of the VSM system?
6. Do you think the VSM system requires a lot of effort/knowledge to use?
7. Now that the VSM system trial has ended, do you wish to use the system again? Why?

Technology Solutions Provider

1. What motivated your organization to collaborate with Hospital A to develop the VSM system?
2. What were the resources provided by your organization for this collaboration?
3. Can you describe how your organization went about to develop the pilot?
4. Who do you liaise with the most over the course of the pilot implementation?
5. What were the issues encountered during the pilot implementation?
6. How do you feel about the outcome and benefits of the pilot?