Workarounds in the Use of IS in Healthcare: A Case Study of an Electronic Medication Administration System

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ABSTRACT

Healthcare information systems such as an Electronic Medication Administration System (EMAS) have the potential to enhance productivity, lower costs, and reduce medication errors. However, various issues have arisen from the use of these systems. A key issue relates to workarounds as a result of a misfit between the new information system (IS) implementation and existing work processes. However, there is a lack of understanding and studies on healthcare IS workarounds and their outcomes. This paper applies the theoretical perspectives of accommodation to misfit and IS evolution to understand the phenomenon through an in-depth case study of an EMAS implemented in a large public hospital. Based on the findings, it develops a process framework to explain how the benefits, issues, and workarounds inter-relate and determine the impacts of the system. The findings have implications for research and practice on workarounds in the use of healthcare IS.

Keywords: Healthcare IS, Workarounds, Issues, Benefits, Augmenting, Fitting, Electronic Medication Administration

1. INTRODUCTION

Organizations are adopting information systems (IS) with the aim of tapping their potential value. However, although IS can bring about various benefits, the issue of workarounds for new IS implementations has often surfaced (Ignatiadis and Nandhakumar, 2009). Workarounds have

been defined as alternative procedures employed by users to accomplish a task in response to a misfit between computer-based and existing work processes (Gasser, 1986; Koopman and Hoffman, 2003). More often than not, workarounds are viewed negatively and management will attempt to reduce them. However, they can rarely be eradicated (Hayes, 2000) and need to be managed effectively. As a result, this has led to calls for a deeper understanding of workarounds and their impacts in IS implementations (Orlikowski and Yates, 2006).

With respect to the implementation of new IS, the healthcare industry had been relatively slow in their adoption as compared to other industries (Chiasson and Davidson, 2004). However, with increased healthcare demands due to affluence and aging, the industry is becoming more pro-active in introducing IS to ease the strain on medical services (Schikhof et al., 2010). IS are increasingly playing an important role in transforming the way healthcare professionals work and are viewed as a means to address issues such as medication errors (Kohn et al., 2000). Healthcare IS applications have been found to improve documentation (Poissant et al., 2005), enhance communication and coordination (Menon et al., 2009), assist in decision making (Mekhjian et al., 2002), reduce task completion times (Verhoeven et al., 2010) , and alleviate common problems such as illegible handwriting (Bates et al., 1998).

However, the deployment of healthcare IS have also brought about unintended consequences that have led to resistance and workarounds by users (Ash et al., 2007; Lapointe and Rivard, 2005). When a new healthcare IS is implemented, users may encounter hindrances in workflow caused by various reasons such as inefficient process design, poor system usability, inadequate user training, and inflexible clinical guidelines (Edwards et al., 2008; Halbesleben et al., 2008; Vogelsmeier et al., 2008). In response, they may find alternative routes to get the work done with possible negative impacts on job performance. Particularly, these workarounds may

lead to violations or deviations from safe operating procedures and standards, which can compromise a key objective of implementing these healthcare IS i.e., reducing medication errors (Runciman et al. 2007).

Despite the prevalence of workarounds in healthcare IS implementations and the potentially grave implications particular to this industry, previous literature has devoted little attention to them and there is limited understanding of their impacts on the organization (Nemeth and Cook, 2005). Among the few studies in this area, Azad and King (2008) empirically examined workarounds of a pharmacy dispensing system through a case study. Other purely empirical studies i.e., without theorization, include Koppel et al.'s (2008) work to identify the causes and possible consequences of clinicians' workarounds when using barcoded medication administration system. Further, Vogelsmeier et al. (2008) documented the workarounds associated with the implementation of electronic medication administration record systems in five nursing homes but did not study their impacts. On the other hand, Harrison et al. (2007) used a socio-technical perspective to conceptually study user interactions during a generic healthcare IS implementation without empirical validation. While these studies have added to our knowledge of healthcare IS workarounds, there is a lack of theoretically grounded and empirically tested understanding on the causes of user workarounds and their impact on the outcomes from the implementation of a healthcare IS (Halbesleben et al., 2008).

Our research aims to address this gap in healthcare IS literature by proposing a process framework to explain workaround creation, accommodation, and impacts for the implementation of a new healthcare IS. In particular, our study is motivated by the trend towards introducing Computerized Physician Order Entry (CPOE), Electronic Medication Administration Record (EMAR), and Bar-Code Medication Administration (BCMA) systems in hospitals with the

objective of reducing medication errors and improving workflow (Halbesleben et al., 2008). Collectively, these systems have been termed as an Electronic Medication Administration System (EMAS). However, despite the benefits EMAS can provide as compared to paper medication records, changes in workflow with the new system may produce unintended consequences such as workarounds (Ash et al., 2007). Workarounds may be performed to circumvent the issues of the new system and the system may not reap the full benefits it is designed for. In view of the significance of workarounds in healthcare IS implementation, this paper seeks to answer the following research questions: (1) How do issues of a healthcare IS lead to workarounds? ; (2) How do workarounds influence the impacts of the healthcare IS?

This paper applies two theoretical perspectives from IS research i.e., accommodation to misfit (Gasser, 1986), and IS evolution (McGann and Lyytinen, 2008), to understand the phenomenon through an in-depth exploratory case study of a new EMAS in a large public hospital. As Gasser's (1986) work is a key contributor to the understanding of workarounds (Gasparas and Monteiro, 2009), we find it suitable to use the accommodation strategies proposed by Gasser (1986) as initial categories for our study. However, Gasser's (1986) study does not discuss the transitions among the three strategies (augmenting, working around, and fitting) for the accommodation to misfit. For this purpose, we consider McGann and Lyytinen's (2008) comprehensive framework of IS evolution that allows us to understand the transitions i.e., how accommodations by users could lead to changes in processes or IT systems, which is aligned with the fitting strategy suggested by Gasser (1986). Thus, based on the case findings, this paper integrates and extends the two perspectives to develop a process framework inter-relating the issues, workarounds, and impacts of healthcare system implementation. Overall, it aims to

contribute to healthcare IS research through the development of a framework to understand workarounds and their impact on the benefits of such systems.

Further, although workarounds for CPOE (Ash et al., 2003), EMAR (Vogelsmeier et al., 2008) and BCMA (Koppel et al., 2008) systems have previously been studied separately, there is a lack of study of these systems as a whole i.e., EMAS. Moreover, as the component systems work together to ensure a smooth medication delivery process and are used by different groups (e.g., physicians and nurses), this study can demonstrate how workarounds performed on one component by a user group can affect other components used by other groups. This study also expects to inform practitioners through a detailed analysis of the issues, workarounds, benefits obtainable, and impacts from the use of such systems.

2. CONCEPTUAL BACKGROUND

In this section, we will first describe the components of EMAS (i.e., CPOE, EMAR and BCMA). Next, we review past studies on workarounds in the use of healthcare IS for an understanding of the gaps in existing research. Subsequently, we discuss prior theoretical perspectives on workarounds in IS to guide us in our case analysis and in the development of our framework.

2.1 Benefits and Issues of CPOE

CPOE is defined as "a variety of computer-based systems that share the common features of automating the medication ordering process and that ensure standardized, legible, and complete orders" (Eslami et al., 2008, p.366). Physicians use this system to initiate the medication delivery process which is critical for downstream processes such as medication serving.

Table 1 summarizes the potential benefits of CPOE. The motivations of introducing CPOE include reducing medication errors (Anderson et al., 2002), decreasing medical costs

through better decision making (Mekhjian et al., 2002), obtaining better quality of care, and increasing compliance of health care professionals (Cunninghan et al., 2008). With CPOE, illegible handwriting, incomplete documentation, and loss of documents are unlikely to occur (Hwang et al., 2002). CPOE may also be able to improve efficiency by reducing the time needed for information to be transferred to the pharmacy (Mekhjian et al., 2002). Overall, CPOE can improve the quality of healthcare provision if appropriately implemented (Eslami et al., 2008).

Potential Benefits	Source
1. Reduction in Medication Errors	
• Ability to intercept errors before they occur due to system safeguards • Eliminates issue of illegible handwriting • Improves quality and safety by recommending dosage or actions to perform	Anderson et al.(2002); Ash et al.(2003); Bates et al.(1998,1999); Hunt et al.(1998)
2. Increase in Compliance	
• Improved auditability for compliance checks against incomplete documentation • Guidance on dosage amounts increases compliance to hospital practices	Cunninghan et al.(2008); Eslami et al.(2008); Hunt et al.(1998); Hwang et al.(2002)
3. Time and Cost Savings	
• Significant reductions in medication turn-around time • Ability to reduce number of excess days of hospitalization leading to reduced hospital and pharmacy costs • Reduced loss of documents eliminates time required for search	Anderson et al.(2002); Hwang et al.(2002); Kuperman et al.(2007); Mekhjian et al.(2002)
4. Increase in User Satisfaction	
• Due to increased productivity, increased ease of use, impact on patient care and ability to reduce medication errors	Eslami et al.(2008); Lee et al.(1996)

Table 1: Potential benefits of CPOE

However, implementation of CPOE in hospitals has proved to be challenging due to various issues faced. Table 2 summarizes the potential issues of CPOE. Among them, resistance by users to changes in work practices and power structures had forced the abandonment of some implementations (Bartos et al., 2008). Also, with the change in nurse-physician communication patterns in CPOE, nurses do not take part in the decision making of medications (which is left to physicians) and may thus miss out on critical information (Pirnejad et al., 2008). While CPOE is expected to reduce medication errors, implementation of CPOE instead increased medication errors in some instances (Horsky et al., 2005). Such contradictory effects suggest that

management should not assume that implementing CPOE would decisively decrease medication errors. Instead, attention must be focused on aligning work processes with the CPOE to alleviate possible negative effects. Hence, though a CPOE may bring about benefits, a range of issues can cause users to workaround the system.

Potential Issues	Source
1. Increase in Medication Errors	
• Inflexible ordering formats causing physicians to generate wrong orders • Absence of automated safeguards in some CPOE implementations • System errors causing duplicate medication orders	Henry et al.(2007); Horsky et al.(2005); Koppel et al.(2005); Weiner et al.(1999)
2. Poor Usability	
• Due to poor technical/information technology implementation such as having limited space to type remarks or having messy screen layouts	Ash et al.(2003); Wentzer et al.(2007)
3. Negative Impact on Workflow	
• Previously ingrained routines superseded by CPOE • Many CPOE systems slow down work processes such as clinical documentation and ordering process	Aarts et al.(2007)
4. Negative Impact on Communication	
• Communication between physicians and nurses changed from synchronous to asynchronous, affecting cooperation and creating miscommunication	Beuscart-Zephir et al.(2005,2007); Pirnejad et al. (2008); Weir et al.(2005)
5. Resistance	
• Negative emotional response to CPOE more prevalent than positive and neutral response • Users may resist CPOE collectively and force a response by the management • Paper persistence leading to non-usage of CPOE	Ash et al.(2007); Bartos et al. (2008); Campbell et al.(2006); Eslami et al.(2008); Sittic et al.(2005)

Table 2: Potential issues of CPOE

2.2 Benefits and Issues of EMAR/BCMA

EMAR is a system used by nurses to store patient medication information and to plan for medication rounds in a ward. On the other hand, BCMA is a system where the medication, patients and nurses have a bar-coded identification tag each for verification purposes. It serves to help nurses adhere to the 5 Rights – Right patient, Right drug, Right dose, Right time and Right route (Nelson et al., 2005). The difference between EMAR and BCMA lies in the procedures in serving medication. BCMA utilizes a bar-code scanner to scan patients and medications while EMAR does not provide verification facilities. Therefore, BCMA is often seen as an add-on feature to the more commonly used EMAR.

Table 3 summarizes the potential benefits and issues of EMAR/BCMA. Both EMAR and BCMA were developed for the medication administration phase. In an experiment performed by Paoletti et al. (2007), a 54% reduction of medication administration errors was observed with both systems. However, despite observed benefits, several issues have also surfaced with such systems. As nurses have to perform scanning of barcodes with BCMA at the patient's bedside, difficulties in scanning could lengthen medication serving times (Onzenoort et al., 2008). As a result of usability issues, nurses were found to perform workarounds so that served medications could be registered into the system (Vogelsmeier et al., 2008). Contradictory effects with respect to medication errors were also observed for such systems, as with CPOE.

Potential Benefits	**Source**
1. Decrease in Medication Errors	
• Eliminates physicians' and nurses' transcription errors • Ability to serve medication in a timely manner with fewer errors	Carroll (2005); Mekhjian et al.(2002); Nelson et al. (2005); Paoletti et al.(2007)
Potential Issues	
1. Increase in Medication Errors	
• Due to workarounds performed after ineffective reengineering of processes • Due to nurses dropping important activities such as scanning of patient wrist tag while serving medicine to reduce workload	Henry et al.(2007); Patterson et al.(2002); Vogelsmeier et al.(2008)
2. Poor Usability	
• Difficulty in scanning bar codes on medication and patient • Delays in responses from the computerized system	Onzenoort et al.(2008)

Table 3: Potential benefits and issues of EMAR/BCMA

BCMA and EMAR are commonly used in conjunction with CPOE as part of EMAS. Like CPOE, these systems are intended to help reduce medication errors but issues have also surfaced pertaining to their use. The effectiveness of these systems may be reduced when workarounds, performed by users in response to the issues, negate the system benefits (Henry et al., 2007). Therefore, it is imperative to study the effect of workarounds on these system impacts.

2.3 Workarounds in the use of healthcare IS

As mentioned before, IS such as EMAS are being implemented in hospitals to reduce process variability, improve efficiency, and reduce medication errors in healthcare (Mekhjian et al., 2002). However, as these systems are introduced, workarounds are observed (Ash et al., 2003; Vogelsmeier et al., 2008) and may be a concern for practitioners if they negate system benefits.

In response to calls for a deeper understanding of the phenomenon, a few studies have investigated healthcare IS workarounds. The conceptual and empirical studies on different IS are now described. In a conceptual study, Harrison et al. (2007) proposed a model grounded in a socio-technical approach to emphasize the interactions between new healthcare IS and existing social systems, technologies, and physical environments. The paper suggests that when a new healthcare IS is introduced, poor implementation and changes in workflow and communication patterns can cause workarounds to occur. However the model was not empirically tested.

Azad and King (2008) empirically studied workarounds through the case of a pharmacy dispensing system and observed the difference between the formal policy and enacted process for medication dispensing. Besides describing workaround practices performed during the dispensing process, they also emphasized the role of social interactions in eliciting cooperation among users for the enactment of workarounds. They found that workarounds being enacted could benefit a certain group of users but inconvenience others. In other empirical studies on CPOE systems, Ash et al., (2003) and Koppel et al. (2005) highlighted a number of instances of workarounds. Gathering data from three healthcare organizations, Ash et al. (2003) observed that it is common for physicians to trick the system by using workarounds because of usability issues. In a study at a teaching hospital, Koppel et al. (2005) found that information errors and human-

machine interface flaws could facilitate medication errors instead of reducing them. For example, physicians chose to rely on verbal orders as the ordering process in CPOE was cumbersome.

For EMAR implementations, a qualitative empirical study on in five nursing homes, Vogelsmeier et al. (2008) found that workarounds were consistently observed across all nursing homes. The paper further identified that workarounds occurred when work flow blocks were introduced by technology and when organizational processes were not reengineered effectively. Consequently, these can lead to threats to medication safety. In a case study specifically on BCMA, Koppel et al. (2008) described the occurrences, causes and threats of workarounds to patient safety. The empirical study observed that patient safety could be compromised by users omitting process steps, performing them out of sequence, or performing unauthorized steps. For example, nurses sometimes administered medicine without checking the system, to speed up the serving process. Further, Koppel et al. (2008) found that workarounds could be caused by technology, organization, patient, task and environment related factors.

As seen above, prior literature on the use of healthcare IS has documented the widespread use of workarounds in daily clinical routines and their causes. The existence of workarounds can potentially negate the benefits of healthcare IS if the issues are not resolved. However, despite the acknowledgement of possible negative consequences of workarounds such as increased medication errors, theoretically grounded empirical research (previous studies were either conceptual or empirical) on workarounds is limited and there is a lack of understanding about the effects of workarounds on the impact of healthcare IS (Nemeth and Cook, 2005; Halbesleben et al., 2008). Therefore, this study aims to investigate this gap based on workaround concepts from the IS literature.

2.4 Theoretical perspectives on workarounds in IS

The concept of workarounds in IS has sometimes been viewed as a form of resistance by users and a hindrance to system designers in meeting the objectives of the system (Ferneley and Sobreperez, 2006; Markus, 1983). However, we would like to distinguish the concept from resistance which is defined as opposing behaviour by users in response to the changes as a result of an IS implementation (Kim and Kankanhalli, 2009).

In comparison, the typical motive of workarounds is to complete a task by getting around a problem rather than for the purpose of defiance or opposition (Halbesleben et al., 2008). Hence, it is seen as a response by users when a task is not supported in the desired manner due to the misfit between computing and work processes (Gasser, 1986). For example, when a purchasing system did not allow the bulk ordering of parts for a new product, the misfit pushed users to revert back to paper ordering to workaround the issue. Similarly, Koopman and Hoffman (2004) proposed that workarounds are performed with the intention to complete tasks, extend functionality, and evade designed limits in computer systems. Although the last intention appears to have a negative connotation, Koopman and Hoffman (2003) commented that this may sometimes be for a constructive purpose. Moreover, Halbesleben et al. (2008) argued that workarounds have not been clearly delineated from other constructs such as error and mistakes, deviance, and shortcuts. In combination, these literatures suggest that workarounds are usually performed with functional intentions and not necessarily as a form of opposing behaviour, though the consequences may be negative.

In the IS literature, workarounds have been explained from the perspective of accommodation to misfit (Gasser, 1986). As an early and influential contributor to the understanding of workarounds (Gasparas and Monteiro, 2009), Gasser (1986) posits that a misfit

would typically exist because tasks can change in unforeseen but important ways when a new IS is implemented. As a result, readjustment of work is usually performed to accommodate the misfit and is classified into three types of strategies, i.e. *augmenting*, *working around*, and *fitting*. Table 4 shows the definitions and examples of these strategies.

Strategy	Definition	Example
Augmenting	Undertaking additional work to make up for the misfit	Having to print and submit a form manually though online submission was already performed due to unreliability of the system
Working Around	Intentionally using computing in ways for which it was not designed or avoiding its use and relying on an alternative means of accomplishing work	Calling a purchasing officer to request purchase instead of entering request through system due to tedious process of filling up details
Fitting	The activity of changing computing or changing the structure of work to accommodate for the computing misfit	Improving the user interface of the system to address usability issues faced by users

Table 4: Strategies for Accommodation of Misfits (adopted from Gasser, 1986)

Although the transitions among strategies were not discussed in Gasser's (1986) work, it is possible that an initial strategy may lead to another later on. In our study, these three types of strategies are used as initial categories to identify the accommodations in our case and subsequently included in our process framework, which also explains transitions among strategies.

To explain the transitions, we make use of another perspective of workarounds based on IS evolution. Specifically, McGann and Lyytinen (2008) suggested that organizational routines and IT constantly evolve and when there are shortcomings in existing IS, ad hoc adjustments (or workarounds) can occur in two dimensions, i.e., process (Weick, 1998) or IT (Orlikowski, 1996). As workarounds progressively become common, these adjustments may be formalized by management for use across the organization. These changes to process and IT are termed by McGann and Lyytinen (2008) as *process embellishment* and *IT modification* respectively. Process embellishment is a stage in IS evolution where current ineffective processes are

improved upon to leverage the routines supported by the system and are extended for use across the organization. Likewise, IT modification refers to the change in IT systems where ad hoc IT improvisations are integrated into current systems to improve alignment with current processes. McGann and Lyytinen (2008) introduced these concepts to explain how accommodations by users could lead to changes in processes or IT systems, which is aligned with the *fitting* strategy suggested by Gasser (1986). However, they also recognized that all workarounds do not go through either process embellishment or IT modification and that an understanding of the impact of these unresolved accommodations is lacking. Therefore, we attempt to address this gap to understand the effect of workarounds of a new IS.

3. RESEARCH METHODOLOGY

A qualitative case study approach was adopted to understand the phenomenon of workarounds in the use of an EMAS in Hospital A (name anonymized for this study). A case study approach is considered suitable since it answers questions of how the phenomenon occurs (as in our study) and allows the investigation of the phenomenon within its real-life context (Dube and Pare, 2003; Yin, 2009). Through use of a revelatory case study (Yin, 2009), we aim to explore the issues, benefits, workarounds, and impacts of a new healthcare IS and develop a framework that inter-relates them. Using an exploratory approach (Dube and Pare, 2003), our theoretical framework is generated based on existing theory and our case study findings.

The selection of Hospital A for this study was in response to a discussion with the management who asked the researchers to provide a better understanding of a new EMAS and its impact on the organization. This presented the opportunity to study an EMAS implementation that was in the process of being rolled-out.

3.1 Case Background

Hospital A is a public hospital with more than 900 beds and employs more than 3000 professional staff members to provide a wide range of healthcare services. Riding on the momentum of previous IS implementations such as an Electronic Medical Records (EMR) system, the management identified inpatient medication errors as a recurrent problem after a review of hospital incident occurrence records. After rounds of sourcing for solutions, the decision was made to implement a combination of CPOE, EMAR and BCMA systems as a replacement of the paper Inpatient Medication Records (IMR) which had been used in the hospital since the past 50 odd years. The integrated system was named EMAS (Electronic Medication Administration System) with combined functions of CPOE, EMAR and BCMA. Figure 1 shows the general architecture of the EMAS.

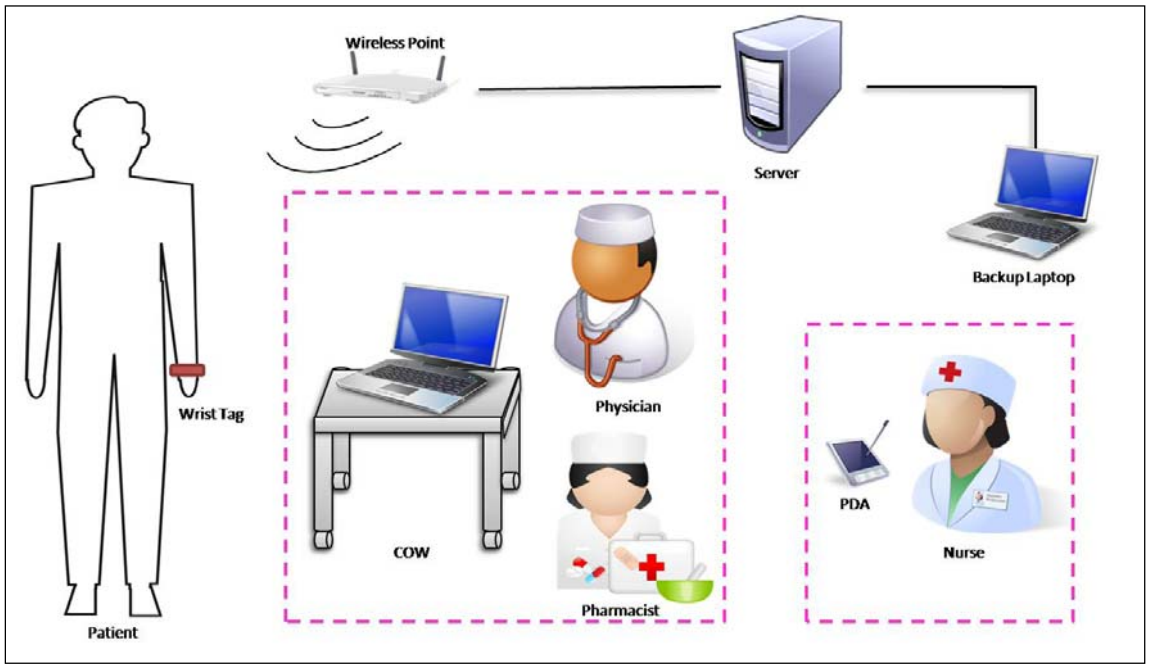

Figure 1: General Architecture of EMAS

CPOE and EMAR are accessed through a laptop mounted on a trolley referred to as a Computer-On-Wheels (COW) and BCMA is implemented through a Personal Digital Assistant (PDA). Due to the need for mobility, transactions are done through a wireless connection to back-end servers.

A backup laptop is also located in each ward and is used in the event of a network or power failure.

3.2 Intended System Use

During patient admission, a set of records is created for inpatient medication orders usage. With EMAS, a physician can access patient information from the COW remotely or within the ward. This allows for easy reviewing of past medication and ordering of new medication. Besides providing automatic patient allergy alerts, the system also assists physicians in the filling up of orders through suggestions for type of medicine and dosage. After this, the physician can submit the medication order and log out of the system.

Pharmacists then use the system to verify medication orders submitted by physicians and are able to access patients' information remotely from the pharmacy. If there is a need for an intervention, an event can be raised to alert both the physician and nurse to block medication serving. Thereafter, a physician will be required to enter the system to make the appropriate changes before serving can be resumed.

Nurses use the system to assist them in medication serving. Prior to their work shift, they can view and prepare for upcoming medication servings. During serving, nurses scan the wrist tag on the patient with the PDA to ensure the right patient is served the correct medicine. In the event of a mistake, an alert will be shown to stop the nurse from administering medicine. Additionally, the system can highlight omitted medication that would require immediate attention. The use of EMAS is aimed to assist nurses in accomplishing the 5 Rights - Right patient, Right drug, Right dose, Right time and Right route (Nelson et al., 2005).

3.3 Data Collection

At the time of the study, the paediatrics and cardiac wards in Hospital A had implemented EMAS. Therefore, users from both wards were interviewed to detect any ward-specific issues in relation to the use of EMAS. The paediatrics ward had used the system for nine months at the time of study as compared to four months in the cardiac ward. Also, the cardiac ward had a smaller scale implementation due to smaller size of the ward.

Interviews were conducted by two of the researchers with key personnel and users from the two wards. The interviews provided an insight into the background, purpose, and workarounds of EMAS. Using two researchers allowed the case to be viewed from different perspectives and thus enhanced confidence in the findings (Eisenhardt, 1989). The interviews were performed on individuals who had different roles in the organization. Healthcare professionals who were using the system on a daily basis and had exposure to it for at least a month were suitable candidates for the study. Specifically, the champions, project managers, physicians (i.e., registrar, medical officer and house officer), pharmacists, and nurses (i.e., senior nurse manager, nurse manager, senior staff nurse and staff nurse) were involved in the interviews. Interviewing individuals with different job functions allowed the researchers to analyse responses from various stakeholders to remain objective and reduce bias. Interviews with project managers and champions lasted an average of 1 hour 30 minutes while interviews with physicians, pharmacist and nurses lasted an average of 30 minutes. Table 5 shows a summary of the interviews performed.

From	Role	Interviewees
Hospital A	Clinician Champion *	1
	Nursing Champion	1
IT Department	Project Manager	2
Pediatrics Pharmacy	Pharmacist	1
Pediatrics Ward	Pediatrics Clinician Champion	1
	Physician	5
	Nurse	11
Cardiac Ward[#]	Cardiac Clinician Champion *	-
	Physician *	-
	Nurse	8
* Role played by same individual	**Total:**	**30**
# Size of ward is smaller		

Table 5: List of Interviews with Roles

Besides interviews, several secondary data sources were also utilized. Presentation slides of briefings to introduce EMAS were obtained to better understand the features of the system. The researchers also had the opportunity to attend EMAS training lessons for nurses to gauge their response. Last, visits to the wards allowed the researchers to observe first-hand the issues that EMAS users faced on a regular basis. Triangulation was achieved through the use of multiple data collection methods and was able to provide stronger substantiation of constructs and relationships (Eisenhardt, 1989).

3.4 Data Analysis

Data analysis was performed in several steps. First, coding of interview transcripts and secondary data sources was carried out based on the previously described categories extracted from prior literature, with the possibility of surfacing new categories (Dube and Pare, 2003). *Issues of the existing approach* (paper IMR) were coded as a baseline for further comparison. *Benefits of the system* (EMAS) over paper IMR were identified based on the categories in Tables 1 and 3. Coding of *issues of system* (EMAS) was based on the categories in Tables 2 and 3. Accommodations were coded into the three different categories i.e., *augmenting*, *working around*, and *fitting*, as per previous literature (see Table 4). The second step involved linking

relevant constructs in order to develop the process framework in accordance with strategies recommended in Langley (1999). This included linking issues of the existing approach and benefits of the system to unresolved issues, issues of system to the different forms of accommodation, and each accommodation to the potential impact of the system in terms of enhancing or reducing the benefits.

4. FINDINGS

In this section, the case findings are described that address our research questions. First, *issues of the existing approach* (paper IMR) are presented to surface the need for EMAS. Second, the *benefits of the system* (EMAS) are listed before outlining the *issues of the system* (EMAS) which are categorized as technology, task, and organization related. Next, the *augmenting* and *working around* accommodations are described and linked to the issues that caused them. Subsequently, *fitting* initiated by the organization is explained before presenting the impacts of the system with and without fitting. In the following section, a process framework is developed which is derived from the theories and integration of the case findings to answer both our research questions.

4.1 Issues of paper IMR

The issues faced by users with the paper IMR system are described in Table 6 along with evidence in the form of interview quotes. For example, one issue occurred when physicians, nurses and pharmacists required the use of the paper IMR for their routine, but the document was often misplaced. Also, as orders were handwritten, users may misread them and cause medication errors. These past issues are indexed (e.g., PI-1) for easy reference.

Index	Issue	Quote
PI-1	Missing paper IMR • Inability to perform medication ordering and serving	*"Sometimes we couldn't find the paper IMR...We had this problem where the physician took the paper IMR to another ward and she didn't realize it."* - ***Nurse***
PI-2	Use of wrong paper IMR • Caused by pasting of wrong label on clinical board	*"If I'm in charge of bed 23, then I administer medicine to [the patient in] bed 23 but [suppose] he has already been discharged and I got a new patient, I can serve the wrong medicine to him."* – ***Nurse***
PI-3	Illegible handwriting • Could cause medication errors due to misreading by physician, pharmacist or nurse	*"Sometimes nurses are not able to interpret our handwriting and not only them, it also happens ... when we transfer to a new IMR if it [the old paper IMR] is full, we have problem with that as well. Sometimes we cannot decipher what they are trying to write."* – ***Physician***
PI-4	Backdating of late medication servings • Caused by nurses trying to avoid escalation of an incident occurrence report • Could cause medication errors	*"One thing is that nurses can cheat on the timings. They can give [the medicine] slightly later than the prescribed timing for example, giving at 3pm instead of 1pm."* - ***Nurse***
PI-5	Failure to inform nurse of medicine to be served immediately (stat dose) • Could cause delay in recovery time of patient due to late medicine serving	*"For paper IMR, medication errors are quite common because sometimes the doctor doesn't remind you that he ordered a stat medicine. We wouldn't know about it and that would cause a medication error."* - ***Nurse***
PI-6	Unaware of medication order • Contributed by messy paper IMR due to highlighting, modifying and cancelling	*"At times we can overlook because the columns [on the paper IMR] are small ... some write and sign beyond the columns and we can misunderstand that particular action had been performed though it hasn't."* - ***Nurse***
PI-7	Failure to verify the 5 Rights • Caused by nurses who do not adhere to the mandatory checks	*"When you go to the bedside, sometimes when the patient is sleepy and when you call them, 'are you so and so?', they just say yes even though they are not and if we fail to check the wrist tag, we will give them the wrong medication."* – ***Nurse***

Table 6: Issues of paper IMR

4.2 Benefits of EMAS

EMAS was developed to address issues of the paper IMR with benefits as described in Table 7 along with the supporting interview quotes. For example, as the use of IS can improve accuracy and efficiency, time savings and reduction in medication errors can be realized. All benefits for our case are indexed (e.g., B-1) for easy reference.

Index	Benefit	Quote
B-1	Reduction in medication errors • No need for physician to write orders or transcribe paper IMR • Assistance in entering of medication orders through medicine and dosage suggestion • Ability for pharmacist to verify medications more frequently • Ability to assist nurses check the 5 Rights	*"Patient safety is improved because EMAS takes away the need for handwriting...half the time the nurses will be like, 'Can you help me check this handwriting?'."* – ***Physician*** *"[With EMAS], I can review when an order comes in … I can check the order twice a day instead of once previously*." - ***Pharmacist*** *"I feel I am more efficient now and it can help me prevent medication errors because it is one of the key performance indicators and if it improves then my job appraisal will improve."* - ***Nurse***
B-2	Increase in compliance • Timing and identity for each transaction logged to promote timeliness of serving and non-repudiation • Increased adherence to hospital medication ordering practices • Nurses' requirement for ensuring the 5 Rights enforced with the use of PDA	*"EMAS can really record [the timing] down then we cannot cheat so it shows your integrity... earlier when the nurses want to cover for one another, they will change the timing..."* - ***Nurse***
B-3	Time savings • Eliminate occurrence of missing paper IMR • Easy transfer of patient across wards • Ability for physician and pharmacist to order or verify medication remotely • Ability to review past and current medications easily	*"Save time. Sometimes we have to spend time searching for the paper IMR. For EMAS we can just use the computer"* – ***Nurse*** *"It shortens our time because with EMAS we can access it anywhere. After we transfer the patient the other side can show the administrations so it also shortens the time for medication."* - ***Nurse*** *"With EMAS, if a patient requests for a simple medicine, we can call the doctor and he can order it though EMAS without coming down or give a phone order."* - ***Nurse*** *"You can see quite clearly the past medications that have been given and stopped because sometimes in paper IMR when you transcribe then the old one is gone, you can't find them easily."* - ***Physician***
B-4	Increase in job performance • Reduction of workload due to clear serving times in EMAS • Ability to improve nurses' time management	*"You can actually cut down on a lot of workload. You don't need to communicate so much with the physician on what they are ordering... can better focus on serving medicine and all these can help reduce errors."* - ***Nurse*** *"I think EMAS is more organized. It does planning for you and it lessens your burden."* - ***Nurse***

Table 7: Benefits of EMAS

Benefits of EMAS were then compared to those found in previous studies (see Tables 1 and 3). The first three benefits in our study correspond to those found in the previous literature while the fourth benefit refers to the overall increase in job performance as opposed to increase in user satisfaction in the previous literature. However, on closer examination, the previous literature

(Eslami et al., 2008) also referred to increase in productivity and ease of use that led to higher user satisfaction. With reference to the issues of paper IMR, EMAS was able to mitigate most of the issues that plagued the old approach. This is mainly possible because of computerization as it reduces the number of human mistakes that could occur along the complex medication workflow. Table 8 summarizes how the benefits solved past issues in our study.

Issue of paper IMR	Benefits of EMAS resolving issue
[PI-1] Missing paper IMR	Eliminate occurrence of missing paper IMR • [B-3]
[PI-2] Use of wrong paper IMR	Ability to assist nurses check the 5 Rights (Right patient) • [B-1]
[PI-3] Illegible handwriting	No need for physician to write orders or transcribe paper IMR • [B-1]
[PI-4] Backdating of late medication servings	Timing and identity for each transaction logged to promote timeliness of serving and non-repudiation • [B-2]
[PI-5] Failure to inform nurse of medicine to be served immediately (stat dose)	*Issue is not resolved by the new system*
[PI-6] Unaware of medication order	Ability to review past and current medications easily • [B-3]
[PI-7] Failure to verify the 5 Rights	Ability to assist nurses check the 5 Rights • [B-1]

Table 8: Influence of Benefits of EMAS on Issues of paper IMR

4.3 Issues of EMAS

In spite of the benefits, with a new IS implementation, an exact fit between computing and tasks is unlikely. Though EMAS brought about a wide range of benefits, new issues were also created in tandem. These issues are grouped according to the categories suggested in Koppel et al. (2008), i.e., technology related, task related, and organization related. Patient and environment related issues were not reported in our study. All issues of EMAS are indexed (e.g., I-1) for easy reference.

4.3.1 Technology Related

Technology related issues encompass the hardware and software aspects of EMAS that users face difficulties with. For example, due to poor user interface design, nurses found it difficult to navigate within the software. Moreover, due to low robustness of the system, nurses were faced with delays in medication servings. This category also includes the effect of these issues on the perceptions of users as shown in Table 9 along with the relevant quotes.

Index	Issue	Quote
I-1	Lack of availability of COW in ward • Occurs when both physicians and nurses require the COW during peak periods • Often caused by uncharged batteries of COW or PDA	*"When the morning rounds come especially and if it is a mixed discipline ward, different teams of doctors will be going around and all need the COW so when everyone is there at the same time ... there will not be enough COW for use" – **Nurse***
I-2	Poor mobility of COW • Space constraints within some ward cubicles prevented bed-side usage	*"The main concern we have is the difficulty of moving about with one big computer. Sometimes the ward is busy and packed with people then it gets very crowded so it can be quite difficult to park it. "- **Physician***
I-3	Poor PDA usability • PDA screen too small for viewing for several nurses • Poor user interface design slowed down serving • Unnecessary information transferred slowed down PDA • Barcode on wrist tag tough to scan with PDA. Possibly due to creased bar code or faulty barcode scanner	*"Some older staff members might not be able to see the screen. It's too small because when we actually see it from the COW it's much clearer. The font size is too small" - **Nurse*** *"... it's a little bit tedious in the sense that you need to scroll the long list of medication ...and you need to go back to another screen to click medication that you want to serve. Click and scroll, click and scroll." - **Nurse*** *"The PDA yes it is useful because you can scan the name tag but the sensor isn't very good." - **Nurse***
I-4	Low robustness of system • Sluggishness of EMAS due to connectivity, bandwidth or system related issues causing delays • Poor connectivity due to wireless blind spots within ward rendering device use impossible • Unscheduled downtime prevented nurses from performing tasks	*"... if you have a slow connection it really holds up a lot. The logging in is slow, the ordering is slow, keying in is slow. It really takes up a lot of our time." - **Nurse*** *"There are still some blind spots here and there...sometimes certain areas you just cannot [connect] so you have to park outside the cubicle instead." - **Nurse*** *"The whole system shut down...a few times - even the PDA also, so we just waited." - **Nurse***
I-5	Lack of user confidence in system • Due to ease of use of paper IMR • Doubts on the reliability and accuracy of the system	*"... the incident happened a few weeks ago so I do not feel very confident about the system because we still have a few problems we encounter..." - **Nurse***

Table 9: Technology related issues of EMAS

4.3.2 Task Related

Task related issues concern the misalignment between workflow processes and the requirements of EMAS. For example, as the use of the PDA does not allow for viewing of past medication servings that was important for the nurses, it slowed down the medication serving process as nurses require this information and had to retrieve this information from other sources. As a result of these issues, users may not be able to complete their tasks efficiently and effectively. The task related issues of EMAS found in our study are shown in Table 10 along with supporting quotes.

Index	Issue	Quote
I-6	Use of PDA slows down medication serving process • PDA does not meet nurse workflow needs such as ability to view past several medication servings • Past practices easier to perform task and using BCMA perceived to be troublesome	*"On the PDA we can only see the last administration time. On the COW, we can trace back how many dose was given, so [the PDA] is slower"* - ***Nurse*** *"... with PDA we spend much longer on PDA because...sometimes it hangs, it is slow to boot up...it's a lot of time wasted which with the paper IMR you don't need to waste."* – ***Nurse***
I-7	Miscommunication due to changes in interaction • Past transfer of paper IMR from physician to nurse presents opportunity to inform of stat dose but EMAS does not require this transfer thus increasing chance of uninformed stat doses	*"The problem lies when between medication serving times, when we are busy and the doctor orders a stat order in EMAS without informing us. We wouldn't know about it and by the time we find out, it might be an omission already."* – ***Nurse***
I-8	Incompatibility with ward medicine ordering/serving practices • Time - EMAS stringency for ordering differs from past ward practices as orders made after ward serving timings with EMAS would not be served immediately unless a stat dose is ordered, causing delayed treatment • Dosage - Medicine dosage suggestions by EMAS does not meet current ward requirements especially for paediatrics ward	*"...because our cut off time is 8am so anything [ordered] by the doctor after that unless they order stat dose, it won't show up on our side."* - ***Nurse*** *"Some of the orders in EMAS are not correct so we don't follow it at all. For IV, the strength, the diluents, the time, we don't even add more water inside but the computer will say you need to add water but not really."* – ***Nurse***
I-9	Inability to use/scan wrist tag of patient • Reluctance to inconvenience patient (e.g. sleeping) • Removal of wrist tag by patient violates use for ensuring the 5 Rights	*"..because the kids do not like to put on the wrist tag so on and off they like to take it out so if you use it to scan, it's not very safe after all."* - ***Nurse***

I-10	Incorrect use of system • Signing of served medications performed wrongly due to unfamiliarity with system • Ordering of medication performed wrongly due to unfamiliarity with system	*"If in EMAS we click the wrong thing, for example when I went to serve the medicine but I just click wrongly... cannot undo all the things so we need to call the doctor to order" - **Nurse*** *"... if the physician didn't give the right timing while ordering then later it will not appear for nurses to pick. I think basically we need physicians to know how to order... [or else] it will mess up everything." - **Nurse***

Table 10: Task related issues of EMAS

4.3.3 Organization Related

Organization related issues refer to policies and practices by the management that do not support workflow procedures. For example, management policy requires medication to be ordered by physicians before nurses can serve the medication, but this causes issues in emergency cases when doctors do not have the time to prescribe medication through EMAS and thus nurses are unable to serve the medication promptly. It also includes organizational actions that may trigger workarounds in the use of EMAS. These issues for our case are shown in Table 11 along with the supporting quotes.

Index	Issue	Quote
I-11	Training inadequate or not attended • Several users unable to attend training thus had difficulties learning on-the-job • Some nurses felt training was inadequate as the learning curve to use EMAS was steep	*"Initially the training looks very complicated when you are just looking at it and not using it in a real-life scenario. But it's more of the job training that is more effective. I wasn't confident initially with the system." – **Nurse***
I-12	Medication ordering not suitable for emergency cases • Ordering process with EMAS meant nurses must wait for physicians to order before serving	*"We had occasions...it's urgent but the physician can't possibly have the time to go to the computer and enter in whereas if it's paper IMR, we can safely just write in and sign off." – **Nurse***
I-13	Unnecessary alerts for PRN medicine • PRN medicine (to be served as needed) appear in EMAS as a regular dose and require a nurse to omit them thus creating additional work	*"PRN is [served] as needed like Paracetamol. Because usually here we order 6-hourly Paracetamol PRN. If there is no fever we won't give but in EMAS it will appear as an omission." - **Nurse***

Table 11: Organization related issues of EMAS

In our study, new categories were created for issues of EMAS thus offering a more detailed analysis as compared to previous literature (see Tables 2 and 3). Although the previous section (4.2) demonstrated the benefits of EMAS that could resolve several problems faced with the

existing approach of paper IMR, it is observed in this section that the adoption of EMAS also surfaced new issues.

4.4 Augmenting and Working Around

When users are faced with the issues of the new system, they may perform *augmenting* or *working around*. For example, when physicians failed to inform nurses of stat doses, nurses had to perform the additional task of checking EMAS regularly. Augmented work performed by EMAS users in our study is summarized in Table 12 and indexed (e.g., A-1) for easy reference.

Index	Augmented Work	Quote
A-1	Nurse checking EMAS regularly for stat dose • Worry by nurse of uninformed stat dose ordered by physicians	*"We need to go to the computer and log in regularly and check whether there is any new order because some doctors don't really tell us."* - ***Nurse***
A-2	Reminders to inform nurse after ordering a stat dose • Given by nurse managers to physicians	*"I already informed the doctors, any stat dose they order, nurses have to be informed, they cannot always expect our nurses to check the system to see if they have ordered a stat dose."* – ***Nurse Manager***
A-3	Nurse writing orders from EMAS onto paper • Lack of confidence and existence of paper persistence leading to uneasiness using EMAS	*"There was one point of time when it was really bad so when we are serving medicine we just stand in front of the COW and wait. I think some of the juniors they know what to expect from the system so sometimes they write all the orders on the paper."* - ***Nurse***

Table 12: Augmented work

As issues of EMAS affected mainly physicians and nurses, workarounds consequently surfaced from these two user groups. For example, due to poor wireless connectivity within the ward cubicles, physicians had to use the COW outside the cubicles instead of by the patient's bedside. When nurses had issues with scanning a patient's wrist tag, they resorted to scanning the barcode on the clinical board instead. Workarounds performed by physicians and nurses in our study are shown in Tables 13 and 14 respectively and indexed (e.g., W-1) for easy reference.

Index	Workaround	Quote
W-1	Physician used paper IMR to order instead of EMAS • Physicians unfamiliar with EMAS • Use of paper IMR created need for another physician to transcribe into EMAS subsequently	*"Sometimes because physicians are not trained or not confident in using EMAS, they still use paper and the rest of the physicians are the ones who have to transcribe into the system. It's really duplicate work."* – ***Nurse***
W-2	Physician used COW outside cubicle instead of bed side • Poor wireless connectivity render COW useless at the bedside • Uncharged batteries prevent use of COW away from power outlet	*"For the COW sometimes you can push it to the patient but sometimes it's so slow so usually we have leave the COW outside because half of the time we need to charge it"* – ***Physician***
W-3	Physician did not fill up columns fully during ordering • EMAS requires all fields to be completed before submission, contrary to paper IMR. • Physicians filling up "N.A" in several fields to get around the requirement	*"Sometimes during input of orders, certain columns need to be filled before EMAS can recognize the orders. That is a problem we have because in paper IMR we will just write 'N.A' and just skip...but sometimes when it's not applicable EMAS will still want us to fill in the columns."* – ***Physician***
W-4	Physician edited dosage forms suggested by the system • EMAS recommends dosage depending on medication selected however physicians may need to make adjustments due to patient demographic	*"Yes we have to make changes to the dosage because the paediatrics doses are not really there. For us it depends on how heavy the child is, the calculation is still manual. So half the time we are overwriting what the computer is telling us."* – ***Physician***
W-5	Physicians shared log in account • Failure of previous users to log out from EMAS after use • Slowness of log-in process leading to sharing of account	*"By right EMAS should introduce accountability but we tend to use other's account occasionally because it just takes a long time to load ours...usually we will try to log off the accounts once we finish our rounds but on occasions we do forget. I still see some of the system accounts lying around."* – ***Physician***
W-6	Physicians requested to reorder medication by nurses • Mistakes in ordering by physician • System errors leading to missing orders	*"It actually happens quite frequently where we key in something and we are sure it's in already but it doesn't reflect on the nurses' part so we end up having to reorder everything again."* – ***Physician***

Table 13: Workarounds performed by physicians

Index	Workaround	Quote
W-7	Nurse used COW instead of PDA • PDA slows down serving process • Poor PDA usability • Cardiac ward has a computer by each bedside thus use of computer more convenient	*"For some older nurses, they might not be able to see the screen of the PDA properly because it's too small. When we actually see it from the [COW] it's much clearer because we can see from the medication administration record when was the last time it was served through the colour indicators which is quite easy but the PDA doesn't have this feature"* – ***Nurse***
W-8	Nurse used PDA to scan clinical board instead of wrist tag • Inconvenience of using PDA for checking 5 Rights.	*"Sometimes nurses choose the easy way out...instead of scanning the patient they scan the clinical board. However the nurse then went to the wrong bed and caused a medication error."* – ***Nurse***
W-9	Nurse picked next time slot to serve because current used	*"There are a lot of times we get held back because the nurses will say that somebody accidentally signed on*

	• Nurse unfamiliar with system and picking the wrong time slot to serve • Some nurses signed on next serving slot for late medication servings	*their dose or rather they missed their dosage then they sign on the next dose. So in the end we have to write a stat dose for them to sign." –* ***Physician***
W-10	Nurse served medication outside of expected timing • Medication errors defined as not serving within an one hour range of intended serving • Oversight by physicians during ordering for medicine with special requirements	*"Sometimes we have this medicine that should be served before meals but doctor order [to be served at] 8pm. So what we do is that we will serve before meal but justify it accordingly as an early serving. The physician should change the timing though." –* ***Nurse***
W-11	Nurse cleared omission for PRN medicine in batches • Batch clearing in response to unnecessary alerts for PRN medicine • Batch clearing reduces accountability	*"..if the frequency is put as PRN, which is when necessary and the nurses never give an exception for that when the patient doesn't need it, it will keep showing as omission and overdue. I'm always the person who clears all these omissions and it's a very long list." –* ***Nurse***
W-12	Nurse clicked medicine to be administered on COW before serving • To save time as nurses are confident of recognizing their patients and knowing their medication needs	*"If serving with the COW, I will click all the medications to be administered then we go to the patient. Skip one step. For other nurses I don't know but for me I will know all the patients before I serve." -* ***Nurse***
W-13	Nurse did not serve medication according to order in EMAS • Ward practice differs from EMAS orders due to stringent entry requirements (e.g., intravenous medicine serving) • Unfamiliarity with orders presented in system	*"The way of giving intravenous medicine is different from the way portrayed in the computer. This is because certain kids we cannot give too much water, but for computer it's already fixed to give that amount so we can't change that ... so we verbally tell each other to not give that kind of fluids." –* ***Nurse***
W-14	Nurse co-signed for another nurse during serving • Co-signing with the use of colleague's password performed by the same person • Nurses feel co-signing process cumbersome	*"There were cases where nurses pick a medication and they key in their colleague's password to co-sign the medicine. By doing so, integrity is compromised." –* ***Nurse***
W-15	Nurse served medication before it was ordered • During emergency when physician could not order medication immediately	*"Because it's an emergency case, we had to give [the medicine] first before [the physician] order in the system." –* ***Nurse***

Table 14: Workarounds performed by nurses

4.5 Connecting Issues of EMAS with Augmenting and Working Around

We now show how issues of a system can lead to different forms of accommodation in order to either avoid or mitigate them. These relationships were deduced and subsequently confirmed with the users of EMAS in our case. In Tables 15 and 16, checked cells indicate issues that resulted in each augmented task or workaround respectively. The tables also show that

augmented work or workarounds may be the result of multiple issues and an issue may result in several augmented work or workarounds. For example, when users were not confident of using the system correctly [I-5], both physicians and nurses used the system in unintended ways (see Tables 15 and 16). Physicians resorted to using paper IMR to order medicines and nurses wrote medication orders from the EMAS on paper.

Type of Accommodation / **Issues of EMAS**	**Augmenting**		
	[A-1] Nurse checking EMAS regularly for stat dose	[A-2] Reminders to inform nurse after ordering a stat dose	[A-3] Nurse writing orders from EMAS onto paper
Technology Related			
[I-3] Poor PDA usability			**X**
[I-4] Low robustness of system			**X**
[I-5] Lack of user confidence in system			**X**
Task Related			
[I-6] Use of PDA slows down medication serving process			**X**
[I-7] Miscommunication due to changes in interaction	**X**	**X**	
Organization Related			
[I-11] Training inadequate or not attended			**X**

Table 15: Relationship between Augmented Work and Issues of EMAS

Type of Accommodation / Issues of EMAS		Working Around														
		[W-1] Physician used paper IMR to order instead of EMAS	[W-2] Physician used COW outside cubicle instead of bed side	[W-3] Physician did not fill up columns fully during ordering	[W-4] Physician edited dosage forms suggested by the system	[W-5] Physicians shared log in account	[W-6] Physicians requested to reorder medication by nurses	[W-7] Nurse used COW instead of PDA	[W-8] Nurse used PDA to scan clinical board instead of wrist tag	[W-9] Nurse picked next time slot to serve because current used	[W-10] Nurse served medication outside of expected timing	[W-11] Nurse cleared omission for PRN medicine in batches	[W-12] Nurse clicked medicine to be administered on COW before serving	[W-13] Nurse did not serve medication according to order in EMAS	[W-14] Nurse co-signed for another nurse during serving	[W-15] Nurse served medication before it was ordered
Technology Related	[I-1] Lack of availability of COW in ward		**X**			**X**										
	[I-2] Poor mobility of COW		**X**													
	[I-3] Poor PDA usability							**X**	**X**							
	[I-4] Low robustness of system	**X**	**X**			**X**		**X**	**X**							
	[I-5] Lack of user confidence in system	**X**												**X**		
Task Related	[I-6] Use of PDA slows down medication serving process							**X**	**X**				**X**			
	[I-8] Incompatibility with ward medicine ordering/serving practices (Dosage)				**X**		**X**							**X**		
	[I-9] Inability to use/scan wrist tag of patient								**X**							
	[I-10] Incorrect use of system						**X**				**X**			**X**		
Organization Related	[I-11] Training inadequate or not attended	**X**		**X**			**X**			**X**						
	[I-12] Medication ordering not suitable for emergency cases															**X**
	[I-13] Unnecessary alerts for PRN medicine											**X**				

Table 16: Relationship between Workarounds and Issues of EMAS

4.6 Fitting

After the introduction of EMAS, feedback from users was communicated to the management through regular sessions involving the users and champions. This provided valuable information on the problems users faced on the ground and also how they reacted to such issues. Based on the severity of the issue, the management then responded by either performing modifications to the system or making adjustments to current work processes. This is also consistent with the IT modification (F-2 to F-4) and process embellishment (F-1 and F-5) strategies suggested by McGann and Lyytinen (2008). Table 17 describes the fitting work performed in our study that are indexed (e.g., F-1) for easy reference.

Index	Fitting	Issue and Fitting description
F-1	Change in ordering process (from interview with physician of paediatrics ward)	[I-8 (Time)] Resolves issue of physicians not ordering stat dose for medication ordered after ward cut-off timing for servings • Mandatory for physicians to order stat dose if order entered after ward cut-off timing but requires immediate first serving • Modifications made to EMAS to prompt physicians asking if stat dose required for order
F-2	Reduction of system errors (from interview with clinician champion of cardiac ward)	[I-5] Rectification of system errors to improve the accuracy and reliability of the system • Improves user confidence in system through increased reliability
F-3	Reduction of unnecessary information downloaded to PDA (from interview with project manager of IT department)	[I-3] Resolves issue of poor PDA usability • Information transferred and displayed on PDA streamlined to improve responsiveness
F-4	Improvement of IT infrastructure (from interview with project manager of IT department)	[I-4] Resolves wireless connectivity issues faced by EMAS users • Increase in number of wireless access points to reduce blind spots in wards
F-5	Reinstate past communication practices (from interview with nurse of paediatrics ward)	[I-7] Resolves issue of uninformed stat dose ordered by physicians • Mandatory for physicians to inform nurses of stat dose even after ordering through the system

Table 17: Fitting work by management

4.7 Impacts of EMAS

Fitting of work processes and IT in response to issues of the new system, augmented work, or workarounds often produces a positive impact on the organization. For example, by adding prompts for doctors to order a stat dose (F-1), medication can be administered quickly as required. With the improvement of IT infrastructure (F-4) and reduction of unnecessary information downloaded to PDAs (F-3), nurses were more willing to use them in their daily routine. This is important as it can greatly help them ensure that medication is served to the correct patient. A summary of the positive impacts of augmented work and workarounds that have gone through fitting in our study is presented in Table 18.

Augmented Work/Workaround	Fitting	Positive Impact (Enhance benefits)
[A-1] Nurse checking EMAS regularly for uninformed stat dose	• [F-5] Reinstate past communication practices	• [B-1] Reduction of medication errors
[A-2] Reminders to inform nurse after ordering a STAT dose	• [F-5] Reinstate past communication practices	• [B-1] Reduction of medication errors
[A-3] Nurse writing orders from EMAS onto paper	• [F-4] Improvement of IT infrastructure	• [B-1] Reduction of medication errors • [B-3] Time savings
[W-6] Physicians requested to reorder medication by nurses	• [F-2] Reduction of system errors • [F-1] Change in ordering process	• [B-1] Reduction of medication errors • [B-2] Increase in compliance
[W-7] Nurse used COW instead of PDA	• [F-4] Improvement of IT infrastructure • [F-3] Reduction of unnecessary information downloaded to PDA	• [B-1] Reduction of medication errors • [B-2] Increase in compliance

Table 18: Impact of Workarounds after Fitting

Though some workarounds (W-6 and W-7) went through fitting, it was observed that many remained unresolved and could potentially dilute the benefits of the system. For example, if physicians share log-in accounts (W-5), it can negate the benefit of increased accountability. However, on closer examination, it was observed that workarounds could also be performed to

improve on workflow as a response to the issues of the system. For example, physicians used the COW outside ward cubicles to allow medication orders to be entered into EMAS for nurses to be able to prepare and serve medication instead of facing unnecessary delays. Therefore it is imperative to recognize both the positive and negative impacts of workarounds. Table 19 presents the workarounds that had not gone through fitting and their impact on the benefits of EMAS.

Workaround	Negative Impact (Reduce Benefits)	Positive Impact (Enhance Benefits)
[W-1] Using paper IMR to order instead of EMAS	[B-1] Reduction in medication errors • Increased medication errors due to illegibility of handwriting, missing paper IMR and error in transcribing [B-3] Time savings • Additional time required to enter handwritten orders in EMAS subsequently	• Reduced medication errors as physicians unfamiliar with EMAS may be prone to mistakes as compared to using paper IMR
[W-2] Physician used COW outside cubicle instead of bed side	[B-1] Reduction in medication errors • Increased medication errors due to wrong patient, medicine, dose, route and/or time	• Allow medication orders to be entered into EMAS for nurses to prepare and serve medication without delay
[W-3] Physician did not fill up columns fully during ordering	[B-1] Reduction in medication errors • Increased medication errors due to wrong dose and/or route served [B-2] Increase in compliance • Reduced compliance to hospital ordering practices	• Reduced confusion with prior ward serving arrangements
[W-4] Physician edited dosage forms suggested by the system	[B-1] Reduction in medication errors • Increased medication errors due to wrong dose, route and/or time	• Reduced medication errors as a result of customizing dosage forms for patient
[W-5] Physicians shared log-in account	[B-2] Increase in compliance • Reduced accountability for medication ordered	• Reduced time to order medication and for nurses to serve
[W-8] Nurse used PDA to scan clinical board instead of wrist tag	[B-1] Reduction in medication errors • Increased medication errors due to wrong patient	• Reduced time for nurses to prepare and serve medication
[W-9] Nurse picked next time slot to serve because current used	[B-1] Reduction in medication errors • Increased medication errors due to wrong time [B-2] Increase in compliance • Reduced accountability for medication served	• Reduced medication errors as a result of nurses preventing medication omission
[W-10] Nurse served medication outside of expected timing	[B-1] Reduction in medication errors	• Reduced medication errors as a

	• Increased medication errors due to wrong time served affecting future timings	result of compliance to medication instructions
[W-11] Nurse cleared omission for PRN medicine	[B-2] Increase in compliance • Reduced accountability due to nurses clearing in a batch	• Reduced confusion among nurses for subsequent medication servings
[W-12] Nurse clicked medicine to be administered on COW before serving	[B-1] Reduction in medication errors • Increased medication errors due to wrong patient	• Increased productivity and efficiency of nurses
[W-13] Nurse did not serve medication according to order in EMAS	[B-1] Reduction in medication errors • Increased medication errors due to wrong medicine, dose and/or route	• Reduced medication errors as a result of customizing dosage forms for patient
[W-14] Nurse co-signed for another nurse during serving	[B-1] Reduction in medication errors • Increased medication errors due to wrong patient, medicine and/or dose [B-2] Increase in compliance • Reduced accountability as nurses could repudiate servings performed	• Increased productivity and efficiency of nurses
[W-15] Nurse served medication before it was ordered	[B-1] Reduction in medication errors • Increased medication errors due to wrong medicine and/or dose [B-2] Increase in compliance • Reduced compliance to hospital ordering practices	• Reduced time for nurses to serve medication during emergency

Table 19: Impact of Workarounds without going through Fitting

5. PROCESS FRAMEWORK

Our case findings aid us in developing a process framework for the antecedents and consequences of workarounds of a new healthcare IS implementation i.e., EMAS in our case (see Figure 2). This framework integrates concepts from McGann and Lyytinen's (2008) model of IS evolution and Gasser's (1986) strategies for accommodation to misfit. McGann and Lyytinen's (2008) description on the type of organization changes in response to a new IS suggests the interactions between the different types of accommodations in the framework. Gasser's strategies are used to categorize the different types of accommodation both users and management perform in response to issues of the new IS. The case findings are used to substantiate the relationships in

the framework. The following subsections describe the framework and how it is derived from the findings in the previous section.

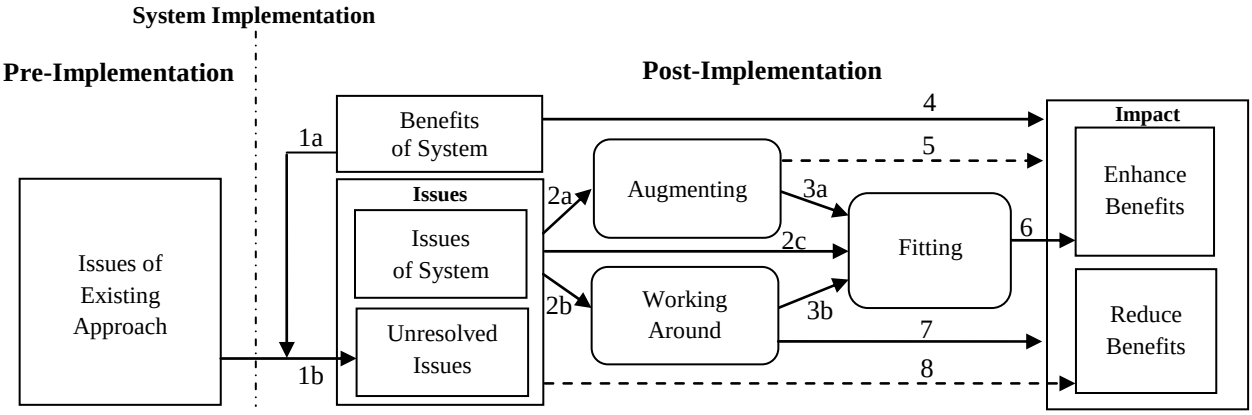

Figure 2: Process Framework for Healthcare IS Workarounds and Impacts

5.1 Pre-Implementation

In the pre-implementation stage, reviews of existing conditions may be initiated to identify problems requiring resolution. In our case, after the review, a decision was subsequently made to introduce EMAS due to its ability to alleviate *issues in the use of the existing approach* (see Table 6). In Hospital A, the existence of medication errors was identified by the management to be a critical issue mainly due to the use of paper IMR. As a result of the assessment that paper IMR could no longer support the needs of the hospital, the search for a replac**e**ment was triggered. Subsequently, with the support from the healthcare professionals coupled with the expectation that the new IS could solve the issues of paper IMR, a decision was then made to invest resources and carry out the implementation of EMAS to support the medication delivery process.

5.2 Post-Implementation

The post-implementation stage consists of the realization of the *benefits of the system, issues of the system, unresolved issues* of the past approach, and the accommodation performed by users through *augmenting* and *working around*. Subsequently, depending on the intent of the management, *fitting* may occur. While accommodations that are fitted may *enhance the benefits* of the system, other accommodations may *enhance or reduce the benefits* for the organization.

In our case, once EMAS was implemented for use in the observed wards, users started to reap the *benefits of system* (see Table 7). These benefits solved the majority of the issues of the existing approach (paper IMR) **[Arrow 1a in the framework of Figure 2]** as summarized in Table 8. However, there were issues from the paper IMR that were unresolved (PI-5 in Table 8) with the new system [**Arrow 1b]**. For example, nurses were still not informed of a stat dose after it was ordered by a physician with the use of EMAS. As a result, medication servings were delayed. In addition to the *unresolved issues* from the paper IMR, new *issues of the system* (EMAS) started to surface (see Tables 9 to 11) due to the misalignment of work processes and computing. For example, poor wireless connectivity prevented EMAS users in Hospital A from using the COW and PDA by the patient bedside.

In response to these issues, users engaged in two forms of accommodation, *augmenting* **[Arrow 2a]** (see Table 15) and *working around* **[Arrow 2b]** (see Table 16). These reflect attempts by users to accommodate to the misfit either by undertaking additional work or using alternative ways to resolve the issue. Common reasons for performing *augmenting* include situations where the information reliability was doubted or when the information was not transmitted in an efficient way. For example, as physicians were more likely not to inform nurses about stat doses, nurses were compelled to check the records through EMAS regularly for

possible updates. This additional work increased the load on the system thus causing slowdowns and reduced the availability of COWs. However, although this augmented work consumed time that could have been better utilized in patient care, this was essential to prevent medication errors from occurring. In effect, augmented work can create a trade-off between the efficiency and the effectiveness of the system.

Working around reflects more serious issues that require attention. This is because such activities often circumvent important safety features of the system designed to reduce medication errors. For example, some nurses chose to workaround the difficulty of scanning a patient's wrist tag by scanning the sticky label on the clinical board instead. By doing so, the intended benefit of ensuring the right patient was served was not met and thus increased the chances of medication errors. However, it was also observed that working around may sometimes be necessary because the system does not support a particular aspect of the work. For example, when paediatrics physicians edited dosage forms suggested by the system, it was because the preconfigured dosage was not suitable for children in the ward. By working around, it allowed the physician to customize the dosage form according to the patient's needs.

Augmented work and workarounds often remain localized and do not propagate to the organization level. Also, some issues (e.g., I-8 in Table 10) do not go through augmenting or workarounds. However, when any of these (augmented work, workaround, or issues of the system) is surfaced to the management, some may go through process embellishment or IT modification for *fitting* **[Arrow 2c] [Arrow 3a] [Arrow 3b]**[1]. For example, standardizing the requirement for physicians to inform nurses of stat doses (process embellishment) reduces the

[1] As elaborated later, dotted arrows 5, 8, and solid arrow 7 indicate those issues that did not go through fitting.

need for additional work to be performed by the nurses. The resolution of system errors (IT modification) reduces the need for physicians to reorder medication that can, in turn, lower the chances of medication errors. Both process embellishment and IT modification depict the elevation of issues, augmented work, and workarounds from a localized ad hoc improvisation to the organizational level (McGann and Lyytinen, 2008).

Fitting performed on augmented work **[Arrow 3a]** (see Table 18) usually appears in the form of an adjustment to eliminate the need for the extra work. When nurses resorted to writing EMAS orders on paper for verification by the bedside due to poor connectivity, it resulted in extra work that could compromise patient safety. To combat this, the management took steps to improve the system infrastructure so that nurses could use the COW or PDA easily by the bedside of a patient.

Fitting for workarounds **[Arrow 3b]** (see Table 18) should be of high priority for the management so that workarounds do not reduce the benefits of the system. When physicians regularly received requests from nurses to reorder medication that had been ordered previously, the management recognized that these workarounds should not be occurring. Further investigations revealed system errors as the root cause of the problem. In response, these errors were eradicated and users did not need to make such requests any more.

Besides performing fitting as a result of the two types of accommodation, some issues of the EMAS were also resolved either through process embellishment or IT modification **[Arrow 2c]** (see Table 17). As changes to the medication ordering practice with EMAS meant that a stat dose is required if a medication is ordered after ward serving timings, physicians often failed to

order the stat dose resulting in delayed treatment. As a response to this issue, management opted to modify the system to prompt physicians asking if a stat dose is required after ordering.

As a result of the system implementation and accommodations, this could enhance the benefits of the system in three ways. First, the implementation of EMAS brought immediate benefits to users as compared to the previous approach (paper IMR). For example, there would no longer be cases where paper IMR goes missing and requires a search. As a result, such benefits of EMAS will have a positive impact on the users and organization **[Arrow 4]**. Second, though *augmenting* requires additional work by users thus reducing efficiency, it can possibly mitigate the issues of the system even without fitting. Although not observed in our study, a possible example is when nurses made the decision to write medication orders on paper to prevent any possible omission of medication in case of an unscheduled system downtime. Therefore, although it can reduce some benefits of the system, augmenting can also enhance certain benefits **[Arrow 5]**. Last, when *fitting* occurs, both process embellishment and IT modification are performed with the aim of alleviating the potentially detrimental accommodations that users have engaged in. Issues accommodated through fitting would thus have a positive impact on the organization **[Arrow 6]**. For example, improved connectivity and reduction of unnecessary information loaded into the PDA further encouraged nurses to use the PDA for better outcomes (as seen in Table 18).

However, there may be reductions in the benefits of the system as well. Some issues and workarounds may not go through process embellishment or IT modification since they may not be a priority for management or due to cost constraints. First, for those issues unresolved by management, there is a possibility that they can reduce the benefits of the system **[Arrow 8]**. Second, by not engaging in *fitting* for certain workarounds, the management signifies their intent

to discourage such activities. For example, when some physicians used paper IMR to order medication after EMAS was introduced, the management actively discouraged it and encouraged physicians to comply. However, as with the case of *augmenting*, workarounds may also be performed to ensure the smooth flow of activities. For example, physicians shared log-in accounts to reduce the time to order medication and serve it. Therefore, workarounds may both enhance and reduce the benefits of the system **[Arrow 7]**. Table 19 summarizes these activities that did not go through process embellishment or IT modification in our case.

6. DISCUSSION AND IMPLICATIONS

The analysis of the case and the development of the process framework in the previous section have revealed several insights about the use of healthcare IS, specifically EMAS, in response to our research questions.

It was seen that *benefits* brought about by EMAS were manifold. The system improved the work of users through benefits such as time savings that allowed users to place more emphasis on their main duties, and improved patient safety with medication and dosage suggestions. These contributed to the main objective of reducing medication errors as intended by the management of Hospital A. Most issues that plagued the paper IMR system were also resolved. This case thus supports past findings on the benefits of an EMAS in improving efficiency (e.g., time and cost savings) and effectiveness (e.g. reduction in medication errors) of healthcare professionals' work in a hospital (Anderson et al., 2002).

However, this paper also supports the claim that there is no perfect alignment between computing and work processes (Gasser, 1986). EMAS was developed with the intention of improving work processes of its users and designed following regular consultations with

physicians and nurses during the IS development. Despite these efforts, new issues surfaced after its implementation. This implies that a new system may bring about benefits to address past problems but may unintentionally create *new issues*.

As seen in our case, system users responded to issues they faced in two main ways, *augmenting* and *working around*. The approach chosen depends on what is appropriate to accommodate the misfit between the system and the specific work process. As these accommodations occur, the management may initiate *fitting* to alleviate the potential negative impact posed by these actions. While some accommodations go through fitting in the form of *process embellishment* or *IT modification*, others may remain as ad hoc adjustments. A probable reason for not fitting all accommodations at the organizational level is that some of them may not a management priority or the fitting may be costly to undertake.

As this study involved two separate wards with differing patient needs and time of implementation, several differences were observed in the workarounds. As the cardiac ward had a computer by each patient's bedside, nurses did not find it necessary to use the PDA for medication serving. However, the nurses in the paediatric wards had to use the PDA which had usability issues. Physicians of the cardiac ward also had fewer issues with the medicine dosage recommended by the system which was suited for adults but not children. As the implementation of EMAS in the cardiac ward was 5 months after it was first implemented in the paediatrics ward, some teething problems with the system may also have been resolved prior to EMAS introduction in the cardiac ward. As users were more aware of the potential problems they could face with EMAS, the transition from paper IMR was deemed to be easier and smoother in the cardiac ward than the paediatrics ward. This implies that within an organization, contingencies and differing requirements may result in variations in the workarounds of a system.

6.1 Theoretical Contributions

This paper contributes to healthcare IS research in several ways. First, this paper builds on previous theories to develop a process framework for better understanding the impact of workarounds in an organization. The framework integrates two theoretical perspectives in IS research i.e., accommodation to misfit (Gasser, 1986), and IS evolution (McGann and Lyytinen, 2008), and applies them to the study of workarounds in healthcare IS. It illustrates factors that lead to workarounds and inter-relates accommodation strategies in response to the issues. The framework identifies the relationships between accommodation strategies i.e., how *working around* and *augmenting* can be antecedents of *fitting*, not explained before.

Second, this paper highlights the unique aspects of workarounds for healthcare IS such as EMAS. While workarounds if not accommodated may have negative consequences of reducing efficiency and effectiveness in other industries as well, the healthcare industry is characterized by its strict regulations on medication ordering and serving (Halbesleben et al., 2008). Thus the prevalence of workarounds has additional critical consequences in terms of violating guidelines and patient safety that may cause concern to healthcare organizations (Runciman et al., 2007) and must be managed effectively.

Third, this is an initial attempt to study the components of EMAS (i.e., CPOE, EMAR, BCMA) as a whole, as the components have been studied separately previously. Since the components work interdependently in the medication delivery process (i.e., CPOE for medication ordering, EMAR and BCMA for medication serving), this paper demonstrates that workarounds performed on one component can affect the use of other components. For example, when physicians used paper IMR to order medicines instead of EMAS (W-1), as nurses were

unable to retrieve medication orders through the system, they were compelled to transcribe the handwritten orders into the system for the physicians. In addition to previously documented workarounds in the use of the components of EMAS, our paper extends the literature by highlighting new types of workarounds performed by users of EMAS. For example, due to the slowness of the log-in process in the CPOE system, some physicians decided to workaround the issue by sharing log in accounts. As a result of unnecessary omission alerts for use-as-necessary (PRN) medicines in the EMAR system, nurses had to perform batch clearing to resolve the issue.

Fourth, this paper provides a more detailed analysis of the benefits of EMAS as compared to the previous literature. Also, we found support for three out of the four benefits outlined in previous literature (see Table 1). Among the four benefits, user satisfaction was not prominent in our study likely because at the time of the study, the presence of issues masked this benefit that users enjoy from the system. In addition, compared to previous literature, another benefit in the form of increase in job performance was also observed.

Last, the findings on issues of EMAS were consistent with previous literature (Ash et al., 2007; Bartos et al., 2008; Campbell et al., 2006; Eslami et al., 2008; Sittic et al., 2005). However, the aggressive resistance characterized by lobbying for system removal by users in previous work (Lapointe and Rivard, 2005) was not found in this study and could be attributed to the feedback mechanisms in place that allowed the management to acknowledge, understand, and rectify the issues of EMAS in a timely manner. In addition, we call for a differentiation between workarounds and resistance by contending that workarounds are performed for a functional purpose and not necessarily as a form of opposing behaviour.

6.2 Practical Implications

The findings of this study offer several suggestions for practitioners such as management and users of the system. First, benefits of the EMAS are detailed to serve as a realistic checklist for management seeking to implement similar systems. Second, issues of a new EMAS surfaced in this study allow for early detection of problems and are categorized for easy assessment by management, who could implement changes to alleviate the problems quickly. For example, technology related issues could be resolved by anticipating and introducing changes to the hardware or software of the system as required. Third, this study documents the workarounds performed by different users and identifies the causes of such accommodations. With such information, management could uncover the cause of these workarounds so as to identify solutions to rectify them.

Fourth, this paper aids management in understanding relationships between workarounds and their impact on the benefits of the system. The process framework also highlights the necessity for the management to be involved in *fitting*. This is because the lack of fitting of workarounds may negate the benefits of EMAS. In addition, though augmented work does not necessarily have an adverse impact on the effectiveness of the system, management should also seek to resolve them as augmenting can reduce the efficiency of users. Fifth, management should carry out variations in implementation that may be needed to account for different ward requirements. For example, wards with a computer at every bedside (e.g. the cardiac ward in our case) could have a barcode scanner added to achieve the same functionality without the use of a PDA.

Sixth, as apparent from our case study, it is essential for management to formulate a regular audit or review of systems for delivering quality healthcare services. To deliver quality, organizations must consistently review their processes and systems to look for process improvement opportunities (Ravichandran and Rai, 2000; Shaw and Stahl, 2008). With such reviews, management would be able to ensure that procedures are being followed, and if they are not, why and how this can be addressed. For example, within a short period of introducing EMAS in the hospital, many issues were surfaced to the management and users created workarounds. If a review showed that physicians are not confident in using the system, more training sessions can be organized. In addition, systematic feedback mechanisms should be implemented as in our case in order for management to recognize the issues faced by users.

This study also has practical implications for users of EMAS. As medication safety is paramount, both physicians and nurses should refrain from performing workarounds as far as possible due to their potential consequences. Instead, if issues are encountered, which are common in the early stages of IS implementation, it is important to provide feedback to the management as early as possible so that the issues can be resolved quickly. Users should recognize that although medication orders through EMAS are automatically routed to different parties, verbal communication of these orders still serves as an affirmation or clarification. As the chief producers of information for the medication delivery process, physicians should understand the safety features integrated into the system such as dosage form suggestions that is in accordance with hospital guidelines. However, should there be a need for deviation from the given guideline, it is necessary to communicate this to the relevant pharmacist and nurse to avoid possible miscommunication. Besides pharmacists, nurses play a critical role in preventing medication errors from occurring. In the event of any doubts in medication servings, nurses

should contact the physician for clarification, even if it is more cumbersome. As the system demands the timely administration of medication, similar to how another nurse is required for co-signing during medication serving, nurses can form a buddy system to check and remind each other about any upcoming servings.

6.3 Limitations and Future Work

While this paper proposes a framework to explain the causes and impacts of the occurrence of workarounds in healthcare IS, the limitations should be considered when interpreting the findings. First, since this study is based on an EMAS implementation in a few wards in a single hospital, the findings may not be generalizable to other healthcare organizations or to other systems. Therefore, while the case study approach allows for in-depth investigation of the phenomenon, future work can test the framework through other methods across other healthcare IS or organizations. Second, though the findings of this study have qualitatively validated the components and their relationships in the framework, future research may want to validate the framework through quantitative means.

In addition, future research can investigate the relationship between the levels of regulation in the hospital and the occurrence of workarounds that was not analysed in this study. This could further extend our understanding on the prevalence of workarounds in the healthcare industry and guide practitioners in future policy-making.

7. CONCLUSION

As the healthcare industry seeks to reduce medication errors, healthcare IS such as EMAS have garnered attention for their ability to alleviate this long-standing problem. However, there is a lack of research and understanding of the issues and workarounds in the use of these systems and

the resultant impacts. This understanding is essential for organizations because these systems often require considerable financial investments and can pose a substantial risk to patients if not used appropriately. This paper sheds light on the potential issues of such systems and how users may respond to these problems through the different forms of accommodation. Subsequently, depending on whether fitting is performed by management, the resultant impact on the organization is analysed. The findings are synthesized into a framework that shows the causes, workarounds, and impacts of the new healthcare IS and the inter-relationships among them.

In conclusion, although new IS in healthcare such as EMAS have gained popularity for their potential to reduce medication errors, workarounds that appear after their implementation may lower the efficiency and effectiveness of these systems. With scarce research and understanding of the effect of workarounds in these systems, this paper takes a step towards addressing this gap and guiding healthcare organizations in obtaining the benefits of IS implementation.

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