Technological and Organizational Adaptation of EMR Implementation in an Emergency Department

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Implementation of large Health Information Technology (HIT) systems is critical to healthcare organizations and has seen heavy investment. However, research has not fully explored the adaptation of HIT systems, particularly the tensions between individual flexibility and organizational needs in the adaptation process. This study analyzes how Emergency Department (ED) clinicians adapted to a new hospital-wide Electronic Medical Records (EMR) system. We present four adaptation cases revealing two interrelated types of adaptations—technical and organizational—as responses to the new system in use. First, individual clinicians respond to the immediate alteration in workflows caused by the EMR, while the organizational adaptations later mitigate the changes in healthcare quality control resulting from the clinicians' initial adaptation. Our analysis reflects the critical nature and value of both adaptation types, with an emphasis on the triggers and process of organizational adaptation, for the successful implementation of a socio-technical-political system in a healthcare organization.

Categories and Subject Descriptors: H.0 [**Information Systems**]; K.4.3 [**Organizational Impacts**]: Computer-Supported Collaborative Work

General Terms: Design

Additional Key Words and Phrases: Electronic Medical Record (EMR), implementations, adaptation, workaround, design, clinical practices

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1. INTRODUCTION

Technological adaptation is widely studied in the process of information system implementation [Leonard-Barton 1988; Orlikowski and Hofman 1997; Tyre and Orlikowski 1994]. During the adaptation process, problems and contingencies that were not apparent before the implementation can be identified as users to adapt their behaviors to accommodate the needs of the newly implemented technologies [Rosenberg 1982; Dutton and Thomas 1985]. Technological adaptation is defined as the process intended to modify new technology or aspects of the operating context, including the users' skills or procedures [Tyre and Orlikowski 1994], to make the newly implemented system work.

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Despite a government initiative on implementing Health Information Technology (HIT) systems [Hillestad et al. 2005], hospitals are lagging behind in adopting these large HIT systems [DesRoches et al. 2008; Jha et al. 2009]. After the HIT implementation, clinicians and staff are expected to maintain and optimize their work performances with the use of the new system. However, the introduction of HIT systems, including Electronic Medical Record (EMR) and Computerized Physician Order Entry (CPOE), often slows down individual providers productivity and often leads to unintended consequences, such as extended documentation time [Cyert and March 1963; Poissant et al. 2005], increased workload [Richardson and Ash 2008], incompatible workflow [Cyert and March 1963; Saleem et al. 2011], and even system-induced medical errors [Han et al. 2005; Koppel et al. 2005]. To alleviate these problems, clinicians often engage in various problem-solving strategies. One typical strategy is to create and use "workarounds" to accommodate the unintended impacts to their work practices [Azad and King 2008; Koppel et al. 2008; Niazkhani et al. 2011; Saleem et al. 2011; Vogelsmeier et al. 2008]. Workarounds are used to improve work processes, to bypass the deficiencies or issues of new technology, or to cope with unexpected issues after system deployment. For example, one study found that nurses use safety alert overrides and documentation shortcuts to minimize workflow disruption in the use of the electronic administration medication (eMAR) system [Vogelsmeier et al. 2008].

While system adaptations and workarounds have been widely studied in past HIT literature, the majority of them focus on adaptation behaviors made by individual users, by studying how individuals modify their behaviors to meet increased demands imposed upon them by the newly deployed technologies, for instance. Less is known about how organizations respond to the impacts of these new technologies, and how organizations strive to manage the quality of work practices that may be jeopardized by individual-level adaptations (e.g., overriding medication alerts). One recent piece of work [Novak et al. 2013] on HIT implementations in two organizations reveals that, in addition to individual-level adaptations, organizational-level adaptation efforts also occur; these may include reconfiguring the functions of the technologies, designing new bridging artifacts, and modifying work policies to be more technology friendly. Nevertheless, as the authors noted in the paper, this research reveals only minor organizational adaptations, without looking at the relationship between the two types of adaptations. This research calls for a more systematic approach to studying different types of adaptation behaviors and how they evolve.

Indeed, the need for studying organization level adaptation particularly arises when an organization has unique goals to maintain throughout the implementation process. In the domain of the study of this research, the primary goal of healthcare organizations is to improve the quality, safety, efficiency, and effectiveness of health care for all patients [Armijo 2009]. Many healthcare organizations have expected information systems to improve both the efficiency and quality of their patient care, as well as facilitating quality measurement [Armijo 2009]. Upon system implementation, these health organizations set up and deploy various policies and regulations to manage and control the quality of their clinicians' performances [Black et al. 2011]. While adaptations initiated by individual users, such as workarounds, help improve work efficiency and productivity, they may also reduce the reliability and consistency of work processes by potentially violating the policies and regulations set in place by the health organizations. In some cases, it can jeopardize patient safety, diminish care quality, and lead to adverse healthcare outcomes [Ash et al. 2004; Niazkhani et al. 2011]. Therefore, it is important to investigate how organizations standardize and control adaptation behaviors to meet the critical needs of quality control in such a highly reliable field. The latter control process, at the organizational level, has seldom been studied in prior HIT implementation and adaptation literature.

To explore the ways in which organizations address the unintended consequences of information system implementation, we conducted a qualitative study on the adaptation of an EMR system in an Emergency Department (ED), affiliated with a large teaching hospital. Specifically, we focused on the behaviors clinicians engaged in while adapting to the new system and how the department created consequent controls to make sure these adaptation behaviors fit into the organizational context. We describe four adaptation cases that each illustrates a clinicians' initial problem-solving effort, and the following responses taken by the organization in managing these adaptation behaviors. Our findings reveal that there are two phases of the adaptation process, each with its own distinct goal. First, clinicians engage in individual efforts to make the information systems work and easy to use; and second, at the organizational level, the ED leadership adapts their policies and practices to make sure the individual efforts meet the quality requirements set forth by the health organization. In this article, we refer to these two adaptation stages as *technological adaptation* and *organizational adaptation*. In our study, we define technological adaptation as the approaches employed by individual users to address the immediate impact introduced by the system in order to make system use possible and easier. Second, organizational adaptation consists of approaches used to mitigate the consequences resulting from initial technological-level adaptation (e.g., clinicians' workarounds) by setting up new policies and guidelines at the department/organization level. This two-phased adaptation process is necessary in healthcare organizations because work productivity and quality measurements are equally essential in such a highly reliable environment.

In particular, the significance of this study lies in the identification of the interrelated nature of these processes of technological and organizational adaptation in a domain that is known for its high safety and quality standards. Prior studies have noted both types of individual adaptations—direct technological impacts and organizational-level adaptations that aim to minimize these impacts in a more standardized manner. However, to our best knowledge, no study has examined the goals, triggers, process, and relationships between the two levels of adaptation processes systematically in the HIT field, especially the association between the organizational-level adaptations performed by administrators and policy makers, and the technological-level adaptations by individual users. In this study, we report how users' initial responses to new technologies (i.e., technological adaptation) lead to consequent policy, personnel, and rule changes in organizations (i.e., organizational adaptation). More importantly, we find that these organizational adaptations are guided by the unique goals and needs of health organizations that are highly regulated and controlled, which differs from technology adaptation in many other workplaces. Although organizations sometimes modify their policies and physical infrastructure to meet the needs of upcoming technology rollout, we want to note that our study focuses on technology adaptation *after* system implementation. We believe the identification of this dual-phase process of technological and organizational adaptation is crucial for highly reliable domains where work practices have to follow strict standards and quality control criteria, as they do in the healthcare field. Our analysis further points to the critical value and needs of organizational-level adaptations for successful and mindful socio-technical-political system adaptation. By revealing the dynamics between these two interrelated, but coevolving adaptation processes, this study provides a deeper understanding of how technology implementation is handled in organizational settings, and how organizations should respond to increasingly common technological adaptations.

2. RELATED WORK

Technology adaptation has been widely studied in organizational and social behavioral literature. Adaptation is commonly viewed as the process intended to modify new technology or relevant aspects of the operating context, including users' skills or procedures [Tyre and Orlikowski 1994]. Current literature provides multiple ways to conceptualize technology adaptation in organizations. The initial studies in technology adaptation treated technology as an independent factor that did not interact with the social context in which it was situated (e.g., Huber [1990]); later studies began to view technology as part of a complex process where technology and social processes mutually influence each other over time [Grudin and Palen 1997; Barley 1986; Locke and Lowe 2007]. In this latter view, some authors focused on the role of human agency in influencing technology in practices [Orlikowski 2009; Broudreau and Robey 2005]. Recent studies suggest another perspective, where technology is part of a relational ontology where the social and the material are inherently inseparable and must be considered as whole in practices [Latour 2004; Orlikowski and Scott 2008] or a process of imbrication [Leonardi 2011].

In addition to the various perspectives toward adaptations, past literature has also introduced various models that viewed adaptations: a discontinuous pattern after initially intensive adaptation activities [Tyre and Orlikowski 1994]; a sporadic and ongoing process of altering existing conditions and structures of the group/organizational environments [Majchrzak et al. 2000]; a constant fabrication of the system [Locke and Lowe 2007]; a group knowledge sharing activity [Convertino et al. 2007]; a mutual transformation between technology and its environment [Leonard-Barton 1988]; and a routinization process [Goh et al. 2001]. However, even though these prior studies provide different understandings and perspectives on the adaptation process, few researchers have looked at what motivates users to actively adapt to new systems, how individuals' adaptation behaviors might impact practices at the organizational level, and how such impacts are regulated and controlled in organizations. In particular, prior studies have seldom examined high-reliability domains like healthcare organizations, where strict organizational regulations and procedures are mandatory in comparison to user performances that can be initiated at the individual level.

Technological adaptation has been recently studied in the healthcare domain since numerous HIT systems have been introduced and implemented, with hopes of improving efficiency, patient safety, accountability, and billing [Hillestad et al. 2005; Wang 2003]. Many studies have examined technological systems that are deployed in clinical practices, such as EMR systems [Ash et al. 2004; Boulus and Bjorn 2010; Cyert and March 1963; Hersh 1999]; bar code medication administration systems [Koppel et al. 2008; Patterson et al. 2006]; a computerized medication dispensing system [Azad and King 2008]; and a computerized prescription order entry system [Zhou et al. 2011; Niazkhani et al. 2011]. These HIT systems offer many benefits to healthcare practices, including easy access to patient information and better administration of patient medication [Kaptelinin and Nardi 2006]. However, failures or unintended consequences of using these systems have been frequently reported in prior literature. These include prolonged documentation time [Cyert and March 1963; Poissant et al. 2005], increased interruptions [Richardson and Ash 2008], system-induced medical error [Ash et al. 2004; Kobayashi et al. 2005], incompatibility with clinical workflow [Cyert and March 1963; Saleem et al. 2011], and even increased mortality rate [Han et al. 2005].

In medical literature, clinicians' adaptation to a new system is often discussed as workarounds. A "workaround" is a specific type of adaptation that is widely reported in HIT implementation literature (e.g., Koppel et al. [2008] and Novak et al. [2013]). Workarounds are ways of overcoming an impediment or problem brought on by the newly deployed IT system and the efforts initiated by clinicians in making the system easier to use [Azad and King 2008; Zhou et al. 2011]. Many studies have reported the emergence of workarounds after system deployment and their potential negative impacts on the quality of healthcare practices. For instance, when nurses used extra copies of bar codes, instead of scanning patient armband or medications, to work around the inefficiency introduced by the newly deployed bar coded medication administration (BCMA) systems, this might put patient safety at risk because the important safety checks required by the BCMA system could be missing [Halbesleben et al. 2010; Koppel et al. 2008]. Thus, the benefits of these HIT systems may be undermined by the risks associated with these workaround behaviors, resulting in the need to alter the technology, the work process, or management policies related to medication management.

As we have shown before, clinicians' use of workarounds can be problematic from the organizational perspective because adaptation behaviors may vary from person to person, and thus affect the standardized, consistent, and quality-assured work practices health organizations strive to maintain. Different from many other organizations, the goal of health organizations is not only to get work done effectively and efficiently; there are also numerous policies and regulations that dictate how such practices should be performed in order to ensure the quality and safety of patient care [Armijo et al. 2009]. Instrumental to this are organizational and management structures to support the design and implementation of quality improvement initiatives and the creation of mechanisms for the accountability of care [Glickman et al. 2007]. The role of leadership and organizational-level decisions has been emphasized in several studies with regard to the implementation of quality improvement mechanisms in organizations. In a survey of 2,193 community hospitals, Weiner et al. [1997] found that an active involvement of senior administrative leadership, including hospital management and physician representation, promoted quality improvements in the participating hospitals. Lukas et al. [2007] also claimed that an important factor in successful organizational change and adaptation is the concept of "alignment," which maintains, regardless of the deployment of IT systems, consistency in plans, processes, information, resource decisions, actions, results, and analysis to support key organization-wide goals.

The adaptation behaviors described earlier may have helped clinicians get work done with the system in use, but did not always follow the policies and regulations of the health organizations in maintaining the quality of their work practices. From the perspective of the organization, certain adaptation behaviors may even lead to various safety hazards for the patient, inconsistencies in care plans, and poor healthcare outcomes [Koppel et al. 2008; Novak et al. 2013; Niazkhani et al. 2011]. Yet, prior studies on clinical workarounds do not cover the questions of how leadership/institutions cope with the unintended consequences of individually initiated workarounds, and how organizations manage behaviors to standardize and guarantee quality care following the technological adaptation period.

To answer these questions, this study investigates the IT adaptation process of a newly deployed EMR system at both the individual and organizational levels in an emergency care setting. Specifically, this study intends to answer two questions. First, how do individual users and a health institution respond to HIT implementation; and second, how do institutions respond to the unintended consequences of the adaptation behaviors of individual users' adaptation behaviors to meet healthcare practice objectives and requirements.

3. METHOD

This study was carried out in an ED at a large teaching hospital located in Southern California. A large-scale comprehensive EMR system, which was designed by a vendor company and was locally customized at our field site, was deployed in the ED. To examine the user adaptation process, we started our fieldwork in May 2010, about 3 months prior to the EMR deployment. Our study continued for 9 months after the EMR implementation to obtain a comprehensive understanding of the impacts and longitudinal adaptation behaviors in response to the system. This period of time provided us

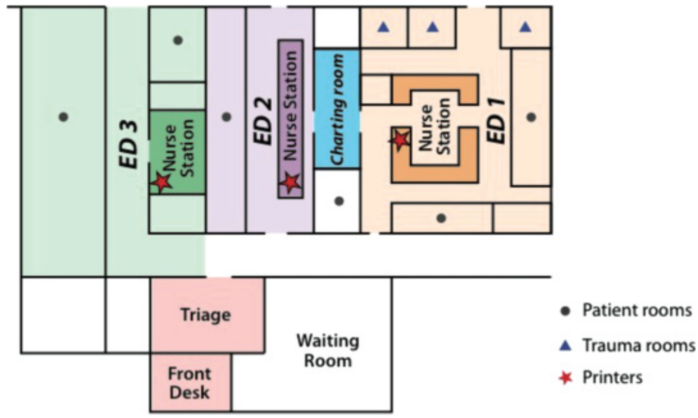

Fig. 1. A map of main ED area.

with a unique opportunity to observe the user adaptation behaviors performed by the individual ED clinicians, as well as the consequent responses at the organizational level. Then, we briefly followed up about 6 months after to just see how things were going at the field site.

Since the EMR deployment, ED clinicians have been using the system to perform their daily work: Doctors use the EMR to generate patient records, such as admission, progress, and discharge notes, and to perform ordering tasks such as labs, medications, or x-rays; triage nurses document their assessment notes in the system; and bedside nurses record their nursing care plans and conduct order-related tasks in the EMR. Other documents, such as patient flow sheets, are still in paper format at present.

3.1. Setting

The primary goal of ED medical practice is to rapidly stabilize patients' medical conditions and decide either to admit or to discharge them. The ED being studied consists of six areas: waiting room, triage, ED1, ED2, ED3, and the doctors' charting room (Figure 1). The waiting room is where arriving patients (except trauma patients) check in at the front desk, then wait to be triaged. In the triage room, nurses perform an initial assessment of a patient's condition and quickly determine its urgency before handing the patient off to a nurse in one of the ED units. The ED units are divided into sections by the severity of patient illness, ranging from ED1 for the most severe illnesses to ED3 for the least severe. In addition, each ED unit has a nursing station where nurses of the unit stay and work during their shift. ED doctors often stop by to talk to nurses, and use the computers and printers at the nursing stations. Lastly, the doctors' charting room is a separate room for doctors to document patient information, enter orders, and discuss patient cases. The charting room is located at the center of the ED, allowing doctors to conveniently walk into different ED units to check on patient conditions.

3.2. Data and Data Collection

We completed a qualitative field study using ethnographic methods. Two researchers, including the first author, conducted field observations and other data collection, such as informal and semistructured interviews with ED clinicians. The goal of these research activities was to gain an in-depth contextual understanding of how ED clinicians carried out their work prior, during, and after the EMR deployment, and how different behaviors and strategies were developed in supporting clinicians' work practices. In

Table I. Data Collection Including Method, Participants, and Time Spent

Data collection methods.				
Role	Data Collection Method	Number of Participants	Data Collection Time (in hours)	
Attending Physicians	Observation Interviews	9 3	40.5 2	
Residents	Observation Interviews	12 5	60 3.3	
Nurses	Observation (Informal interviews included)	23	122.5	
Total data collection time				228.3
Total number of ED staff observed				46

the study, we shadowed clinicians' day-to-day work and followed artifacts and patient flows (e.g., paper charts, and admission and discharge processes) to understand their work practices and workflows from a variety of perspectives. We also observed staff meetings, such as nurses' shift meetings. The study was approved by the hospital's Institutional Review Board (IRB). All the study participants verbally consented following our IRB requirements.

We have conducted a total of 230 hours of field observations over an approximately 1-year period (Table I). Each session ranged from 2 to 7 hours. Observations took place during both day and night shifts, weekdays, and weekends. In particular, we studied 12 residents, 9 attending physicians, 3 charge nurses, 15 registered nurses (including both triage and room nurses), 2 float nurses, 2 front desk clerks, and 1 hospital unit service coordinator. In addition, we have interviewed 8 doctors and 15 nurses to gather clinicians' perceptions and opinions regarding the EMR implementation and other related issues, such as the workarounds, that emerged post EMR deployment. The semistructured interview explored the following three sets of questions:

—*How clinicians perform their work practice (e.g., consultation, documentation, communication, hand-offs) before and after EMR deployment;*
—*How EMR affects the clinicians' workflows and how they deal with changes;*
—*Clinicians' perceived challenges and expectations for system deployment.*

Interviews were recorded and transcribed for analysis. Audio recordings were discarded after transcription and the data were available only to the research team and were kept secure, as instructed by our IRB protocol.

To analyze the observations and interviews, we reviewed all the data collected in the study to understand the ED clinicians' adaptation, with special attention to how these behaviors first emerged, and then evolved over time. Initially, we used various diagramming methods [Beyer and Holtzblatt 1997], including communication diagrams, information flow, and artifacts diagrams, to understand the process of ED work practices from multiple perspectives. We also coded the field notes, including informal interviews and conversations held with participants during the course of fieldwork to obtain insights regarding clinicians' perceptions and motivations pertaining to the adaptation of the EMR-based work practice. These initial analyses helped us map out when and how the EMR system was used at work. Then, we used the open coding approach via the grounded theory approach [Glaser and Strauss 1967] to look for recurring themes regarding the differences in work processes before and after the EMR rollout. In the opening coding method, each of three authors independently and continuously compared each incident, event, quote, and instance gathered during the data collection to look for similarities and differences. Weekly discussions were held to interpret the meanings and themes from the beginning of the study. We made sure the three researchers reached agreement about the findings of the study. Coding categories reflected a variety of behaviors of the study participants and covered both positive and negative views toward the implementations.

After adaptation emerged as the key theme from the initial analysis, we followed a process of comparing the data on clinicians' work practices before and after the EMR rollout. We extracted different types of adaptation behaviors from the data, then reanalyzed them into different categories according to the goal, stakeholders involved, and the timing when these behaviors appeared in the ED. After different adaptation behaviors were identified in the data, we then followed up with each one to trace how it was used by ED clinicians, and how it has been continually used or modified after the initial creation. This analysis revealed another stage of the adaptation process in our field site that was intended for organizational control and quality maintenance (e.g., "violation to patient privacy"). The latter form of the adaptation process was much more nuanced and was identified only after the initial analysis was completed. The longitudinal data collected in this study afforded us a unique opportunity to reveal this intertwined two-stage adaptation process. During the data analysis, we discussed our initial findings with participants through a series of informal conversations to clarify any misconceptions and verify the validity of the themes identified in this study [Klein and Myers 1999].

4. FINDINGS

Although carefully designed and customized, the deployed EMR system was found to lead to many difficulties in clinicians' work practices. These difficulties consequently made clinicians find ways to adapt to the newly deployed system in order to overcome or optimize these challenges. The initial adaptation was to help individual clinicians accomplish their tasks more efficiently by reducing the immediate difficulties encountered with the system in use. However, many of these initial adaptations brought in unintended effects, which posed potential threats to the organizational goal of managing the quality of care. The effects of the initial adaptation thereby led to the development of additional problem-solving efforts at the organizational level. In this section, we describe the adaptation process that individual clinicians and the ED department engaged in through four cases extracted from our field study: (1) managing privacy after ED doctors' personal note use, (2) revised workflow and workload after centralized printer use, (3) information quality control after use of tailored triage questions, and (4) policy and role creation for expediting patient flow. These cases elucidate the typical adaptation behaviors both from the perspective of individual users and from the collective goal of health quality in the ED. We chose these four cases as examples in this article because they cover the two-phased adaptation processes from multiple perspectives, including informational artifacts, workloads, work processes, and work roles. We believe these diverse cases serve as the best scenarios to illustrate the critical needs for having both technological and organizational adaptations in the healthcare domain.

In each case, we will describe the two-phased adaptation process: first, the individual's initial adaptation to the system deployment, and then, the subsequent organizational adaptation intended to address the negative consequences resulted from the individual's response.

4.1. Case 1: Managing Privacy after Personal Note Use

Soon after the EMR implementation, ED doctors started using personal notes to work around the system because the EMR could not support collecting, retaining, and

Fig. 2. Personal note use (carried by doctors).

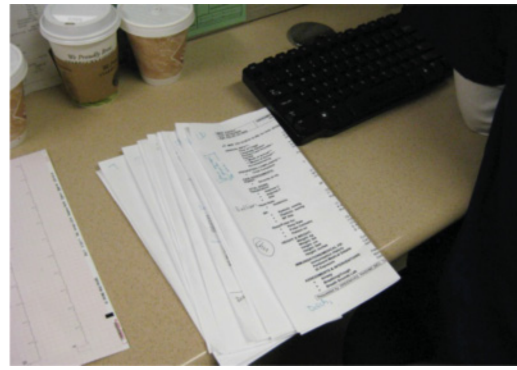

Fig. 3. Personal notes left on the desk from another resident after charting at computer.

transferring information from the patients' bedside to the computer. The initial workaround of paper notes served as a memory aid to overcome the inconvenience brought by the EMR system. With the EMR system in use, ED doctors found the computer system could not support bedside documentation efficiently, as the doctors felt that typing out all the required information in front of patients was too time-consuming, and they preferred to have natural, face-to-face interactions with patients. As a result, doctors had to memorize all relevant information they had gathered at the bedside in order to document it later in the charting room. Memorizing patients' information is particularly challenging when a doctor has to take care of multiple patients at the same time. To make the deployed system fit in their actual workflow, doctors therefore created a workaround to use paper notes as a memory aid (Figure 2). On the personal notes, doctors first jotted down basic information for each patient (e.g., bed number, age, chief complaints, medical history), and then updated these notes to record new procedures and medications. As we observed in the study, ED doctors actively developed different customized strategies in using the personal notes: Some compiled a set of questions to mirror the structure of the formerly used paper charts; others even drew separate tables to organize multiple patients' information to manage multiple patients' situations concurrently. The use of personal notes was an adaptation behavior ED doctors actively engaged in to make their work easier to perform, and to make the deployed system workable.

Despite the benefits of having these personal notes at the ED, this convenient, hybrid paper-electronic documentation introduced new concerns among the ED leaders regarding patients' privacy. Most of the notes contained private patient information, and should have only been accessible to those involved in the patient case. As observed in the study, paper notes were, at first, discarded everywhere after use—piled up on desks in the charting room, left next to computers at nursing stations, and left in scrubs or lab coats previously worn by ED doctors (Figure 3). Sometimes the notes were even brought out of the ED environment accidently. Since there were no rules regarding how to manage the paper notes when the workaround was first developed, paper notes were easily misplaced or left unattended after use.

In order to address the concern of potential privacy breaches, the associate chief medical information officer, who was also an ED attending physician, suggested all ED doctors utilize electronic "triage printouts" as their personal notes. Using triage printouts instead of random paper scraps, allowed doctors to easily recognize and distinguish personal patient notes from other papers, and prevented doctors from taking notes on patients on random paper scraps. Similarly, a “shredder box” located in the charting room was deployed to manage paper notes in a centralized manner.

Doctors were required to discard their notes in the shredder box after use. The collected notes in the secure shredder box were then disposed of centrally by the ED department. After this new internal rule was implemented, the use of triage printouts as personal notes and discarding of them in the shredder box soon became common practices in the ED. Now, all the private information documented in the initial workaround is controlled centrally. This collectively adaptive behavior enacted at the department level enabled the ED to control the distribution of personal notes and protect the patient privacy that may have been at risk by the initial behaviors of the doctors.

This case of personal notes clearly demonstrates the importance of the two-phased adaptation process in the ED. First, to continue working with the newly deployed system, doctors used paper notes as a memory aid for remembering patient care information. This initial adaptation worked around the original system design, and made intensive ED documentation work possible. Nevertheless, this initial workaround soon led to another issue in the workspace—the possible mismanagement of the private patient information in the doctor’s notes. Second, to address the consequence of this workaround, the ED administrator decided to manage, store, and discard the used personal notes through a single, reliable disposal method (the shared shredder box) and through a single physical medium (triage printouts). The latter phase of the adaptation was for the ED to prevent any potential negative impacts resulting from the doctors’ initial adaptation to the new technology.

4.2. Case 2: Revising Workflow and Workload After Using a Centralized Printer

The use of the EMR did not only change the clinicians’ documentation process, it also impacted the ways in which clinicians processed orders. Prior to EMR use, ED doctors could print out transmittals using any computer and any printer. A transmittal is a printed copy of an electronic lab order that must be sent along with each lab sample in order to verify the status of the order. After the transmittals were printed out, doctors would bring printouts to the nurses so that the nurses could administer the orders. Nevertheless, after the EMR deployment, for security reasons, doctors were no longer able to print the transmittals in the old means; the system only allowed doctors to print the transmittals from the computer in which they had initially logged on. Because of this, doctors were not able to print orders out at just any printer. Instead, they had to remember which computer they first logged in on to know where the transmittals would be sent. As a result, many ED doctors constantly complained about not being able to retrieve printed transmittals from the right machines. To fix this problem, the associate chief medical information officer reported the printing problem to the hospital IT department, and the IT team redesigned the printing system to make all transmittals print from a single printer located in ED1 (see Figure 1). This change simplified the previously mentioned issue by allowing doctors to use any computer to print, with the printouts coming only from the ED1 printer.

However, despite the convenience of locating printed orders in the initial adaptation, using the centralized ED1 printer complicated the ED doctors’ workflow significantly because they now had to walk to ED1 to pick up transmittals, a location that was often far away from patient rooms, particularly for ED3 (see Figure 1). Consequently, this change caused many interruptions in the ED doctors’ workflow because doctors had to go over to the printer at ED1 to pick up the transmittals frequently. To overcome this inconvenience, doctors often asked other residents or nurses to pick up printed copies on their way to or from ED1, or waited until three or four orders were printed so that they could pick them up all at once. When doctors were busy, they occasionally even forgot to pick the orders up. During the observation, we saw the printed transmittals pile up on the ED1 printers, leading to the possibility of misplacement or delay in patient care.

To address the possible problems of lost transmittals and delays in patient treatment brought about by this initial adaptation process, ED clinicians later unanimously made a decision to shift the task of printing transmittals from doctors to nurses. It is now the nurses' responsibility to check orders, and print and pick up transmittals after the doctors enter them in the system. Although this new work process seems to give more tasks to nurses, surprisingly, most nurses enjoyed having more control over the ordering process because they were able to execute orders more quickly, instead of waiting for doctors to pass them along. This change in responsibility also allowed doctors to concentrate more on their own work without being interrupted to pick up and send transmittals to the nurses. Doing so also eliminated potential delays in the patient care process. Shifting responsibilities pertaining to the transmittals improved work efficiency for both doctors and nurses and ensured continuity within the patient treatment process.

In the printing of transmittals case, our study revealed that the inflexibility and inconvenience of the initial printing setup forced ED administrators to create a centralized printing system as the initial adaptation in allowing easy printing within the EMR system. Nevertheless, upon discovering that the centralized printing system also distracted doctors from their workflow and caused a delay in the ordering process, ED clinicians then redistributed the transmittal management responsibilities from doctors to nurses. The latter adaptation, notably, does not change the design or configuration of the system, but rather changes the workflow and workload shared between ED nurses and doctors. This adaptation was made at the organizational level, where a norm was developed based on the shared understanding and expectation among clinicians in order to achieve the collective goals of work effectiveness and patient care quality.

4.3. Case 3: Controlling Information Quality and Use of Tailored Triage Questions

Similar to the case with the doctors' electronic documentation practices, the shift to a digital system in the triage room also led to a two-phase adaptation in optimizing the triaging process. The goal of triage is to conduct an initial medical assessment and quickly decide to which ED unit the patient should be admitted. Triage nurses are responsible for gathering necessary information from the patient in order to make a rapid decision about a bed assignment, and filling out the Medical Screening Exam (MSE) form. The MSE form is then shared with ED doctors and bedside nurses. Compared to paper forms, the electronic MSE dramatically increased triage time in the ED. This is because the paper MSE covered only key questions (e.g., medical history, allergies, or medications) that could be completed in 5–7 minutes, whereas the electronic MSE requires at least 10–15 minutes to complete. This detail-driven but more time-consuming documentation resulted in prolonged triage documentation and made the triage a bottleneck of ED patient flow.

To speed up the triage process, nurses developed a workaround through "tailoring" the questions in the electronic MSE form by asking only selected questions they believed to be relevant for a given patient. The use of tailored questions reduced the triage charting time to almost the same as paper charting and helped nurses move onto the next patient quickly. However, despite the shortened triaging time, this initial workaround led to a new problem of information inconsistency and that could jeopardize the quality of patient care, since there was no standard on how questions should be tailored. Sara, charge nurse told us:

"There's no consistency. So, not everybody is always checking all the same boxes. Some people—there are certain things that are supposed to be checked, but not everybody is checking it. Like, they ask you, have you had a recent weight gain or weight loss? And Marla (educator) tells us that's important. But not everybody's clicking those two boxes. And it's a yes or no question. So, there are some inconsistencies, as when people are triaging."

As Sara indicates here, the question-tailoring process was largely done by individual nurses and lacked consistency on how questions should be selected. Nurses could ask different questions based on their own preferences. As our observation showed, when reviewing the MSE during patient consultations at the bedside, ED doctors sometimes found that, for patients with similar illnesses, different information had been collected and sometimes crucial information about a patient's medical history was missing in the notes.

To resolve this issue, the ED clinical educator, who examines clinical requirements for the entire department, redesigned and deployed a new version of the electronic MSE, called Rapid Screen Exam (RSE), to be used in the EMR system. Different from electronic MSE, RSE includes a short list of required questions, such as chief complaints, height and weight, vital signs, medication list, and any medical history related to the current complaint. It also has a flag function that uses exclamation points and asterisks to indicate important questions that cannot be bypassed. If nurses fail to enter an answer for questions marked with exclamation points, the system marks the document as incomplete; and if an important asterisked question is left uncharted, the system will not even let nurses save the form. After the RSE was rolled out, triage nurses could document important baseline questions while maintaining the consistency of all triage questions simultaneously.

Similar to the use of standard personal notes and the use of the shredder box to control the distribution of private patient information, in order to adapt to the EMR-based triage practice, ED clinicians revised their initial workaround and deployed a new protocol, RSE, to maintain the consistency of information collected in the triage process. The latter adaptation was designed to alleviate the potentially negative impacts brought in by the initial workaround adopted by triage nurses. Notably, the ED staff responded to this problem in a more formal manner, by implementing a new electronic triage form in the EMR system. This is because the risks entailed by the question-tailoring behaviors could have serious impacts on the quality of patient care in the ED and could directly affect the collective goal of quality control and improvement in the entire ED.

4.4. Case 4: Creating a New Coordinating Role in the Department

As we described in the previous case, the increased waiting time with electronic triage became a bottleneck in ED patient flow, affecting the overall operation of the entire ED. Since quick patient turnaround is considered critical in ED care, in addition to the shortened triage documentation process, the department made another effort to expedite the patient workflow by deploying a new procedure to send patients directly to beds without triaging.

To solve the problem of the prolonged patient waiting time, a committee including ED faculty, the ED nursing director, and the chief information officer decided to apply a procedure called *pull-to-full* to bypass the triage process. Pull-to-full allowed staff to send patients directly to ED rooms based on a patient's chief complaint as assessed at the front desk of the waiting room—without being triaged. The initial detailed assessment, which was previously conducted by triage nurses, was now performed at the bedside by a regular nurse. The procedure was carried out in the 7 a.m. to 11 a.m. time slot on a trial basis. During this time slot, the triage was closed and two triage nurses working at the front desk quickly interviewed patients and acted as a transporter to bring patients to ED units directly. Most patients were brought to ED3 (which is for the less severely ill patients) unless their case was very urgent or they needed heart-monitoring equipment, for example, for chest pain. Then, the triage nurse briefly reported the patient's situation to a bedside nurse when handing the patient over. For example, when a patient arrived at ED3, guided by a triage nurse, the triage nurse verbally provided a minimum amount of information, such as the chief complaint, and wrote one to two lines on the nursing note. An ED3 nurse then conducted an initial assessment at the bedside—the assessment that would previously have been conducted in triage.

Although the pull-to-full procedure accelerated patient flow by reducing patient waiting time and solved the issue of the overcrowded ED waiting room, it resulted in several consequent issues in patient care. First of all, because the detailed triaging process was skipped, the lack of appropriate patient information often resulted in incorrect decision-making, and patients were often found to have been assigned to the wrong ED unit/bed. For instance, we saw a patient assigned to ED3 because of abdominal pain, but after a more detailed assessment, it turned out to be a psychiatric patient who should have been sent to ED2, which is equipped for patients with psychiatric illness. These erroneous allocations occurred frequently, and patients had to be moved a second time. In addition, the pull-to-full procedure also increased the workload of ED3 nurses because they had to perform triage work on top of their regular duties. This problem was exacerbated when more than two patients came to the ED at the same time. If more than two patients arrived at the same time, and all ED3 nurses were already engaged in triage work, the newly arrived patients could have to wait in their beds for a while before they could be triaged and treated. Consequently, the increased workload for ED3 nurses affected the other care team members' work in the ED. For instance, sometimes when doctors arrived at the bedside, the patient had not yet been seen by a nurse, meaning vitals had not been measured and were not available for the doctor. During our observation, Adam, a resident, expressed his frustration about this new procedure: "*The process can be messed up. Sometimes I go first [before a nurse triaged a patient], and nurses even don't know whether I've been there or not [since the nurses are still busy triaging the previous patients].*" This quote illustrates the consequences of nurses being held up by the triaging work at bedsides; during busier times, the nurses were not able to provide the necessary information (e.g., vital signs) for the subsequent care team members—such as doctors—in a timely manner.

Because the original workaround was found to lead to the previously mentioned issues, consequent adaptation efforts were made by the committee to create a new role called "Triage Care Coordinator (TCC)." The role of the TCC aimed to address the shortcomings of the pull-to-full procedure, and to reestablish the function of triage work in the waiting room. The TCC's job is to increase the efficiency of triage by making quick decisions for incoming patients at the front desk based on their chief complaints. The TCC conducts an expedited triage for patients with only urgent matters (e.g., chest pain patients) by sending them directly to ED1; the other patients continue waiting for their turn and have to go through a conventional triaging process. With the creation of the TCC role, time is saved for all the patients by sending urgent patients directly to the units. It also resolves the issues of potential bed-assigning errors and the work overload of ED3 nurses due to the lack of a triage work process. The creation of this new role reflects the department's appreciation of the importance of triage work's function after the pull-to-full trial period.

To summarize, to respond to the slow patient flow in the ED, the pull-to-full procedure was initially deployed at the ED by sending patients directly to ED units. However, this new procedure has found to lead to many undesirable breakdowns, such as imposing more workload on ED3 nurses, and consequently making the doctors and other nurses' workflows inefficient. Since the initial adaptation highlighted the critical importance of having rapid assessment, particularly obtaining vital signs early on to make the right care decisions for patients before sending them to the bedsides. To resolve the breakdowns from the first adaptation, the ED administrator created a new role, keeping the positive aspect of the pull-to-full procedure while eliminating the detrimental ones. With the consequent adaptation, the ED was able to resolve the issue of the prolonged waiting time, as well as to address the problems encountered by the initial adaptation.

5. DISCUSSION

The EMR system at our field site was designed to serve as an information infrastructure supporting clinical documentation and other work activities. However, we found that the system implementation impacted ED clinicians' work practices, creating challenges in documenting patient charts, printing lab orders (transmittals), and performing triaging work. In handling these challenges, clinicians at our field site engaged in a two-phased adaptation process. First, there were initial, immediate adaptations to make the system fit within the clinicians' working environment. Later, in order to ensure the quality of patient care and work practices, a series of consequent adaptations were deployed to address the potential negative impacts resulting from the initial adaptations. These two adaptation phases are both necessary since getting work done and controlling the quality of work are equally important in healthcare practices where high reliability is crucial.

In this section, we first discuss the distinct nature of the two phases identified through this study. Then we discuss the design needs for organizational adaptation in high-reliability fields such as healthcare. Finally, we conclude with some suggestions for socio-technical-political system adaptations for practices in these domains.

5.1. Making HIT System Work and Making Healthcare Practices Accountable

The four cases described in the article—though with different goals, tasks, and stakeholders—all demonstrated that there is a two-phased adaptation process that first aims to respond to the direct impacts of a newly deployed information system—*technological* (immediate) adaptations, and second, uses organizational control to manage the quality and variability of work practices, leading to *organizational* (consequent) adaptations. Technological adaptation is the prompt response that attempts to *alleviate the immediate problems* introduced by the IT system, such as problems that directly and obviously impact clinicians' workflow and cause breakdowns in their work. Technological adaptations tend to emerge in the early stages of the system adaptation process because it is driven by the use of technology. Organizational adaptation is the consequent response designed by healthcare organizations to alleviate the issues that emerge when solving the immediate problems. In particular, organizational adaptation aims to *control the quality of healthcare practices* in order to have consistent, efficient, and effective care that complies with the unique requirements of healthcare practices (e.g., privacy protection or medical errors).

The main characteristic of technological adaptation is that it tends to be a "quick fix" that makes the system workable and fits into the clinicians' work practices. As we described earlier, initial adaptations are mainly for solving or working around the obstacles, breakdowns, or other problematic situations resulting from the system deployment. As such, technological adaptation arises to address the instantaneous, direct impacts of technological use soon after the EMR enters employees' work practice. Because system use interferes with their original workflow and work routines, clinicians become actively involved in immediate problem-solving activities; they strive to locate the flexibilities of the system design and develop new ways of working with the system. Similar technological adaptations have been reported in prior organizational studies. This includes a focus on the role of human agency in enactments of different technologies in organizations, such as appropriation and improvisation technology in practice enacted by individual workers [Orlikowski 2009], as well as improvised learning and reinvention processes to work around system constraints in unintended ways [Boudreau and Robey 2005]. However, these prior studies were not conducted in the healthcare domain and the adaptation behaviors reported were acceptable in organizations as long as they addressed the initial challenges of system use.

In our study, doctors and nurses developed various adaptive behaviors, also known as workarounds, in the process of solving immediate problems. Soon after system deployment, clinicians tried to negotiate with the system in use and make work possible, meaning if they can adapt or alter the system itself, they do; or if they cannot, they create new tools (e.g., paper notes) or reconfigure the physical work environment (e.g., relocating printers). For example, in the case of the electronic triage charting, triage nurses realized that the lengthy questions being asked in the EMR did not support the goal of fast triage work at the ED (*problem as a direct impact of new system deployment*). As an immediate response, nurses started tailoring the questions on the electronic MSE form in order to shorten the triage process (*making the system workable*). With similar goals, in other cases, clinicians had to utilize paper notes as a workaround to memorize patient care information, or to reconfigure the setup of the printing system to overcome the issues directly introduced by the use of EMR.

Nevertheless, these immediate technological adaptation behaviors, although effective, were soon found to be problematic by the ED leadership, mainly because they were inconsistent with the goals health organizations strive to maintain. Take the personal notes case as an example; the potential privacy infringement introduced by the first phase of adaptation led to the consequent policy on how and where the notes should be discarded. The latter adaptation would not have been developed if there were no pervasive use of personal notes in the ED, and the deployment of the new procedure is regulated by the strict privacy requirements in healthcare organizations. In other words, the organizational adaptation process may not have existed in other domains if privacy was not the foremost requirement in the work. Similarly, when triage nurses tailored and shortened triage questions, the doctors who carry out the next step of patient care started noticing missing or discrete information on the triage note. This issue was reported to the ED clinical educator and she started investigating this information issue because inconsistent information can dreadfully affect patient safety and the care quality of ED work. Likewise, across all four cases, the unintended outcomes induced by immediate adaptation in reaction to new technology interfered with institutional/organizational goals that the healthcare organization strived to maintain, and thus led to the consequent organization-level adaptation process. In our study, these were often identified by personnel who oversee the overall clinical work process but also work closely with individual clinicians, such as the associate chief medical information officer and ED clinical educator.

Thus, the organizational-level adaptations were created and deployed at our field site mainly for the purpose of mitigating the potential hazards introduced by technological adaptations to maintain the quality of practices in a health organization. Our analysis found that organizational adaptations tend to respond to organizational-level impacts of system deployment to make the healthcare practices more accountable and comply with the quality measurements required in the field. Once a technological adaptation is used to quickly fix the direct impacts of the system, it can lead to tensions between the efficiency of work and the strict organizational goals in the healthcare domain because quality assurance may not always align perfectly with the work efficiency. Contrary to fixing immediate breakdowns, the need to control the quality of practices is less visible. Consequently, organizational adaptations often become necessary after the initial technological adaptation with the intent to address the consequences of the initial adaptation only. In our research we found that in response to this need, organizational adaptation is designed as a commonly agreed practice, imposing a new work norm, and affecting work culture and work policy. This consequent adaptation is specifically designed to cater to the unique needs in healthcare practices and management—i.e., care quality, data quality and standardization, and patient safety and privacy in the ED, whereas the immediate adaptation is only to provide an immediate fix to the negative impacts caused by the system.

For instance, in the earlier example of EMR-based triage work, doctors and ED clinical educators recognized that the nurses' work practice of tailoring questions led to a problem concerning inconsistency in patient information, and possibly jeopardized the quality of patient care (tension created by technological adaptation). As a result, to maintain information consistency in triage nurses' use of the electronic MSE as well as shorten the triage charting time, the ED clinical educator had to compare the previous work practice with paper triage notes and the questions the electronic system required nurses to ask. This resulted in a shorter triage question list being developed, while maintaining consistency between the questions asked by each nurse. The RSE, a new version of the electronic MSE, was developed to ensure both care quality and efficient patient flow to fulfill organizational goals. The consequent adaptation could potentially improve the quality of healthcare practices because both work efficiency and patient safety have been improved after the second adaptation. In particular, by making the questions consistent but shorter, the organization ensured that all ED patients were examined in a standardized, but quick manner. Across all cases, organization adaptations serve similar goals, namely, improving and controlling the quality of care after the system is adapted and workable in the ED—for example, the deployment of a shredder box and triage copies for *patient privacy*, the redistribution of labor in printing transmittals for work effectiveness and *patient care quality*, and the creation of a new TCC role for *rapid patient flow* and *reducing medical errors*. Therefore, these consequent, organizational adaptations are devised in a more top-down manner and reflect a concern for homogenizing work processes and performance within the department/institution through the deployment of organizational-level decisions and policies.

In prior literature on organizational learning, technological and organizational adaptations are similarly manifested as "first-order and second-order problem solving" [Tucker and Edmondson 2002; Argyris and Schon 1978; Vogelsmeier et al. 2008]. In particular, Tucker and Edmondson [2002] studied nursing problem-solving behaviors and found that, other than direct problem-solving activities made by frontline health providers, organizational-level interventions, such as training, rewards, and workload balancing, were implemented to leverage individual behaviors. This research suggests a dual individual- and organizational-level model in responding to routine exceptions in healthcare context, where the first-order problem solving is an approach that seeks to remedy only immediate problems by working around them, and the second-order problem solving is an attempt to remove the underlying causes of the problem so that the problem does not reappear. The identification of the second-order solving in meeting quality requirements in healthcare delivery environment is similar to the organizational-level adaptation found in our study. However, this empirical study was based on the responses in exceptions occurring during routine healthcare practices, instead of investigating the impacts and user responses after major work process shifts; in contrast, our case focuses on the implementation of a large-scale HIT system, and provides useful insights for future technology implementations in the healthcare domain.

In addition to the first- and second-order problem-solving behaviors, our work tackles the process of adaptation and how the first-order changes relate to and trigger the second-order changes in a domain requiring high quality standards. We argue that the immediate adaptations arise from the process of *adapting to technology itself*; and the consequent adaptations arise from the subsequent process of *adapting to the healthcare practice* that requires conformity with certain goals and regulations, and the fulfillment of certain needs and objectives. This implies that the development of the adaptation process while using, altering, and adjusting to new technology and work practices is likely to be a lengthier process rather than a quick fix. Nevertheless, the nature of these two distinctive types of adaptations, which exceed the bounds of the computer system itself and encompass protocols, roles, and policies insofar as they interface with organizational impacts, is not always recognized and incorporated into system implementation.

5.2. The Need for Organizational Adaptation in High-Reliability Domains

Although adaptation in general has been frequently studied in prior literature [Ash et al. 2004; Boulus and Bjorn 2010; Cyert and March 1963; Hersh 1999], many studies focused on how users adapt to technologies to make their work possible (e.g., overriding medication alerts [Koppel et al. 2005]). In particular, in the healthcare context where this study was carried out, many prior researchers have revealed and studied the "workaround"—a type of adaptation behavior that creates new ways of using and navigating the system to make it workable. Our study shows that clinicians create various workarounds as ways of adapting to the difficulties and breakdowns imposed by technologies immediately after deployment. In addition to the initial adaptation efforts, the organization has to modify and develop consequent means to collectively manage the initial technological adaptations. We found that the goal of controlling the quality, and consistency of work practices led to the organizational-level adaptations at our field site. Compared with other studies on organizational adaptations, organizational-level adaptations in our study are deeply rooted in the goals of healthcare practices, and can be applied to many highly reliable fields.

Quality control, as a collective goal, is critical to healthcare practices where the goal is not only to get work done, but also to conduct it according to quality control guidelines [Juran et al. 1999; Kepner and Tregoe 1976]. Our empirical study conducted in the ED reveals a *conflict* between two parallel sets of goals in responding to the new technology implementation—the individual caregiver's pursuit of efficiency at work, and the institution's pursuit of quality control. When clinicians improve individual task efficiency using immediate workarounds, this may negatively affect the institution's ability to pursue collective goals and eventually create a need for institutional-level decisions. In contrast, when the department or institution regulates clinical work for the purpose of care quality control, this directly affects the ways individuals perform their work. Hence, the problems in healthcare practice cannot be easily "fixed" in a single step (workaround) or using a single, one-time set of measures to achieve the clinicians goals; the institution's collective goals must also be taken into account for the problems to be truly solved.

As our study shows, technology implementation and adaptation is an ongoing, mutual transformation of the HIT system and the organization. Technological adaptations are initially developed to cope with the direct impact of system deployment. Subsequent organizational adaptations are then implemented to alleviate the problems caused by the immediate response (i.e., initial workaround use). Through this process of reflecting and balancing the needs of both individual caregivers and the caregiving institution's organizational concerns, adaptation by ED clinicians and the department emerges during the time period following the system deployment, and can be seen as a coevolving

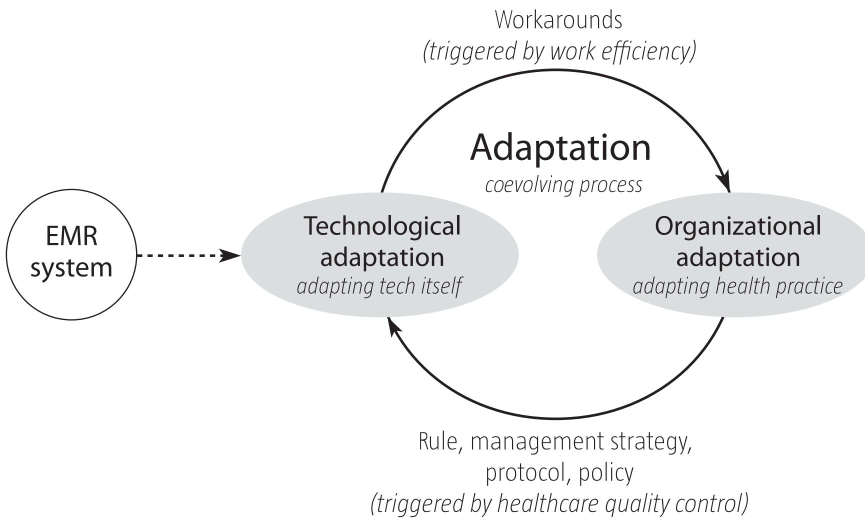

Fig. 4. Technological and organizational adaptation process model.

adaptation process. A coevolving process is a stabilization of efforts between two types of adaptations during the adaptation period; it is a crucial practice that enables both individual clinicians and the collectivity of the caregiving facility to negotiate and harmonize the pursuit of their respective goals when adapting to the new work practice (Figure 4).

In addition, during the coevolving process, it is especially important to examine why these two types of adaptations occur in this particular order. Our study offers insight into this phenomenon insofar as it indicates that clinicians do not necessarily welcome off-the-shelf systems; instead, they need to actively devise ways of incorporating the EMR system effectively into their local workflows by developing different workarounds while they are using the system. However, it is obviously not desirable for clinicians to make unrestricted use of workarounds without regard for institutional goals and regulatory requirements. This is why the two types of adaptations take place in this order—users first need to integrate the system into their work to achieve their work goals, and then require another round of adaptation to ensure that these modified work processes still fulfill organizational goals. This specific order for two adaptation types is relatively distinct in relation to prior adaptation models in organizational studies, such as adaptation as a gradual process of reducing misalignments [Leonard-Barton 1988], a discontinuous process [Tyre and Orlikowski 1994], and as a sporadic and ongoing process of modifying existing structures [Majchrzak et al. 2000]. This is because the second adaptation arises specifically as a result of certain structures, rules, and requirements that are unique to the healthcare work environment. We do not advocate that this particular order—the sequence of technical first and organizational later—be considered a "gold standard" for clinical IT system implementation, nor should it be universally followed and adapted. Instead, we believe that the ongoing coevolving process between technological adaptation at the work-efficiency level and organizational adaptation at the institutional and policy level should be recognized and should inform adaptation processes by clinical IT. Therefore, it is our view that the coevolving process is necessary, as both types of adaptations are required to coexist side by side to meet individual work efficiency and collective organizational standards, which represent essential needs in healthcare practice.

Furthermore, our study points out that the organizational adaptation needs to be addressed from a more collective, policy-driven approach. As described earlier, the organizational adaptation takes place as a consequent response to solve the problems that arise after the immediate response, and is also driven by collective departmental/organizational goals. A number of system implementation studies have examined clinical workarounds and have focused on ways to make HIT systems successful and compatible with healthcare practice. However, healthcare is a unique work setting regulated by many organizational, institutional standards and management norms. These norms and regulations require us to consider concerns beyond the goal of simply making the system work: It is also necessary to make the entire healthcare practice functional and sustainable. Thus, this imposes new requirements and additional instances of adaptation, just as we have seen in the organizational adaptation in the adaptation process of our study. This new insight also ventures beyond the scope of previous literature on workarounds and problem- solving practices. Existing literature in HIT implementation mostly focuses on the first immediate adaptation, such as clinicians' use of problematic workarounds. Therefore, it is very crucial that the consequent organizational-level adaptation is recognized and highlighted in system implementation. Careful internal analysis might be necessary to identify which adaptations (here, organizational adaptation) should be supported, rather than merely eliminating problematic immediate adaptations. This requires policy-driven solutions by diagnosing and addressing workflow problems that may lead to patient risks, ultimately impacting patient safety, rather than merely technical system design changes, to address healthcare practice needs.

In its analysis of the generation of immediate and consequent adaptations, our work highlights the importance of policy-making and the institutional/organizational context, which are not generally considered in the literature on information infrastructure system implementations. In their review of 25 years of Computer-Supported Cooperative Work and Social Computing (CSCW) research in healthcare, Fitzpatrick and Ellingsen [2012] note that only a few studies focus on the "policy" level. As they point out, most studies describe the current situation in the healthcare setting from the perspective of clinical work or organizational work practices, but there has not been much work on analyzing the larger (adaptation) processes related to policy formation and subsequent acquisition after system implementation. Our findings show that in large-scale projects like EMR system implementation, a large project team, managers, administrators, policy makers, and health authorities have a crucial role in shaping technology apprehension and adaptation among users and within the institution itself. The fact that healthcare is a practice that requires a highly regulated and controlled work environment calls for a particularly strong need for appropriate, updated policies pertaining to system implementation and adaptation. In deploying socio-technical-political systems, the system needs to be harmonized with evolving work practices and adapted by its users, but its usage also needs to be aligned (or realigned) with broader institutional and regulatory needs; ultimately, implementation must prioritize these broader organizational needs over small-scale work practice concerns through designing policies with system implementation accordingly.

6. CONCLUSION

In our analysis of the adaptation process of clinicians in an ED after an EMR deployment, we found that adaptation comprises two stages: immediate technological adaptation and consequent organizational adaptation. The technological adaptation is an effort ED clinicians made to adapt to the new system in use. In contrast, the organizational adaptation is a departmental or organizational-level effort to adapt healthcare practice by controlling the quality of information and care *after* the immediate technological adaptation. Although these adaptations differ in many ways, both types are necessary and must coexist, and coevolve throughout the system adaptation period. In particular, our study notes that organizational adaptation is an undervalued, yet critical component in healthcare practice, where highly regulated and standardized work is demanded for both individual workers and the organization as a whole.

Based on the results of this study, we identify implications for healthcare and design practice. Our findings help illuminate the current challenges of EMR use and the dual responsibilities of healthcare professionals in this regard due to the quality control requirements of healthcare practice. In our study, when the EMR was introduced, triage nurses had to find quick and efficient ways to conduct triage work to avoid any patient care delay; meanwhile, their practices were subject to the overall quality requirements imposed by healthcare practices, and in this case, the need for consistent and standard information. These twofold needs required an adaptation period to be carefully designed to offer both benefits. Thus, future system implementations in healthcare or similar high-reliability fields should consider the immediate work practices, as well as the unique requirements demanded by health fields in general. Furthermore, the results from the study are also applicable to other organizations dealing with the introduction of a large-scale information infrastructure into a context of strict work regulations in which system users struggle with competing responsibilities and challenges in using the system.

Notably, our study shows not only technological adaptation occurring via the involvement of individual "frontline" workers; more importantly, we also reveal more subtle organizational adaptations that are often initiated by policy makers, administrators, and decision makers (e.g., clinical educator). This latter organizational adaptation highlights the significance of having policy-level changes in the IT adaptation process.

The findings of the current study suggest that the implementation of HIT systems should contain appropriate administrative management plans to accommodate the issues associated with technological adaptations. Nonetheless, despite the importance of organizational adaptation, most HIT implementation literature has focused on users' responses to technology in the adaptation process, without considering the consequent effects of these adaptive behaviors from the organizational perspective. Only very few HIT studies have mentioned the later stage of adaptation [Novak et al. 2012, 2013; Goorman and Berg 2000] For instance, Novak and her colleagues reported individual as well as organizational-level adaptation. After BCMA implementation, nurses had to integrate a new set of procedures or artifacts, as well as an orientation to medication safety, into everyday work [Novak et al. 2013]. However, as noted by the authors, this research only uncovers minimal organizational adaptations. The authors suggest future research to examine the evolving process of HIT adaptations more systematically. In particular, it calls for investigating "how do adaptations evolve?" and "what classes of adaptations are found following technology implementation?" The findings in our work provide empirical insights into these questions because the contribution of this research lies in the identification of the two types of interrelated adaptations, and discusses how one type of adaptation evolves into the other in a highly reliable work domain. Specifically, we reveal the triggers for, and relationship between the immediate technological adaptations and consequent organizational adaptations in the EMR implementation process. The findings of our study suggest the latter organizational-level adaptation was deeply rooted in the high quality assurance requirements set forth by the health organization. It calls for a careful consideration of an organizational-level adaptation process in similar organization settings. Designing for organizational-/management-level adaptation requires careful reviewing, assessing, and reevaluating the consequences of technological adaptations, and discovering misalignments with the goals of the health organizations. Further, future research may benefit from targeting such adaptation by interviewing the department or institution's decision makers and leaders and discovering in what ways organizational bodies recognize, facilitate, and develop adaptations.

Finally, our study suggests that a mindful adaptation process is required and can improve the adaptation process after the introduction of a new socio-technical infrastructure. Better departmental awareness of the underlying processes of the technological and organizational adaptations will help decision makers take a more objective or positive approach to shifting practices throughout the infrastructure deployment and ensure that they are focused on moving forward, instead of looking back on the failures that occurred after the implementation. Creating a new role—such as an "observer" who detects discrepancies between the system-intended workflow, actual workflow, and the workflow desired for the purpose of preserving care quality, or an "intermediary" who helps resolve the discrepancies between the hypothetical and the actually achievable workflows—may expedite the adaptation process by supplementing and improving individual or departmental responses to breakdowns. Without mindful adaptation considering both adaptation phases, the adaptation will most likely take more time and more effort, and may cause delays and problems; hence, it is crucial for departments and institutions to be aware of both types of adaptations and anticipate their interrelated impacts.

Furthermore, our work offers a stance on workarounds by considering them instances of conscious, positive action. As compared to most previous works, which have seen them as an unintended consequence of system deployment, we see them as an effort driving the inevitable and robust process of adaptation to the new practice—a view that aligns with our previous work and Flanagan's recent work [Park and Chen 2012; Flanagan et al. 2013].

In summary, our work calls for system designers and Human-Computer Interaction (HCI) researchers to consider carefully the value to be derived from both adaptation types—technological and organizational—for the successful deployment of socio-technical-political systems in a healthcare organization. We also call for healthcare organizations to be more critically reflective of their own engagement during the adaptation period through mindful adaptation efforts.

STATEMENT OF PREVIOUS RESEARCH

An earlier draft of this work was published in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2012),* "Park, S. Y. and Chen, Y. (2012). Adaptation as Design: Learning from an EMR Deployment Study. In *Proceedings of CHI 2012,* 2097–2106." However, this article offers a completely different Discussion and Conclusion and ultimately makes a new argument altogether. This new article's Findings section also covers a large amount of new material, comprising about 50% of the section. Therefore, we believe this work provides a substantial amount of new material.

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