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THE ROLE OF WORKAROUNDS DURING AN OPEN-SOURCE ELECTRONIC MEDICAL RECORD SYSTEM IMPLEMENTATION

Research-in-Progress

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Abstract

A significant degree of customization of medical information technology is required to effectively integrate the promise of IT with the diversity and complexity of medical work. In the absence of such customizations, dissatisfaction and resistance toward the system arise. Indeed, the complexity of the medical work and the inability of software to tailor to the diverse medical practices may explain the limited diffusion of health information systems especially in North America. We study the role of workarounds during an open-source Electronic Medical Record System (EMR) implementation at a medium-size urgent care clinic in a major Canadian city. We found that the technology appropriation process involved the evolving of number of non-trivial workarounds in order to match the EMR to medical work. The emergence of workarounds is conceptualized as a knowledge creation and integration process. This perspective allows us to look at the antecedents and the change dynamics of workarounds in the clinic. Furthermore diverging from the negative view toward workarounds, we discuss the importance of incorporating workarounds during and following system development. The workaround perspective shed the light on how users' behavior can be channeled into a constructive development effort. This paper contributes by examining the workaround of medical practitioners using an open-source electronic medical record system as well as offering a knowledge perspective for the study of EMR appropriation.

Keywords: Software Workarounds, Health Information Systems, Information Systems Appropriation, Work practices, Open-Source EMR, Electronic Medical Record, Knowledge Creation, Knowledge Management

Introduction

The early failure of many information systems projects has led the researchers to investigate the causes in order to avoid them in subsequent projects (Hirschheim et al. 1988; Wallace et al. 2004). Despite the breadth of generated research and the prevalence of IT in other fields, we are still observing failures in adopting and implementing medical information systems (Blumenthal et al. 2007). The complexity of the medical work and the inability of software to tailor to the diverse medical practices may explain the limited diffusion of health information systems especially in North America (Blumenthal et al. 2007; DesRoches et al. 2008).

The richness and diversity of medical practices demand high customizations to the medical information system to match users' needs at the implementation site. This customization requirement pressures the already soaring price of the software. In the absence of such customizations, dissatisfaction and resistance toward the system arise. Medical practitioners may also be able to achieve their desired functionalities by working around the system.

In this paper we study the role of workarounds during an open-source Electronic Medical Record System (EMR) implementation at a medium-size family ambulatory clinic in a major Canadian city. We study workarounds to model users' behaviors and actions toward the EMR. The emergence of workarounds is conceptualized as a knowledge creation and integration process. This perspective allows us to look at the antecedents and the change dynamics of workarounds in the clinic. Furthermore diverging from the negative view toward workarounds, we discuss the importance of incorporating workarounds during and following system development. The open-source development model is unique in its emphasis on the participation of users in the development process. The workaround perspective shed the light on how users' behavior can be channeled into a constructive development effort.

Why Implementation of Medical Software is Difficult

The use of technology in healthcare is associated with many advantages such as cutting down healthcare costs and improving the quality of care. It is estimated that, by improving health care efficiency and safety, the widespread adoption of EMR systems in the US can save more than \$81 billion annually (Hillestad et al. 2005). Despite the importance of EMR systems, adoption in North America has been hampered by many issues. Only 4% of physicians in the US reported having a fully functional EMR system and 13% have reported having a basic system (DesRoches et al. 2008). The situation in hospitals is even worse. A recent study reported that only 1.5% of US hospitals have a comprehensive EMR system and only 7.6% have a basic system (Jha et al. 2009).

While cost is identified as the main barrier of adopting an EMR, recent studies looked at other social barriers such as the complexity of the implementation and the incompatibility between the long established traditions of the medical work and the new technology (Safadi et al. 2010). Studying the sociological aspect of medical records, Berg et al. (1997) argue that the implementation of EMRs is not merely a technical problem of designing and implementing the appropriate interface. The medical record is deeply interwoven within the structure of medical work, and different medical record systems represent different notions of how medical work is organized. Similar results are reported by other research. Kaissi et al. (2007) found that the fit between organizational culture—beliefs, values and artifacts—and organizational structure—recurrent patterns of routing interaction and behavior—affected the rate of medication errors when using EMR and drug interaction systems.

The previous results imply that for EMR systems to succeed, they should be highly flexible and allow for customizations and modifications in order to match the particularities of the medical practices in the deploying site. This requirement may not be easily satisfied by commercial systems at reasonable cost. Commercial vendors aim to maximize their revenues and minimize the development cost by offering general software packages—software for the masses. This trade-off between customization and cost is a major issue that inhibits the adoption of medical software. We propose that open-source software may provide a solution to this problem.

Potential of Open-Source Software

The open-source software development movement has gained momentum in the last years and emerged as a serious competitor to the traditional proprietary software development model. Several open-source EMR systems were developed in North America. A comprehensive review of such systems is provided in Faus et al. (2008). The success

of open-source software may translate to the medical field. More specifically, the unique features of open-source software may alleviate some of the obstacles traditionally associated with proprietary systems. Advantages of the open-source solution include: the low cost (no software cost, no licensing cost) of acquisition and maintenance, greater possibility of customization, lower exposure to vendor failure or product termination. On the other hand, several unique disadvantages may hurt the open-source EMR: lack of integration with existing vendor-based hospital systems, a fragmented development effort, a limited number of firms that support installation and training, and a lack of clear software development roadmap.

An open-source EMR differs from typical open-source software in the amount of customization required to make it workable in a specific context. The EMR has to comply with the legal requirements, drug nomenclatures and references, billing systems, integration with state agencies, and local practices. Given the high amount of customization the involvement of users (i.e. medical practitioners) in the development process is crucial for its success. While the recent software engineering literature stresses the importance of feedback in the software development process (Sommerville 2000), it limits the scope of feedback to explicit communication between developers and users of the system.

This paper deviates from previous research in that it looks into the behavior of users as an important feedback resource that may be used to improve the system. We propose that workarounds encode rich knowledge about the needs of the users and the required customizations of the system. This is very relevant in the context of medical software first, because of the complexity of the implementation and the high amount of required customizations, and second because medical practitioners are not tech-savvy to make software modifications themselves and may not have the time to engage with developers in formal communication.

The Relevance and Importance of Workarounds

Computer workarounds are practices that deviate from the standard workflow of the system (Kobayashi et al. 2005). Workarounds are a newly studied phenomenon; therefore there is no consensus on its definition in the literature. One inclusive definition is: "Computer workarounds are a post-implementation phenomenon widespread in organizations. They are commonly defined as non-compliant user behaviors vis-à-vis the intended system design, which may go so far as to bypass the formal systems entirely" (Koopman et al. 2003).

Workarounds are a known but understudied phenomenon in Information Systems (IS). Workarounds appear when users do not comply with the intended and prescribed use of the system after implementation. Instead, they accomplish their tasks with unintended patterns of usage (Azad et al. 2008). In some instances workarounds may try to bypass the whole system at once (Koopman et al. 2003). Workarounds have been studied extensively in the medical field. The premise is that workarounds are undesirable because they imply deviation from standard process which reduces the efficiency of the medical operations (Halbesleben et al. 2010).

Recent studies explored workarounds as a related but separate phenomenon from resistance. Workarounds were suggested as a framework to model the relationship between motivations for diverting from procedures and the resulting activities associated with this divergence (Ferneley et al. 2006). This framework suggests that the concept of resistance is better understood as a two-step process. The first step comprises the emotional reaction toward the system, and the second step is the resulting workaround behavior. Workarounds have been looked into from a social perspective. Studying workarounds in the context of hospital computer system, Azad et al. (2008) focused on understanding the specific roles, temporal configurations and interactions observed in the enactment of workarounds in the hospital. Using a theoretical lens, the study was able to identify repetitive patterns in four practices in the hospital: concurrent approval, habitual emergency, verbal signature and failsafe. This paper diverges from previous studies in that it focuses on the antecedents of workarounds and how workarounds emerge and diffuse in the organization.

Previous research on workarounds focused on the relationship between workarounds and previously established frameworks in IS such as resistance (Ferneley et al. 2006), and situated practices (Azad et al. 2008; Faraj et al. 2006). In addition, it has been argued that workarounds are undesirable because they reduce the efficiency of the system, and therefore increase the cost of medication (Azad et al. 2008; Koppel et al. 2008). In this paper, we focus on workarounds from a knowledge management perspective. More specifically, we study how workarounds arise and how they diffuse in the organization. In contrast to previous IS literature that concentrated on strategies to overcome resistance (Hirschheim et al. 1988), we study how workarounds may be integrated in the implementation process in order to improve the quality of the system.

In the context of EMR implementation, workarounds are informal customizations of the system done by the medical users. Workarounds encode rich knowledge about both the system and the medical practices and about the missing and desired features of the EMR. Workarounds are more pronounced in open-source software because of the initial immaturity of the system and its flexibility and openness. In this sense workarounds present a risk and opportunity. They imply the medical users are unhappy with some aspects of the system, at the same time they encode rich knowledge about these worked-around desired aspects. If this knowledge can be transformed to formal customizations, both the quality of the EMR and the satisfaction of its users increase.

Preliminary Model

Knowledge has been characterized as one of the most important resources in an organization (Barney 2000; Conner et al. 1996; Grant 1996). Knowledge creates capabilities (Kogut et al. 1992), and helps sustain the competitive advantage of the firm (Clemons et al. 1991; Mata et al. 1995). The successful acquisition, coordination and integration of knowledge lead to positive organizational outcomes (Faraj et al. 2000; Jarvenpaa et al. 1997; Sabherwal et al. 2005; Tiwana et al. 2003). Knowledge has been viewed as a duality by many researchers (Hildreth et al. 2002). These conceptualizations include formal and informal knowledge (Conklin 1996), individual and collective knowledge (Rulke et al. 1998), and tacit and explicit knowledge (Nonaka et al. 1995). The duality perspective acknowledges that knowledge has a second component that is less tangible and more implicit. For example, informal knowledge is difficult to represent in traditional sources of knowledge such as books and articles. Collective knowledge spans many sources and is not represented in one place. Tacit knowledge is context specific and difficult to communicate to others.

Workarounds are knowledge about the IS but in the context of work needs. This knowledge was created because of a missing or an inconvenient feature in the system. To capture workarounds, we adopt Nonaka's view that knowledge evolves during the organization lifetime (Nonaka et al. 1995; Von Krogh et al. 2000). This evolution—characterized as Nonaka's spiral of knowledge—follows repetitive phases at different levels. Knowledge can be explicit or tacit. Explicit knowledge is easy to formalize and transfer whereas tacit knowledge is personal, context specific, hard to formalize and difficult to communicate. Knowledge creation is the transformation of tacit knowledge into explicit knowledge. The spiral of knowledge includes the patterns of knowledge transformation from tacit to tacit, from tacit to explicit, from explicit to explicit, and from explicit to tacit. We propose that workarounds evolve in a four stages process. This process is different from Nonaka's in the order and semantics of the phases:

1. Learning phase: in the learning phase users are confronted with the functionalities and features of the system. Learning can take multiple forms ranging from formal training sessions to personal experiencing and learning by trial. The explicit knowledge about the system, presented via the learning experience, is codified into tacit knowledge by the users. Workarounds arise when users' needs are not satisfied or when the users fail to grasp the intended functionalities of the system.
2. Experiencing phase: with more experience and encounters with the system, users' knowledge that was initially created in the learning phase is internalized. Users may discover new opportunities or recapture missed knowledge. They may also become more dissatisfied and unhappy about the system. Perceptions of the system and reactions toward it are enforced in this stage. Workarounds crystallize and become more pronounced.
3. Diffusion phase: in the learning and experiencing phases, workarounds are tacit knowledge held within individuals. In the diffusion phase, this tacit knowledge is codified and diffused to other users through the process of socialization. Workarounds discovered by users have the opportunity of gaining traction and becoming standardized usage patterns of the system if many users share the same dissatisfaction.
4. Feedback phase: the goal of software developers is to satisfy the needs and the requirements of the software users. Seldom is this, however, realized in the first release of the software. Workarounds represent explicit and collective knowledge about users' needs and reactions toward the system. If developers can recognize and tap into this knowledge, a great opportunity to enhance the software may be realized. Workarounds represent, thus, a new and untraditional communication channel of feedback between users and developers.

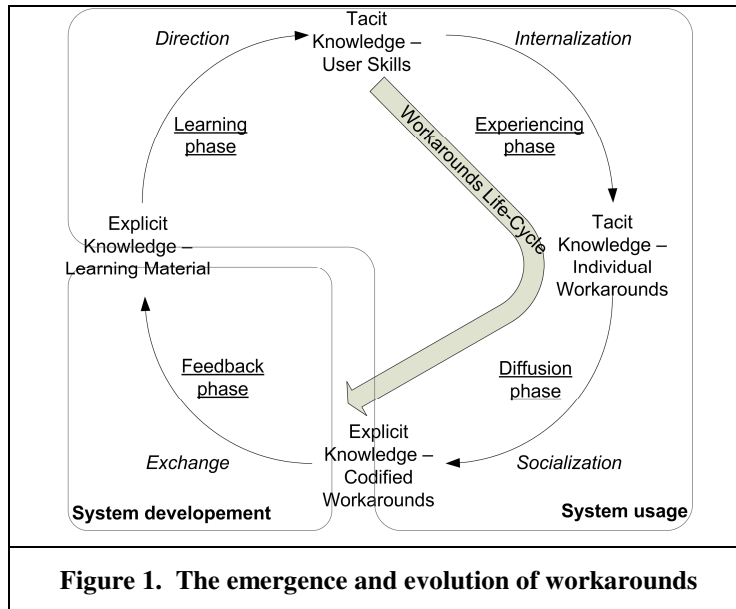


Figure 1. The emergence and evolution of workarounds

Figure 1 depicts the evolution process of workarounds. If the whole process is followed the system can be improved by embedding the workarounds knowledge into its features and functionalities. We suggest that the process incorporates the different mechanisms of knowledge integration as proposed by Sabherwal et al. (2005):

1. **Direction:** in the learning phase the explicit knowledge of developers about the system is transformed to users in the form of a tacit knowledge. Reaction toward the system emerges and may develop into the form of a workaround.
2. **Internalization:** the learned tacit knowledge is internalized in the individual users through the repetitive usage of the system during the experiencing phase. Workarounds as a tacit knowledge are enforced.
3. **Socialization:** individual knowledge about workarounds is combined via the socialization process in the organization. Workarounds are enforced and diffused. The result is a new codified explicit knowledge.
4. **Exchange:** The resulting explicit knowledge about workarounds may be taken into accounts by developers in order to enhance and improve the system. The result is a new version of the system that represents a new explicit knowledge for users to learn.

Can Learning Theories Contribute to the Knowledge Creation Process?

Having adapted Nonaka and Sabherwal models to explore the diffusion of workarounds we postulate that the four-phase process can be viewed with different theoretical lenses. Of a particular interest are learning theories that focus on the role of the actor—i.e. the users—in the knowledge creation process. Learning is happening in the first three phases, the fourth phase also entails learning by the developers. We propose that during the initial phases in the process the Behaviourism and Cognitivism theories (Jordan et al. 2008) may explain well how users initially receive the system via formal training and instruction since the two theories emphasize the role of stimuli in the learning process. In later stages when users experience the system and learn more about it by interaction Constructivism explains better the mean-making and sense-making process that take place when users interact with the system and review their mental models and schemata about its features, capabilities and annoyances.

Case Study

The Site

We are studying the implementation of an open-source EMR system at a medium-size walk-in clinic in a major Canadian city. The clinic is affiliated with the medical center of university and serves approximately 30,000 patients per year. Its staff complement includes 38 physicians, 15 nurses, and 10 clerks. The clinic switched from paper charts to EMR last year. They have been using paper charts for a long time, but decided to switch to an EMR to reap its benefit. The switch is gradual and the two systems are still operating together with some physicians still using the paper charts.

The Technology

Open Source Clinical Application Resource (OSCAR¹) is an open-source EMR developed at the Department of Family Medicine at McMaster University and deployed in multiple clinics in Canada including clinics in British Columbia, Ontario, and Quebec. OSCAR is indeed a suite of medical applications that integrate with each other. The OSCAR system offers a set of integrated applications, including: OSCAR EMR, the focus of this paper; MyOSCAR, a patient controlled personal health record; MyDrugRef, a collaborative resource for prescription medication; OSCAR CAISI; and OSCAR Resource.

The default installation of OSCAR EMR runs on a stack of open-source applications. Linux is the default operating system, although it is possible to install OSCAR on Windows. OSCAR uses two databases: MySQL for patient data and PostgreSQL for drug data (interfacing with DrugRef, a Canadian standard database of drugs). In addition, Apache is the default web server. OSCAR itself is written in Java Enterprise Edition with HTML and JavaScript code which makes it highly portable to different platforms.

OSCAR EMR features a web-based interface that allows multiple users to interface with the system simultaneously through different browsers and platforms. The web interface also allows accessing the system over the Internet through secure connections which is very handy for geographically dispersed organizations. OSCAR also features multiple administrative and clinical functions. Administrative functions include demographic management, appointment scheduling, reports and billing. Clinical function includes electronic charts, drugs and prescriptions, consultation, flow sheets, laboratory and many other features. Besides built-in function, OSCAR allows the rapid development of plug-in medical forms. This features helps users customize the system without much technical knowledge, all what is required is a basic knowledge of HTML. The studied clinic exploited this feature in order to customize many aspects of the system as discussed in the next sections.

In the studied clinic, the decision to adopt the open-source system (OSCAR) stemmed from its reduced initial and maintenance costs. When evaluating the different alternatives, the clinic found that the open-source EMR system will cost fifth of the cost of alternative commercial solutions. In addition, developed by a Canadian university, OSCAR tailors to the particularities of the Canadian healthcare sector.

Methodology

We adopted an observational methodology in this study. We started attending weekly meetings at the clinics since July 2008 when the system was installed. We attended training sessions, interviewed staff, and observed meetings related to the system. We did not have a preferred theoretical lens when we were first engaged in the study; the theoretical perspective emerged during the first year of observations. We also interviewed different stakeholders and key informants from other clinics that were involved in the implementation.

In addition to observation, the first author took an active role in the implementation process and helped in making modifications and customizations to the system. This helped him understand the workflow and the EMR system. It also allowed him to gain legitimate access to the clinic and facilitated access to resources and people for the purpose of the research. Despite this involvement, we would like to emphasize that we have taken a practice perspective. We

¹ www.oscarcanada.org

are not part of the design and decision making process in the clinic. We are studying the implementation process as it unfolds.

Observations

During the observation period we noticed the emergence and diffusion of many workarounds. Not all workarounds reached the diffusion phase. Indeed, most workarounds are still emerging. Due to space limitation we outline in detail one mature workaround that reached the diffusion phase (out of three workarounds). We also summarize and categorize other workarounds in Table 1.

A Workaround for Finding a Drug

1. Learning phase: OSCAR integrates with DrugRef, a Canadian database of drug names and interactions. The database is extensive and OSCAR provides a search interface that helps searching for a drug based on its name. In addition, once the physician prescribes the drug, he can add it to a list of favorite drugs that shows up in the left pane of the E-Chart screen. In one training session, the presenter was explaining the drug-related functionalities of OSCAR and demonstrating the search functionality. Attending physicians pointed out that the database contains a lot of drugs that they are not familiar with. One physician noted: "I am not familiar with all of these drugs. They remind me of the old days of med school. We certainly need a subset of them."
2. Experiencing phase: in a later training session, some physicians started complaining about the drug interface. The drug database does not include commercial names of drugs. Also, commercial brands differ between Canada and the US. The drug database is extensive and upon issuing a query, the search function returns a large list of drugs based on similarity of the name. For example, a search for aspirin may return more than twenty aspirin drugs differing in the form and the dosage. Assigning each prescribed drug as a favorite quickly fills the favorite list. In addition, the favorite list does not allow classifying the drugs or organizing them in a hierarchical fashion. One physician pointed out that he was assigning his favorite drugs to the "test patient", a dummy patient that comes with the initial installation of OSCAR. Assigning the drugs to the test patient allows the doctor to consult them later to copy and paste the drug name.
3. Diffusion phase: Assigning drugs to the test patient proved popular. In order to classify drugs several dummy patient records were created. The "Cardio Patient" is a dummy patient to whom popular cardiovascular diseases are assigned. "Rheumatoid Patient" is another dummy patient to whom arthritis drugs are assigned. The usage of dummy patients spread among many doctors who refined the list of the drugs assigned to those patients and used them and favored them over the default search interface for common drugs.

Problem	Workaround	Category
Adding a disease to a list of favorite diseases is not allowed unless it is diagnosed to a patient	Use the test patient and diagnose him with the desired diseases and then add them to favorites	Clinical
Long sentences in family history disappear on the right side	Use acronyms, short sentences, and line return	Clinical
Diagnosis lists are too long	Type a few letters and then pick up the one you need	Clinical
Some disease are missing from the database	Enter the longhand description in medical history	Clinical
When writing a consult medical history does not go into the consult form	Copy and paste from the chart screen into the consult screen	Administrative
The lab form is too complicated	Use the paper form instead (system avoidance)	Administrative

Lab results do not go automatically from the lab to the system	Scan the labs to PDF and add it to the system	Administrative
It is difficult to enter diabetics information in the global triage form	Much easier to use the diabetic flow sheet instead	Clinical
The tickler feature (for sharing reminders) is promising but confusing	Doctors can still use paging instead (System avoidance)	Administrative

Discussion

Our observations of workarounds in the clinic comply with the theoretical model. However, not all workarounds have evolved at the same speed or followed the same progression. The initial implementation of the system in the clinic induced positive reactions among most of the physicians and the nurses. They actively attended the training sessions and participated toward the discussion about the system. The training sessions communicated the explicit knowledge about the system via direction. Upon using the system on a regular basis, the medical staff started to internalize the knowledge and attained more experience in using the EMR. They also faced difficulties and obstacles in carrying out some clinical tasks. Some physicians were able to work around some of the obstacles. Some of the workarounds spread among other colleagues through the socialization process and transformed into standardized practices of the system.

Our findings around the importance of workarounds in the implementation of an EMR have implications for better understanding the implementation of IS systems in health care. Given the complexity of medical work, the high reliability aspect of medical work, and the importance of coordination practices in health care, IS researchers need to take the health care context seriously (Chiasson et al. 2004; Davidson et al. 2005; Faraj et al. 2006). Not only are workarounds common and usual during the implementation of commercial EMR (Azad et al. 2008), but the issue becomes increasingly salient during the implementation of an open source EMR. Given the heavy reliance of the open source development model on feedback and input from users, user initiated change and workarounds are likely to become a normal and essential part of the IS implementation process. The implication of such an emergent phenomenon, as shown in the preliminary results of our research, would be to make workarounds an essential aspect of health IT implementation.

Conclusions and Future Work

The complexity and inability of health information systems to comply with the long established medical practices is a major cause of frustration among medical workers. Resistance was used exclusively to conceptualize the attitudes and behaviors of users that arise from their frustration with the system. In this paper, we suggested that workarounds may be more suitable to model users' behaviors toward the IS. In contrast to resistance that is a very broad concept, workarounds have a focused and specific definition. They are tangible behaviors that can be captured by observation.

Workarounds encode sophisticated knowledge about the system. Users' formal training, experience, and social interactions are the ingredient of explicit and codified workarounds. We proposed a four phase process model to model the evolution of workarounds in the organization. The first phase captures the initial reactions of users during their learning of the system. The second stage follows during using and experiencing the system. Individual workarounds arise during this stage. The third stage combines the individual workarounds via the socialization process. The result is a standardized and codified workaround that is shared across the organization.

We have validated the first three stages of the model with data gathered during one year observation of a medium size clinic implementing an EMR system. In the medical context, workarounds are undesirable because they imply an inefficient usage of the system (Azad et al. 2008). While we agree about that we also propose that workarounds are a feedback resource that can be tapped into to improve the system: the knowledge encoded in workarounds can be explicitly integrated within the system. This research is still in progress, we have not yet studied the applicability of this feedback opportunity. We propose that workarounds will be more pronounced in open-source software because of the flexibility and active participation of users in the system development. In order to verify this proposition we have to investigate both the users of the software (i.e. the studied clinic) and the developers (i.e. the OSCAR development team at McMaster University).

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