Work Coordination, Workflow, and Workarounds in a Medical Context

Marina Kobayashi, Susan R. Fussell
Human Computer Interaction Institute
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213 USA
{marinak, sfussell}@andrew.cmu.edu

Yan Xiao, F. Jacob Seagull
Human Factors & Technology Research
University of Maryland School of Medicine
Baltimore, MD USA
{yxiao, jseag001}@umaryland.edu

ABSTRACT
In this paper we report an ethnographic study of workarounds—informal temporary practices for handling exceptions to normal workflow—in a hospital environment. Workarounds are a common technique for dealing with the inherent uncertainty of dynamic work environments. Workarounds can help coordinate work, especially under conditions of high time pressure, but they may result in information or work protocols that are unstable, unavailable, or unreliable. We investigated workarounds and their effects through observation and interviews in a major teaching medical center. Our results suggest 4 key features of workarounds that technologies might help address: (a) workarounds differ as a function of people's role; (b) workarounds draw on tacit knowledge of others' abilities and willingness to help; (c) workarounds can have a cascading effect, causing other workarounds down the line; (d) workarounds often rely on principles of fairness and who owes whom a favor. We provide recommendations for designing systems to better support workarounds in dynamic environments.

Author Keywords
Workarounds, problem-solving, breakdowns, modeling, workflow, coordination, social cognition, awareness, transactive memory, computer-supported collaborative work, CSCW

ACM Classification Keywords
H.5.3 Group and Organization Interfaces - *Computer-supported cooperative work, Evaluation/methodology, Synchronous interaction, Theory and models*

INTRODUCTION
Providing safe, timely, assistance to medical patients requires optimal coordination of staff, resources, equipment, schedules, and tasks. In operating room (OR) suites, this is a difficult task because the workload is constantly changing. The arrival of new cases and changes in the criticalness of existing cases often necessitates last-minute juggling of OR and personnel schedules. To cope with the unexpected events that arise in these complex, dynamic conditions, medical personnel formulate *workarounds*—informal temporary practices for handling exceptions to normal workflow. For example, if an emergent case comes in when all the operating rooms are booked, the staff might perform the operation in the Trauma Resuscitation Unit, which is actually an admitting area.

Although workarounds are common in medical settings [e.g., [1], [7]], little research has attempted to characterize properties of workarounds that might influence their effectiveness. By describing short-term benefits of workarounds (providing temporary fixes to potentially life-threatening problems), investigators may overlook longer-term differences in how workarounds impact a medical organization. Successful workarounds can provide organizational solutions for exceptions that recur, thereby reducing the cognitive effort required to deal with each new emergency. Unsuccessful workarounds, however, may lead to widespread instability in an organization. A deeper understanding of what features lead to successful versus unsuccessful workarounds can help us design tools to facilitate the handling of exceptions.

In this paper, we use ethnographic and modeling techniques to identify how and where workarounds occur in a university trauma surgical suite. We first discuss related research on coordination of medical work. We then describe data we collected in a shock trauma center. We use workflow modeling to characterize the dimensions of work coordination activity in a shock trauma center. Based on the workarounds we found in this setting, we propose several design guidelines for new technology to assist medical personnel in their handling of workflow breakdowns.

PREVIOUS RESEARCH
A number of previous investigators have studied how medical workers coordinate their activities in time-critical contexts such as the OR [e.g., [1], [4], [8]]. Several lines of

CHI 2005, April 2–7, 2005, Portland, Oregon, USA.
ACM 1-59593-002-7/05/0004.

research provide insights into the nature of workarounds in medical settings.

First, dynamic artifacts, such as the large whiteboards used to display OR status, have been shown to play an important role in the moment-to-moment coordination of medical work by helping workers keep abreast of ongoing exceptions and problems [e.g., [1], [5], [8]]. However, many key artifacts leave no lasting body of knowledge. As a result, there is a lack of organizational memory for workarounds and their effectiveness.

Second, despite the omnipresence of cognitive artifacts in the OR, much coordination takes place informally, through conversational and observation, rather than through information systems [e.g., [6], [8]]. Charge nurses and anesthesiologists balance the effort required to gather information against the value of accurate information by performing optimal sampling. [[9]]. This suggests that in many cases, workarounds are devised under situations of incomplete information.

Third, there are limitations in how quickly information is distributed across different hospital locations, even when it is formally embedded in information systems [[3]]. Again, this suggests that workarounds may be performed without full access to the pertinent information.

Fourth, problems in the specification of workflow patterns and the extent to which workflows can handle exceptions also have implications for the types of workarounds devised by personnel and the success of these workarounds [[3]]. For example, static assignments of personnel to roles can create problems when extra help is needed in an emergency.

Finally, observational research on nurses' problem-solving strategies indicates that in the majority of cases, they deal only with the immediate problem rather than addressing its source [[7]]. Attempts to alter the system in order to deal with the root cause occur much more rarely. This suggests that medical organizations have problems developing lasting solutions to workflow breakdowns.

CURRENT STUDY

The present study builds on previous work by looking more closely at workarounds and their effects in medical collaboration. We use a combination of observational and interview methods to collect data on hospital workers' coordination activities and use modeling techniques to illustrate the types of workarounds that occur in this setting. Our overall goals are to (a) develop a framework within which we can characterize different types of workarounds and analyze their short- and long-term effects (b) propose new technologies that take advantage of the characteristics of successful workarounds. Although we perform our analysis within the context of medical collaborations, our aim is to create a general framework that will generalize to the study of other large, complex organizations.

METHOD

Research Context

Our research was conducted in a six-room shock trauma center (STC) in which several units coordinate admissions, resuscitations, operations, and recovery. Work in the center is characteristically unpredictable, with fluctuations in load and cases coming in unexpectedly. Personnel frequently encounter situations in which they have little room for error, very little time to react, and insufficient information about how best to provide care. Surgeons, anesthesiologists, technicians, and nurses make frequent use of workarounds to optimize outcomes given these conditions.

Data Collection and Analysis

Our data consists of approximately 120 hours of observations, interviews, and focus group discussion. Observations began at the hand-off time from night to day shift, in order to capture the period of peak coordination activities, and continued for the remainder of the shift. Interviews and focus groups were audio recorded and transcribed. Participants consisted of shock trauma center employees who were performing the targeted roles of charge nurse, charge anesthesiologist, and surgeons in different services (e.g. orthopedics, neurology).

We drew upon user modeling techniques to identify breakdowns and workarounds in the workflow. User modeling provides a "graphical language to capture knowledge about work" and abstracts the context into focused models [[2], p. 84]. Workflow modeling uses symbols that represent the key information flow, repositories, users and roles. For example, a breakdown symbol can represent problems with communication or coordination.

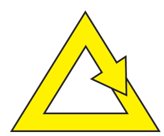

Figure 1. Workaround symbol

Recognizing the mechanism of workarounds and evaluating their reliability and successfulness can be made easier by including them in the modeling process. For this reason, we propose a new representation symbol for workarounds (Figure 1). The explicit modeling of workarounds helps clarify relationships between breakdowns, or potential breakdowns, and the types of solutions people attempt. It also makes the translation from workarounds to institutional practices more straightforward.

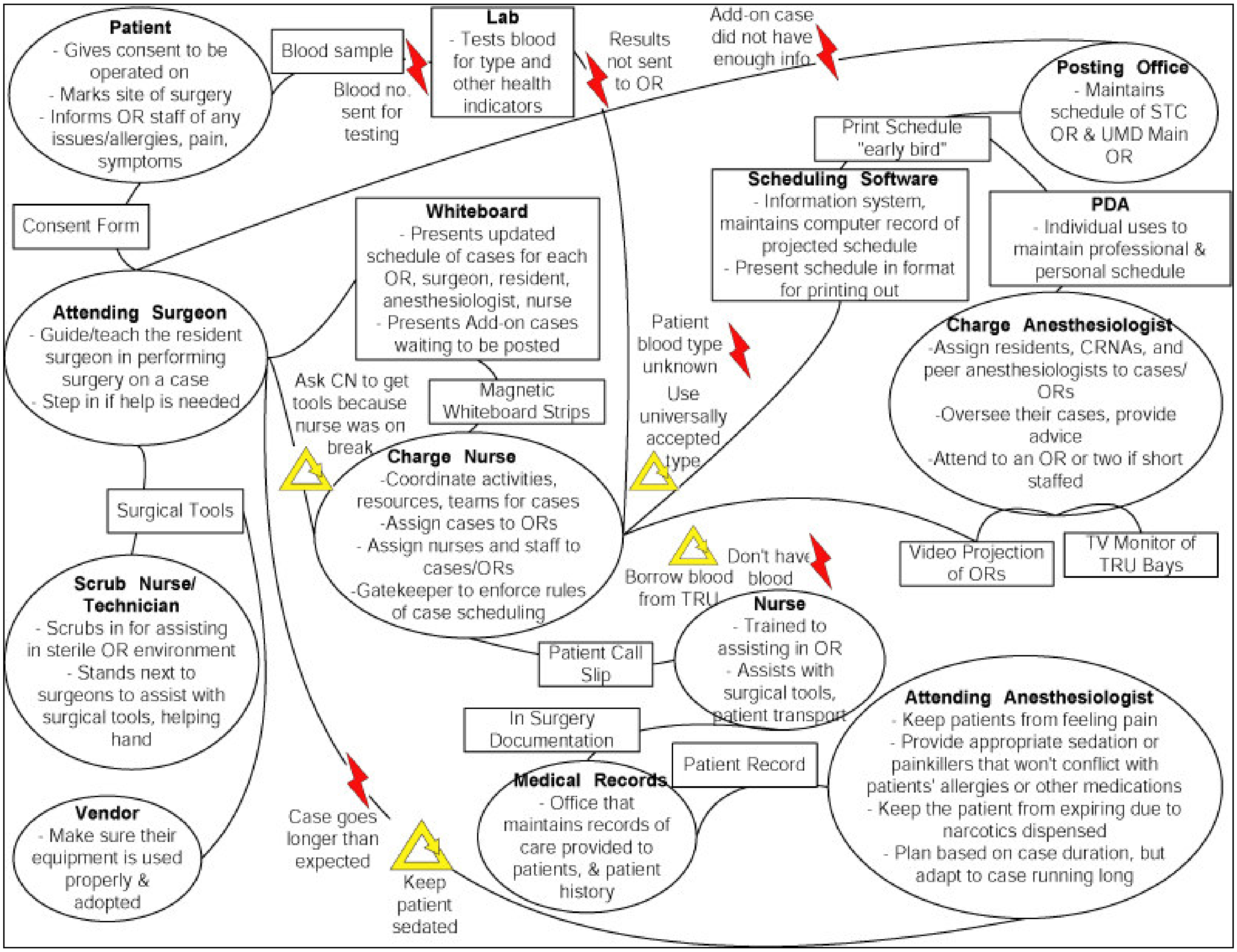

Figure 2. Workflow Model of OR on 3 August 2004. Red thunderbolts represent breakdowns in the system; yellow triangles represent workarounds. (Note: CN-Charge Nurse, CRNA-Certified Registered Nurse Anesthetist)

RESULTS

Figure 2 represents how work was distributed among people, places and things during the observed time period and how participants coordinated to accomplish their collective tasks. Breakdowns in this model represent problems in communication or coordination. Workarounds represent alternative ways to support workflow when events prevent the normal functioning of the system (e.g., obtaining substitutes, borrowing resources). From this model and our analysis of interview transcripts, we identified four key characteristics of workarounds:

Workarounds differ as a function of people's roles

Depending on what role a person is acting in, they may have different goals and priorities. This difference can in turn affect the workarounds they practice. For example, those in managerial roles such as charge nurses can more easily request others' assistance.

Workarounds draw on tacit knowledge of others' abilities and willingness to help

A workaround cannot be effective if the persons involved are not able or willing to perform. Initiators of workarounds take their tacit knowledge of others' skills and abilities into account when deciding how to implement workarounds. As one charge anesthesiologist stated, "[You] just kind of know from experience who your stronger people are, who your weaker people are, who's flexible…".

Workarounds can have a cascading effect

Workarounds can initiate a series of further workarounds before the system is back to a stable state. In one case, for instance, a patient was taken to the OR without blood type information. To deal with this problem, personnel chose to substitute the universal donor blood type O+. However, the success of this workaround depended on a second workaround of borrowing the O+ blood from a neighboring resuscitation area, thereby leaving a potential shortage (and yet another workaround) in that area.

Workarounds often rely on principles of fairness and who owes whom favors

Interviewees reported a sense of memory for workarounds and who was impacted by them. Workarounds were threaded in the sense that people who provide favors were likely to come back later with their own request for a favor. As one charge anesthesiologist stated, "[In any OR management situation] what you really want when you're running the OR is you want everybody to owe you a favor at all times…Ok, now they're the one who has to get bumped. It helps if they can remember last week when you helped them out…and it works the opposite way too, if somebody hurts us they're not going to get the next break."

TECHNOLOGY RECOMMENDATIONS

Based on these general workaround principles we've determined four system requirements for technology to better support workarounds.

Training module. We propose a training module that helps new staff select workarounds and predict their outcomes. The module provides a library of previously used workarounds that indicates what was done by whom, and the outcome. Users are presented with a prioritized list of alternative workarounds.

Memory module. We found that reciprocity of favors was an important principle in creating workarounds. The memory module provides a "score-keeping" mechanism to record persons impacted by each workaround. The module would help remind initiators of workarounds who they can call on for a favor, who can be counted on, and where to find people with particular experience or skills.

Decision-making module. Informed decision-makers make much better decisions than uninformed ones. We propose a decision-making module that allows users to simulate and predict the short and long-term effects of different workarounds. The system could also suggest strategies to best handle repercussions if a workaround is unavoidable.

Awareness module. Finally, we propose an awareness module that provides knowledge of available resources and personnel. An experienced user may already have a general sense of who they can count on or what materials they can substitute for others, but lack of knowledge of the availability of these persons or resources may hinder decisions, or lead to more workarounds later in time.

CONCLUSION AND FUTURE DIRECTIONS

This study investigated workarounds in a trauma center. The most notable findings concern the ways that workarounds are embedded within a wider system: One workaround may lead to the need for others, and a request for a favor puts the requestor in a position of owing others favors in the future. Consequently, technological solutions to help workers cope with unexpected events will need to take into account the historical sequence and organizational embeddedness of workflow exceptions.

In follow up research, we are looking in more depth at workarounds in medical contexts. We focus on the impact of workarounds in short- and long-term coordination of work and on the relationship between a workarounds' effectiveness and its adoption as a standard approach to dealing with certain types of exceptions. We are also developing technology based on our recommendations.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under grant #0325087. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NSF. We thank Mariesa Cash, Joseph Iloreta, Julia Ludwick, Jared Metter, Pablo Quinones, Katie Waite, and Jim Zheng for their help preparing data for analysis, Cheryl Plasters for assisting in collecting data and Tamas Gal for his technical support.

REFERENCES

[1] Bardram, J. E. (2000). Temporal coordination: On time and coordination of collaborative activities at a surgical department. *Proceedings of CSCW 2000*, pp. 157-187. NY: ACM Press.

[2] Beyer, H., & Holtzblatt, K. (1998). *Contextual design: Defining customer-centered systems*. San Diego: Morgan Kaufmann.

[3] Bricon-Souf, N., Renard, J., & Beuscart, R. (1999). Dynamic workflow model for complex activity in intensive care unit. *International Journal of Medical Informatics, 53*, pp.143-150.

[4] Faraj, S. & Xiao, Y. (In Press) Coordination in fast response organizations. *Management Science*.

[5] Nemeth, C. (2003). *The Master Schedule: How cognitive artifacts affect distributed cognition in acute care*. Unpublished doctoral dissertation.

[6] Plasters, C., Seagull, F.J., & Xiao, Y. (2003) Coordination challenges in operating room management: An in-depth field study. *AMIA 2003 Symposium Proceedings,* pp.524-528.

[7] Tucker, A. & Edmondson, A. (2002). Managing routine exceptions: A model of nurse problem solving behavior. *Advances in Health Care Management*, pp.87-113.

[8] Xiao, Y., Seagull, F.J., Faraj, S., & Mackenzie, C.F. (2003). Coordination Practices for Patient Safety: Knowledge, Cultural, and Supporting Artifact Requirements. *Proc. of International Ergonomic Association 2003 (Macroergonomics in Healthcare: Session).*

[9] Xiao, Y., Seagull, F.J., Hu, P., Mackenzie, C.F., de Visser, J., & Wieringa, P. (2003). Distributed Monitoring In a Dynamic Environment: Trade-offs of Information Access and Privacy. *Proc. of 2003 IEEE International. Conference on Systems, Man, and Cybernetics*, pp.1772-1777.