Challenges to Physicians' Use of A Wireless Alert Pager

**Madhu C. Reddy Ph.D.[1], Wanda Pratt Ph.D.[2,3], David W. McDonald Ph.D.[3],
M. Michael Shabot M.D.[4]**

[1] School of Management and Information Systems, University of Missouri, Rolla, USA.
[2] Biomedical and Health Informatics, University of Washington, Seattle, USA.
[3] The Information School, University of Washington, Seattle, USA.
[4] Departments of Surgery and Enterprise Information Systems, Cedars-Sinai Medical Center, Los Angeles, USA.

Abstract

Pagers, personal data assistants (PDAs) and other devices that have wireless connectivity are becoming a popular method for delivering patient related information to medical decision makers. Although medical informatics research has emphasized the design, and implementation of pagers as event notification mechanisms, researchers have not paid as much attention to how this technology impacts medical work. We present a case study of physicians in a Surgical Intensive Care Unit (SICU) using wireless alert pagers.The pagers provide a variety of alphanumeric clinical alert messages and are widely used by SICU physicians. However, the use of the pagers has created unanticipated challenges to the physicians' traditional work practices. These challenges include: (1) flattening of hierarchical workflows, (2) coping with information overload and missing context, and (3) lack of feedback. These challenges are tied to both the specific technical design of the system and the traditional structure of medical work.

Wireless Technology in Hospitals

Wireless technology is becoming a popular method for delivering patient related information quickly to medical decision makers. Mobile devices linked to clinical information systems can provide real-time event notification to health-care workers[1-3]. However, when introducing wireless tools, organizations often underestimate the impact these tools will have on users' work practices. If a new technology confers little benefit and requires major disruptions in current practice, then health-care workers will resist the change. For example, the hierarchical structures of teaching hospitals support useful work practices such as residents and fellows attempting to deal with most patient-care problems before contacting an attending physician. This allows the attending physician to focus on major patient-care issues. The introduction of wireless technology could affect these work practices. A wireless technology can allow the attending physician to learn about a problem at the same time or before a resident or fellow. Although potentially beneficial for patients, such early notification could affect resident's and fellow's work.

Medical informatics researchers are designing and implementing wireless technologies in various clinical settings[4]. These technologies hold the promise of providing users real-time notification of critical patient-care events. Yet, few researchers have investigated the impact of these technologies on the work practices and workflows of their users. We focus on the use of a wireless tool, an alphanumeric alert pager, by physicians working in a Surgical Intensive Care Unit (SICU) of a major teaching hospital. The alert pager supports real-time notification of events including critical lab results, potential medication problems, and critical patient trend information. In this paper, we discuss the challenges that SICU physicians face when using these alert pagers.

Use of Pagers in Hospitals

Pagers have two major roles in a hospital. First, they facilitate communication among staff members. Second, pagers serve as real-time clinical event notification mechanisms for hospital staff. In this role, an individual page notifies a user of a significant event and conveys relevant clinical information.

Pagers are key tools for keeping hospital staff members in touch with each other. In a study of clinical communication, Coiera[5] noted that the pager is a favorite tool of physicians when contacting each other because they can get an immediate response to a page. In related work, Coiera and Tombs[6] described the role of pagers and phones in the communication behavior of physicians and nurses in a general medicine department of a British hospital. They found that the mobility of the staff created communication patterns that resulted in an "interruptive" workplace, which lead to inefficiencies in work practice. They advocated better design of mobile technologies such as pagers to reduce these interruptions.

In addition to providing a communication mechanism for hospital staff, pagers tied to clinical information systems can automatically provide vital patient-related information to the staff. Although they used an early style PDA, Shabot and LoBue[3] were the first to send an alphanumeric text "alert" message directly to physicians from a clinical system, bypassing nurses entirely. Their work showed the viability of using wireless technology to transmit alphanumeric alerts directly to the responsible clinicians. Tate et al.[7]

studied the use of digital pagers to send nurses patient-specific critical lab results from a hospital's clinical information system. Using system logs of alerts and questionnaires, the researchers concluded that without the pager, the nurses were unaware of the critical values the majority (67%) of the time. The pagers played a vital part in ensuring that the nurses were notified of essential patient lab information. Eisenstadt et al.[8,9] discussed the use of pagers as mechanisms to deliver clinical information to health-care workers. The researchers point to the mobility of these workers as major barrier that prevents them from receiving information in a timely manner without the use of wireless technology. They described the implementation and use of two-way alphanumeric pagers connected to a clinical event monitor as a way of dealing with the problem of mobile health-care workers. The pagers were assigned to interns and residents who were later surveyed on their use of the pagers. From the survey responses, the researchers determined that the interns and residents preferred receiving clinical alerts via the pager instead of through e-mail.

Medical informatics research has emphasized the design and implementation of wireless technologies; only a few researchers have paid much attention to investigating how these technologies influence the work practices of their users. For instance, Coiera and Tombs[6] described how the lack of certain technologies (i.e. e-mail) affected the communication patterns in a hospital. Although the research was not conducted in a health-care organization, Orlikowski[10] examined the impact of a technology on users' work practices. She described problems associated with implementing Lotus Notes in a consulting organization. The consultants' work practices of hoarding information did not match the system's information sharing design. Consequently, the system was under-utilized. Her study provides an important lesson for medical informatics researchers by highlighting the consequences of implementing a technology that does not fit users' work practices. If developers want individuals to use medical informatics systems as intended, they must consider the system's influence on the users' work.

Study Methodology

We examined the alert pager use in a SICU of an 840-bed urban teaching hospital. The SICU consists of two 10-bed units each of which has the same technologies, staffing, and physical layout. The Cedars-Sinai Institutional Review Board (IRB) approved this study.

Subjects

We focused primarily on the SICU faculty and house staff because they dealt with the majority of the alerts.

We did not interview the nurses in the unit because they had not recieved these pagers. Subjects who responded positively to an interview request were selected for participation in the study. The subjects included:

- Surgical residents (4)
- Surgical fellows (2)
- Surgical attending physicians (4)

Each subject had been using the wireless pager for at least three months prior to the study.

Methods

We employed qualitative methods utilized in other medical informatics studies of technology use[11] including formal semi-structured interviews and observation. The first author conducted the interviews and observations over a three-month period.

Formal semi-structured interviews – The interviews were used to identify physicians' perceptions of the alert pager. Each of the interviews lasted 30 to 60 minutes. The subjects were asked about their views of the wireless alert pager and its impact on their work. We also interviewed members of the hospital's information systems department to understand the design of the alert system. The interviews were taped and transcribed.

Observations – The observations were conducted as part of a larger study of information seeking behavior of health-care workers in the SICU. The subjects were shadowed during morning rounds over a three-month period. Morning rounds lasted approximately 2.5 hours. During this time, the researcher recorded, as part of the observations, incidents of pager use. These incidents allowed us to witness the effects of pager use on physicians' work practices.

The data was analyzed using grounded theory[12]. Although observation of pager use was limited to the SICU, we believe that this study highlights challenges that many physicians face in using wireless technology.

Alert Pager

The SICU physicians at Cedars-Sinai carry alphanumeric pagers that automatically notify them of certain critical events as soon as the information is entered into the computerized patient record[13, 14]. For example, the Cedars-Sinai alerting system provides critical laboratory alerts. It sends the critical values as an e-mail to the alert pagers carried by the SICU physicians. The pager also provides other types of alerts.

- Critical trend alerts – checks lab values over time to determine if critical trends exist.
- Dynamically adjusted alerts – checks patient physiologic data to ensure that alerts are only triggered when appropriate.

- "Exception condition" alerts – checks for combination of events at one time or over time, or extraordinary single events.
- Medication alerts – checks medication orders against physiologic and lab data for evidence of adverse drug effects.

Pagers are assigned to individual physicians, and each pager has a unique identification number.

SICU Wireless Expectations

SICU physicians closely monitor patient information ranging from lab results to physiological trends. Traditionally, nurses played a significant notification role by informing the physician of changes in the patient results. However, if the SICU is busy, nurses might delay notifying the physician about important patient information. The introduction of the alert pager has provided physicians with automatic, real-time notifications. At the same time, it has freed the nurses from worrying about not being able to give the important information to physicians when the unit is busy. The pager has also ensured that physicians are aware of vital patient information without having to call the lab or ask a nurse.

Most SICU physicians like using wireless technology in their daily work. One SICU physician stated, "In my version of the future, there is going to be a lot more wireless [use] than we had been able to do in the past." Most of the physicians interviewed believed that wireless technology will promote:
- better collaboration
- quicker event notification
- delivery of more accurate information regarding critical events

The physicians use the alert pagers to receive real-time notification of patient-related critical events. This real-time notification provides physicians with novel support for making patient care decisions.

The pager use has changed some physicians' views of how the staff should take care of patients. One attending thought that pagers made the staff more "proactive" instead of "reactive" in patient care. Instead of waiting for nurses to notify them of abnormal results and subsequent problems, the fellows and residents must decide whether the alert requires immediate attention.

Although the pager provided many benefits to the physicians, the house staff and attendings did face challenges in using the pager. In the next section, we discuss three of these challenges.

Three Challenges to Use

The SICU physicians who participated in the study express a generally positive view of the wireless technologies. However, our observations and questions reveal challenges to using the pagers. These challenges point to differences between system use and the institutionalized work processes that are common in a medical setting. These issues are intertwined with each other, the specific use and the work practice of the SICU. We attempt to tease apart the issues and provide insight into designing wireless technologies that account for the work environment.

Challenge 1: Maintaining Hierarchies vs. Lowering Boundaries

Wireless technologies can lower or remove boundaries among levels of a hierarchy. In some cases, lowering boundaries can facilitate collaboration and improve work practice. For example, the hospital has a web-based paging system. Any employee using this website can send an e-mail to the pagers of other hospital staff members, including those up the hierarchy. By lowering the hierarchical barriers, employees can notify the necessary individuals about important problems. However, removing hierarchical boundaries also could have unintended negative consequences.

Traditionally, a nurse notifies a resident when critical results are returned from the lab. The resident either takes corrective action or notifies a fellow. Similarly, the fellow either acts or notifies the attending. Residents and fellows often solve simple problems without bothering the attending physician. Thus, when an attending physician is notified, she knows that the problem is important and needs immediate attention.

In contrast, the alert pagers broadcast the critical lab values to all physicians at the same time. On one hand, this simultaneous notification ensures that the physicians are all aware of the alert. Yet, at the same time, the pagers caused an associated loss of control that moving issues up the hierarchy provided. With simultaneous notification, it is more difficult for residents to fellows to solve a problem before the attending physician learns about it. Residents and fellows no longer "control" the bad news (severely abnormal labs, adverse physiologic events, or medication problems) that they relay to the attending physician. Simultaneous notification also changes the context of the problem for the attending physician. The importance of derived from moving up the hierarchy to the attending physician is lost. One attending stated that he "only wants to be notified when there is a problem." However, the alert pager notified him of incidences that a resident or fellow could easily handle.

Although the main goal of improving patient care may be improved by simultaneously delivering information to all levels of the hierarchy, pager use also affected the role the traditional physician hierarchy played in providing context concerning the importance of clinical events.

Challenge 2: Information Overload and Missing Context

One challenge of wireless technology is to provide appropriate information context without inundating users with too much information or overloading the network.

Physicians are concerned about the number of alerts that they receive from the alert pager. On average, the system produces 16 alerts a day[13]. However, the pagers do not provide a prioritization mechanism for the alerts. Thus, all the alerts look equally important. The number of notifications combined with the lack of prioritization can create information overload. One physician stated that he received too many notifications about results that he considered unimportant. In this respect, the alert pager has reduced the individual's ability to attend to specific notifications by ineffectually differentiating the importance of one notification from another.

The alert pager also provides limited context. The small screen size and bandwidth limits the pager's ability to provide context. Traditionally, a nurse would page a physician and when the physician called back the nurse would tell the physician the problem. If the physician needed additional information, nurses could provide that information. The physician could then make the necessary patient-care decisions. The pager provides patient information but without the heavily contextualized information provided by a nurse. Thus, a physician might still have to contact the nurse to get contextualized information.

The alert pagers have provided physicians with better notification mechanisms than they had in the past, but the pagers do not always provide the context necessary for the physicians to make decisions.

Challenge 3: Missing Feedback Mechanisms

The unidirectional nature of the alert pager prevents the physician from using it to respond to problems. For example, a physician using a pager may notice that a patient's blood pressure trend has been abnormally high. In this situation, the physician might want to order a medication to lower the blood pressure. Because the physician cannot order the medication through the pager, he must call the ICU and verbally order it. An attending physician noted that just viewing the data is half the job because "you also need to have a mechanism to respond to the problem."

Furthermore, when the pager notifies an attending physician of a problem, he wants to ensure that the problem is actively investigated, but at the same time does not want to interfere with the resident's work. For instance, the alert pager will notify the attending physician when a critical lab result occurs, but the pager does not provide notification that a resident has taken action to deal with the problem. Therefore, the attending does not know if anyone has addressed the problem unless he calls and asks the resident. Unfortunately, the resident might interpret such a call as a sign of distrust. One attending physician stated, "as an attending, you don't want to miss anything but you also need to trust the residents." An attending physician has to balance patient care requirements with the autonomy that residents require to learn their skills.

The pager's lack of feedback mechanisms can make it more difficult for attending physicians to maintain this balance. One frequently used solution is for the attending physician to check in the CareVue system for orders or progress notes that indicate the problem has been dealt with. However, this is only a partial solution to the challenge.

Technical and Organizational Design

The alert pager provides SICU physicians with greater access to important patient information. Yet, it also alters the well-established work practices of these physicians. In the previous section, we described three challenges for integrating a wireless system into a physician's work practices. Designers can address some challenges by improving the wireless technology, but other challenges are inherent to the nature of medical work.

One technical advance, the use of two-way pagers, could address some challenges. Two-way pagers can allow physicians to provide feedback via the pager to alerts they have received. For example, when an attending physician receives an alert concerning a patient's critical result, he could send a page directly to the resident treating the patient with advice on how to deal with the problem. Two-way pagers also could maintain the benefits of the hierarchical work structure. Because each pager has a unique ID, the system could designate a physician alert hierarchy. Using the unique pager ID and a two-way pager, the system can send alerts to the residents first and then escalate the alert to the fellow or attending if the resident does not respond within a given time. The introduction of two-way pagers could reduce some disruptions to the physicians' work practices. The Cedars-Sinai technical team is incorporating two-way pagers into the alert system, and has a system in limited use[13].

Technical advances in pager design may also reduce information overload. Newer pagers can be programmed to produce different tones and/or vibrations for different alert messages, based on the contents of each message. A simple alert mark-up language would allow these pagers to differentiate the importance of one notification from another.

However, technically redesigning aspects of the system may not resolve all the challenges. The information-intensive nature of medical work requires interaction between caregivers that pagers cannot re-

place. Pagers replaced some notification duties typically expected of nurses. However, they cannot replace other aspects of the nurse's information providing role. Nurses use their experience to provide important contextualizing information about patients that a pager cannot provide (e.g. interpreting a patient's verbal response to medication). Improving the pager's ability to provide better contextualizing information will still leave large information gaps that require the nurse's input. Although wireless technologies such as personal data assistants (PDAs) and mobile computers[1,2] provide greater access to information than the smaller-screened pagers, they still cannot provide the rich and varied details given to physicians by nurses.

Conclusions

Wireless technologies such as the alert pager are still novel technologies for most hospitals. In our research site, pagers provided physicians and other health-care workers real-time notification of critical events in a way that was impossible less than a decade ago. This real-time notification allows clinicians to improve the quality of care for patients by responding faster to problems. Although, the design and implementation of this technology is important, we must also pay close attention to the impact of the technology on the work practices of health-care providers. For instance, simultaneous paging of multiple caregivers tends to "flatten" the traditional hierarchy of medical information flow, in much the same way that email has flattened communications in large organizations.

This early use study has served to reinforce several important aspects that need to be considered when designing wireless technologies. First, developers must understand the *work* of health-care providers because introducing wireless technologies will affect providers' workflow. Second, because of the collaborative nature of medical work, wireless technologies must support multi-directional interaction between health-care providers. Finally, wireless technologies must carefully balance the information type and volume delivered to users.

Wireless technologies provide tools that enhance the physicians' decision-making capabilities and improve patient care. Although technology can change existing work practices, it is difficult to envision wireless technology rapidly changing the institutionalized nature of medical work. Therefore, as these wireless innovations are being introduced, we must ensure that they support existing clinicians' work activities and needs.

Acknowledgements

References

1. Duncan, R.G. and M.M. Shabot. *Secure remote access to a clinical data repository using a wireless personal digital assistant (PDA).* Proc AMIA Symp, 2000. **155**(2): p. 210-4.
2. Strain, J.J., R.M. Felciano, A. Seiver, R. Acuff, and L. Fagan. *Optimizing physician access to surgical intensive care unit laboratory information through mobile computing.* Proc AMIA Annu Fall Symp, 1996. **47**(3): p. 812-6.
3. Shabot, M.M. and M. LoBue. *Real-time wireless decision support alerts on a Palmtop PDA.* Proc Annu Symp Comput Appl Med Care, 1995. **112**(2): p. 174-7.
4. Ammenwerth, E., A. Buchauer, B. Bludau, and R. Haux. *Mobile information and communication tools in the hospital.* Int J Med Inf, 2000. **57**(1): p. 21-40.
5. Coiera, E. *When conversation is better than computation.* J Am Med Inform Assoc, 2000. **7**(3): p. 277-86.
6. Coiera, E. and V. Tombs. *Communication behaviours in a hospital setting: an observational study.* Bmj, 1998. **316**(7132): p. 673-6.
7. Tate, K.E., R.M. Gardner, and K. Scherting. *Nurses, pagers, and patient-specific criteria: three keys to improved critical value reporting.* Proc Annu Symp Comput Appl Med Care, 1995. **7**(5): p. 164-8.
8. Eisenstadt, S.A., M.M. Wagner, W.R. Hogan, M.C. Pankaskie, F.C. Tsui, and W. Wilbright. *Mobile workers in healthcare and their information needs: are 2-way pagers the answer?* Proc AMIA Symp, 1998. **26**(5-6): p. 135-9.
9. Wagner, M.M., S.A. Eisenstadt, W.R. Hogan, and M.C. Pankaskie. *Preferences of interns and residents for E-mail, paging, or traditional methods for the delivery of different types of clinical information.* Proc AMIA Symp, 1998. **26**(5-6): p. 140-4.
10. Orlikowski, W.J. *Learning from notes: organizational issues in groupware implementation.* in *Proceedings of Computer-Supported Cooperative Work Conference CSCW '92.* 1992. Toronto, Canada; p. 362 - 369.
11. Anderson, J., C. Aydin, and S. Jay, eds. *Evaluating Health Care Information Systems.* 1994, Sage Publications: Thousand Oaks, CA.
12. Strauss, A. and J. Corbin. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques.* 1990, Newbury Park, CA: Sage Publications.
13. Shabot, M.M., M. LoBue, and J. Chen. *Wireless clinical alerts for physiologic, laboratory and medication data.* Proc AMIA Symp, 2000. **355**(1402): p. 789-93.
14. Major, K., M. Shabot, and S. Cunneen. *Wireless Clinical Alerts and Patient Outcomes in the Surgical Intensive Care Unit.* The American Surgeon, 2002. **68**: p. 1057-1060.