Identifying Barriers to the Adoption of New Technology in Rural Hospitals: A Case Report

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Abstract

The purpose of this study is to identify barriers to the adoption of new technology in rural settings. Specifically, this paper focuses on identifying and overcoming barriers to the adoption of a medication error reporting system in eight rural hospitals. Prior research has generally focused on barriers to the adoption of new technology in urban areas, medical centers, or large hospitals. The literature has identified six primary barriers to the adoption of new technology: cost, legality, time, fear, usefulness, and complexity. Although our research recognizes these same barriers, the means through which these barriers may be mitigated are different in rural settings. Our research identified three additional barriers to the adoption of new technology that may be specific to rural areas: personnel, physical space, and Internet access. Our outcome variable, in order to demonstrate our success, is the number of reported medication errors.

Key Words: barriers, technology, medication errors, rural, tracking

Introduction

Barriers to the Adoption of New Technology

As healthcare moves toward the widespread use of technology to meet growing concerns over patient care and safety, the need to create a health information technology (HIT) infrastructure to transport data and to create information-sharing networks between healthcare providers becomes increasingly apparent. In both the Institute of Medicine's (IOM's) report "Crossing the Quality Chasm" and the recent General Accounting Office (GAO) report "Information Technology: Benefits Realized for Selected Healthcare Functions," emphasis was placed on the use of technology to improve patient care and safety.[1, 2] Despite emphasis being placed on the role of technology in addressing our nation's healthcare problems, technology is not being fully utilized. Although it is estimated that $20 billion is spent annually on HIT in the healthcare industry, less than 10 percent of hospitals in the United States have an electronic medical record. Furthermore, it is estimated that only about 19 percent of healthcare providers and 5 percent of clinicians utilize a complete computerized patient record.[1] With the repeated calls for the use of technology in healthcare, there are,

nevertheless, barriers to its adoption. There are six primary barriers to the adoption of technology identified by prior research: cost, legality, time, fear, usefulness, and complexity.[3-15]

Perhaps the most important organizational barrier to the adoption of new technology is cost. For new technology, both start-up costs and maintenance costs can be exorbitant. Moreover, it is often difficult to directly assess the patient and cost benefit savings of new technology on patient care. Consequently, justification of capital expenditure for new technology may be difficult to obtain.[3-5]

In general, legal and regulatory barriers have focused on privacy and security of data transfer, HIPAA, fraud and abuse, intellectual properties, and state licensing laws on adoption of new technology. Many of the problems in the legal and regulatory area concerning the adoption of new technology center on the lack of national standards and role of regulatory agencies.[4, 6-9]

If cost is the most important organizational barrier, time is the most important barrier from the healthcare providers' perspective. In general, time barriers center on acquiring, educating, implementing, using, and testing the efficacy and efficiency of new technology. Healthcare providers, especially those who are in direct patient care, have little if any time to learn about new technology. Before healthcare providers will accept new technology, they must be convinced that the new technology will not increase their workload and time in treating patients but will fit seamlessly into their current workflow.[10-12]

Most healthcare providers are uneasy with change that affects workflow, documentation, and patient care. While technology may have the ability to transform healthcare, unless healthcare providers overcome their fear of change regarding technology, healthcare will continue to lag behind other industries, and the benefits of new technology will never be realized. For example, asking a risk manager to give up paper occurrence reports and use a Web-based electronic health record (EHR) requires a great deal of trust in the new system. Most healthcare providers focus on excellence in patient care; therefore, any technology that will change "tried and true" patterns of care must overcome issues of trust and concern over the well-being of the patient. In order for healthcare providers to accept new technology, the technology must have an observable impact on improving workflow and patient care. All too often clinicians are not informed or do not receive feedback from their use of the technology. Healthcare providers (especially clinicians) need feedback on their personal use of the technology and to see the practical benefits in terms of reduced time, better use of personnel, and improved patient care. Each provider must see the personal utility of the new technology.[13-14]

Similar to fear of change, the literature suggests that a majority of direct care providers perceive technology as being complex, hard to learn, and complicated. As such, it is believed that the new technology will add new time and personnel pressure to their already busy schedules. To overcome this barrier, new technology must seamlessly integrate into workflow processes. While the back end of the new technology may be complex, the user interface must be easy to use and access.[15, 10]

Obviously, as research indicates, technology cannot simply be adopted without sufficient, intentional education in adoption and implementation. But there are differences in the adoption and implementation of technology in urban and rural settings. While this research has provided important insights into the adoption of technology, it has not been sensitive to issues that rural healthcare providers face. For example, rural healthcare providers may not have fully functioning Internet access that may be accessed by all direct care providers. Similarly, urban providers are more likely to specialize in a particular area; whereas, rural direct care providers have competing, disparate responsibilities. For example, large medical centers have an IT department; in rural hospitals, frequently the director of nursing or a pharmacist may be responsible for technology adoption and implementation.

Background: Case Description

In 2004, the Patient Safety Center at the University of Mississippi Medical Center was awarded an AHRQ grant to set up a rural hospital medication error reporting network. Eight rural hospitals including five in the Mississippi Delta and three in east central Mississippi were recruited to participate in the project (See Map). Six of the eight were critical access care hospitals (with fewer than 25 beds). The largest hospital had 69 licensed beds; the smallest had eight beds.

The research objective of this study is to assess the use of our medication error reporting system in rural hospitals. To examine whether or not our medication error reporting system was a success, we compared medication error reporting rates from UMMC to our eight rural hospitals, normalizing for bed size. This comparison is important because we are using the same reporting mechanism and were, therefore, able to assess whether the rural hospitals had adopted this technology as part of their daily workflow. This comparison also allows us to examine rural and urban rates of medication error reporting, and it provides insights into how healthcare professionals in rural areas perceive the role of new technology in enhancing patient care. Of note, here, is our effort to increase medication error reporting. Research from UMMC shows a direct correlation between increased error reporting and decreased adverse events (ADEs) resulting from medication errors. In other words, when medication error reporting decreased, ADEs increased; when medication error reporting increased, ADEs decreased.

To develop our eight-hospital rural network, we targeted two distinct sections of our state from which to recruit our participating hospitals. Five hospitals are located in a region colloquially called "the Delta," a predominantly rural, agrarian region with a high African American population. The other three hospitals are located in east central Mississippi; this area is similarly rural but with a higher Caucasian population, and is less agrarian. The two areas were chosen because of their similarity in rural population parameters and because both lie within the catchment area of UMMC. In selecting these two areas, we have targeted areas of our state with extreme high-density populations of what AHRQ has deemed priority areas and population: rural, low income, minority, women, children, and the elderly.

The hospitals in the Delta include the following: North Sunflower County Hospital, located in Ruleville, with 44 beds and 987 total admissions for 2003; South Sunflower County Hospital, located in Indianola, with 49 beds and 220 admissions in 2003; Tallahatchie General Hospital, located in Charleston, with nine acute care beds and 68 long-term care beds and fewer than 300 admissions in 2003; and Sharkey-Issaquena Community Hospital, located in Rolling Fork, with 19 beds and 10 geriatric/psychiatric beds and 505 admissions in 2003.

The hospitals in east central Mississippi include the following: Laird Hospital, located in Union, Newton County, with 49 beds and 1,748 admissions in 2003; Leake Memorial Hospital, located in Carthage, with 25 beds and 44 long-term care beds and 761 total admissions for 2003; Neshoba County General Hospital, located in Philadelphia, with 82 beds and 368 admissions in 2003.

Methods: Our Experience

In year one, an analysis focusing on technology capacity, physical space, personnel, and current medication error reporting practices was conducted. After collecting data, we developed an educational and implementation strategy. We created customized educational courses that included CE and CME credits focusing on the importance of reporting medication errors and using our Web-based medication error reporting system. Of the 210 direct care providers, 198 attended our educational seminars and received CE or CME credit. (See Figure 1.)

In year two, an interoperable frame relay network using fractional T1 lines and computer hardware and software was installed in each of the eight rural hospitals. In order to reduce downtime and maintenance expense, ClearCube technology, consisting of eight blades and a blade server, was installed at UMMC's Patient Safety Center. I-ports were installed at each of the eight rural hospitals, typically at the nurses' stations; I-ports provide the portal for the users to access the blades at the Patient Safety Center. Where

Internet access was available, icons were placed on user desktops, allowing these computers to connect to the Internet server at UMMC using the HTTPS protocol. Ultimately, we chose to use HTTPS rather than VPN because the implementation of HTTPS was more efficient and less expensive. All T1 lines are connected to UMMC's DS3 lines, which are terminated at the hospital's outside router. (See Appendix 1)

Findings: Successes

The network became fully functional on January 1, 2006. At this time, we began collecting medication error reports from all eight rural hospitals. Data on the number of medication errors reported from the eight rural hospitals and, for comparison purposes, UMMC, between January 1 and May 31, 2006, are provided in Table 1. Data are standardized by number of beds at UMMC in order to make a direct comparison between the eight rural hospitals. Findings from Table 1 show that five of the eight rural hospitals had substantially higher rates of reporting medication errors than UMMC. Of these five hospitals, reporting ranged from 123 percent to 287 percent of UMMCs reported errors over the same period of time. Overall, the network average during the same period of time was 120 percent of UMMCs reported errors.

Identifying Barriers to the Adoption of New Technology

The first and most important organizational barrier to the adoption of new technology is cost, including implementation and maintenance costs. Before we were able to recruit hospitals to be part of our network, we had to assure hospital administrators that there would be no direct costs for implementation and maintenance of this medication error reporting network. Consequently, to overcome this cost barrier in rural settings, our grant paid for the initial implementation and continued maintenance of the technology in these hospitals.

After this initial barrier was overcome, we were able to focus on broader, cultural issues related to the adoption of this new technology. We began by creating a learning organization. Learning organizations are based on the open flow of communication, ideas, and worker empowerment. Our education seminars focused on worker empowerment. During the initial phase, we discussed specific requirements with end users at each hospital in order to customize the procedures and allow users to feel invested in the process. By bringing end users into the decision-making and design processes, we were able to overcome time, fear, usefulness, and complexity barriers. This empowered workers to own the process of electronically reporting medication errors. Furthermore, in doing so, we were able to bring the process into the workflow, thus reducing time and fear. In fact, during one of our educational seminars, a physician who had worked with the system we developed at UMMC noted that "I spend more time here looking for the paper form than I do filling out the report with this new system." By showing end users the practicality of our system as part of daily workflow routine, we gained end user trust.

Part of creating a learning organization is providing immediate feedback and monthly reports on reported medication error outcomes. In order to do this, we created an automated e-mail notification report; details of the report were then immediately faxed to the specific site. On the 15th of each month, each site receives a newsletter and a medication error report that summarizes the reporting behavior and provides a network comparison in order to benchmark progress. Healthcare workers at the eight rural hospitals are able to observe their efforts in comparison to other hospitals in the network.

In addition to the six barriers previously identified in the literature, our research identified three additional barriers to the adoption of new technology that may be specific to rural areas: personnel, physical space, and Internet access. Furthermore, we found that the means through which the six previously recognized barriers may be mitigated are different in rural settings. For example, for rural providers, the previously recognized barrier of cost is closely tied to personnel time—time is money. In other words, we needed to ensure hospital administrators that our reporting system is easy to learn, easy to use, would save time in reporting the medication error, and that we would provide quality assurance reports, thus lessening time demand and responsibilities for the quality assurance director. Therefore, the personnel barrier is

related to previously identified barriers, but it is also a serious, stand-alone barrier in rural healthcare settings.

An additional barrier for rural hospitals relates to space. For most large, urban hospitals, placing a screen and central processing unit (CPU) at a nursing station presents no serious barrier to the adoption of new technology. However, this was an important barrier for all eight hospitals in our rural network. To overcome this barrier, we used ClearCube technology so that we did not have to find space for a CPU; instead, we only needed space for a screen and I-port. This also eliminated service charges, and it centralized maintenance at UMMC. The final barrier specific to rural settings that our research identified was the lack of Internet access for all direct care providers. Initially, we intended to use the Internet as the sole means through which our medication error reporting system could be accessed. However, since not all direct care providers in our rural network had access to the Internet, we used T1 lines and the ClearCube technology to provide access to our medication error reporting system. This provided two ways to access the system, through the Internet where available and through T1 lines and ClearCube technology installed at all eight hospitals in our rural network.

Discussion: Lessons Learned

Our research on rural hospitals' use of a medication reporting system confirmed that there are barriers to the implementation of technology in healthcare. In addition to the six barriers that prior research has identified, we encountered three additional barriers that may be specific to rural healthcare. However, our research also confirmed that technology, when carefully implemented, can improve medication error reporting processes. In fact, our research indicated that no barrier is insurmountable and that working to mitigate these barriers, particularly in rural settings, can vastly improve medication error reporting. In addition to this realization, our experience also taught us several valuable lessons.

First, we learned that—at least in Mississippi—rural hospitals are enthusiastic about participating in technology projects. Before starting this project, we were told by a leading private healthcare agency in our state that we would "be lucky to find eight hospitals to participate," and we were led to believe that, even if we did find eight hospitals, they would not use our system. In fact, 35 hospitals volunteered to participate in our study, and, during the first five months, the eight hospitals that we ultimately included in our network reported substantially more medication errors than UMMC during this time, meaning that they more readily adopted this system. We found that rural administrators and staff are more knowledgeable about the benefits and governmental initiatives to create an interoperable information infrastructure than we initially assumed. Furthermore, to negotiate this relationship with the eight rural hospitals, the UMMC team traveled to these locations, initiating personal contact with administrators and staff, laying the foundation for the trust relationship that has continued to develop.

Second, we learned that setting up the medication error reporting network for our eight rural hospitals required more face-to-face interaction with the end user than we had anticipated. Initially, we thought that we would only conduct a needs analysis and one educational seminar to secure the adoption of this new technology. In point of fact, during the initial implementation, Patient Safety Center staff made a minimum of three additional visits to each of the eight hospitals in our rural network to cultivate a sense of familiarity with the system, inclusion of end users, and trust between UMMC and the staff of the eight rural hospitals.

Third, we learned that technology was not solely responsible for the improvement of medication error reporting. Instead, the care with which technology is implemented, including the considerable time to prepare end users, the inclusion of end users in the establishment of workflow process, and the attention to site-specific concerns strongly impacts the success or failure of the adoption of new technology.

Fourth, the distance between urban and rural sites can be mitigated by technology. In our initial planning for this work, we believed that the value of this work would be the transfer of new information and new ideas in one direction—from the large, urban hospital to the small, rural hospitals. However, once we got

further into the work, we quickly realized that the learning process was recursive and that the beneficial relationship was reciprocal. We learned more about our own error reporting by listening to what was going on in the rural settings, and vice versa. In fact, as we began this project, UMMC was at a similar stage of needs analysis for the adoption of an intra-institutional EHR. The faculty at the Patient Safety Center is involved in the UMMC patient safety and EHR initiatives. This concurrent process of urban and rural needs analysis made it easy to make connections and see both similarities and differences between the two settings. This subtly transformed the UMMC leadership "mind-set" from an inward focus to an outward focus toward the importance of new technology. By achieving its own goals, UMMC could become a stronger leader in the adoption and implementation of a statewide, interoperable HIT infrastructure. Ultimately, by creating this close, reciprocal community of eight rural hospitals and UMMC, the distance between the two settings seemed less significant and the common goals of all participants were reached.

Finally, our experiences taught us that although implementation of technology may be different in rural settings, technology can make measurable improvements in patient safety. As in urban areas, overall, the adoption and implementation of new technology in reporting medication errors has the potential to improve patient safety and patient care in rural areas.

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Appendix 1

In order for data to be safely moved across the Internet, **Hypertext Transfer Protocol over Secure Socket Layer (HTTPS)** is used. HTTPS creates a connection from one computer to another. Both computers work together to create a 128-bit key-based encryption. Only these two computers are able to decipher the encrypted data that flows between them. HTTPS is most commonly used for credit card transactions across the Internet. It is recognizable by "HTTPS://" in front of the web address and the lock symbol in the bottom right corner of the Web page being viewed.

Central Processing Unit (**CPU**) is the brain of the computer system. It contains the processor, the hard drive, memory, video card, and sound card.

ClearCube is a company that developed new technology that allows users to work on a computer without having to be near the actual CPU. This technology has taken on the company's name and is commonly referred to as ClearCube. With this technology, the CPU may be at a central site and remote users have "little black boxes," monitors, mice, and keyboards connected to the I/Port.

I-ports are devices that allow users to access a computer without having to deal with the noise or space confinements of a CPU. The I-port plugs into the network just as any regular computer would, and the monitor, keyboard, and mouse signals are transferred over the network to the actual computer.

T1 lines are lines used to carry data or telephony across a network. They are good because of bandwidth (1.44 Mbps), availability, and distance. These lines can be installed in places that DSL or cable won't go.

DS3 lines are the same as T1 lines but with greater bandwidth (43Mbps).

Frame relay is the protocol that is used to send data across the T1 lines. Frame relay is good because it allows several access points, greatly reducing downtime.

Virtual Private Networking (VPN) is a means of accessing a network from a remote location over the Internet. With VPN, a user can get access over the Internet to resources (printers, files, e-mail, etc.) that are normally not available without being in the office.

Figure 1

Implementation Process for Rural Network Medication Error Reporting

- Met with UMMC Department of Information Services to discuss timelines, procedures, and limitations.
- Ordered equipment and lines from ClearCube, CDW-G, and Bellsouth.
- Sent BCI to each site to install the cabling and set up the routers and switches.
- Visited each site and installed the user equipment.
- Implemented medication error Web page and e-mail response system.
- Visited each site to provide training on the user of the medication error system.

Counties and Facilities in the Rural Network
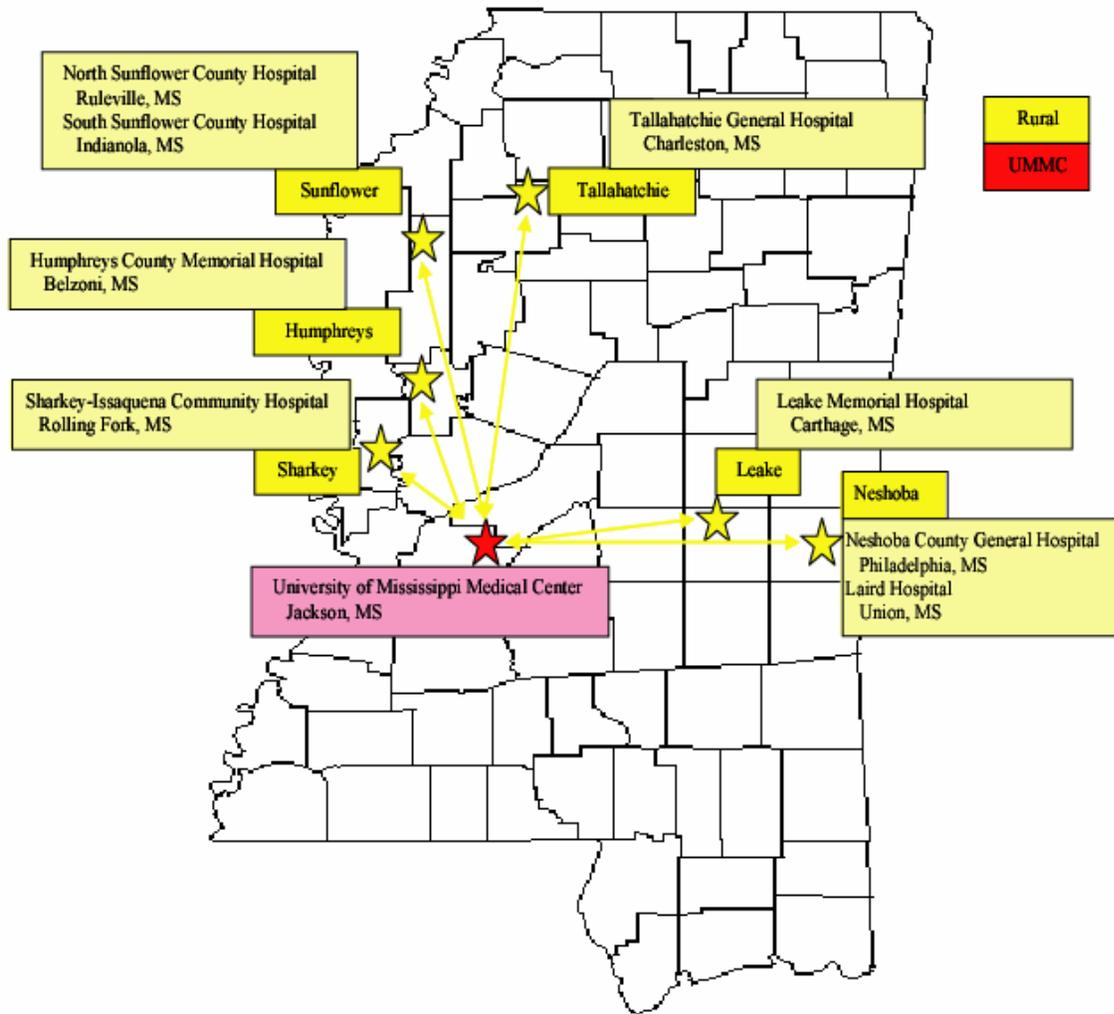
Table 1: Comparison of Number of Reported Medication Errors at UMMC and Rural Sites
January 1, 2006 to May 31, 2006

Facility	Number of Beds	Number of Errors 1/1/06 to 5/31/06	Number of Months	Errors per Month	Size Factor	Errors per Month X Size Factor (projected rate against UMMC)	Comparison by Percentage
A	64 (82 Licensed)	79	5	15.8	710/64 = **11.1**	15.8 X 11.1 = **175.4**	(175.4 / 126.8) X 100 = **138%**
B	25(Census usually 75% to 85%)	64	5	12.8	710/25 = **28.4**	12.8 X 28.4 = **363.5**	(363.5 / 126.8) X 100 = **287%**
C	49 Licensed IP beds - all open	21	5	4.2	710/49 =**14.5**	4.2 X 14.5 = **60.9**	(60.9 / 126.8) X 100 = **48%**
D	10 Acute - 64 LT	11	5	2.2	710/10 = **71.0**	2.2 X 71.0 = **156.2**	(156.2 / 126.8) X 100 = **123%**
E	29 (19 Acute(4 are LT) - 10 Senior Care	18	5	3.6	710/15 = **47.3**	3.6 X 47.3 = **170.3**	(170.3 / 126.8) X 100 = **134%**
F	25	16	5	3.2	710/25 = **28.4**	3.2 X 28.4 = **90.9**	(81.15 / 126.8) X 100 = **64%**
G	25	36	5	7.2	710/25 = **28.4**	7.2 X 28.4 = **204.5**	(204.5 / 126.8) X 100 = **161%**
H	25(Census usually 10-12 / 30%-50%)	10	5	2.0	710/25 = **28.4**	2.0 X 28.4 = **56.8**	(56.8 / 126.8) X 100 = **45%**
University of Mississippi Medical Center	710	634	5	126.8			**100%**

Based on total reported medication errors from January 1, 2006 to May 31, 2006

Methodology:

The number of errors for the period (January 1, 2006 to May 31, 2006) was divided by the number of months (5) to give the number of errors occurring at each site per month.

The number of beds at each rural site was divided into the number of beds at UMMC (710) to give a size factor (how much larger UMMC is than the rural site)

The number of errors per month for each rural site was then multiplied by the size factor to give a projected (normalized) rate for the rural site, if they were as large as UMMC

This projected number of errors was then divided by the monthly number of errors (average) for UMMC (126.8) and multiplied by 100 to give a percentage of errors reported, as compared to UMMC