The Effects of Hands Free Communication Devices: Communication Changes Among Nurses, Nurse Managers, and Information Technology Staff

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ABSTRACT

Background: Hands free communication devices (HFCDs) are an information and communication technology comprised of wearable "badges" and server-based software. The technology is distinguishable by three traits: 1. It utilizes voice-over Internet protocol (VoIP) and wireless local area networks (WLANs), 2. The communication devices are wearable, and 3. The technology possesses voice control capability. HFCDs are increasingly used in clinical care settings, particularly among nursing staff. Quantitative studies and surveys report that clinicians who use HFCDs experience faster communication times but also have concerns about reliability and patient confidentiality.

Methods: The researcher identified and recruited three groups of HFCD stakeholders: staff nurses, nurse managers, and information technology (IT) staff; to participate in a qualitative research project. Twenty-seven subjects from two separate health care organizations participated in semi-structured, recorded interviews and discussed with the researcher what communication effects resulted from the use of HFCDs. The researcher also conducted on-site observations of HFCD use among nurses and clinical staff. Three questions were of central importance: 1. What effect did HFCDs have upon communication among staff? 2. What effect did HFCDs have upon communication in the organization? 3. What unintended consequences, or "surprises," resulted from the use of HFCDs? Interviews were transcribed and coded using a grounded theory approach.

Results: Subjects reported HFCDs helped nurses and nurse managers communicate more efficiently and expediently than telephones, pagers, or overhead pages. Nurses and nurse

managers also felt HFCDs enabled them to find help from one another faster than with previously used communication technologies. Subjects, particularly staff nurses, described the use of HFCDs required them to alter certain functions of their work and forced them to adjust to increased interruptions and develop methods for "controlling" HFCDs. In addition, nurses and nurse managers described the importance of developing communication etiquette. IT subjects described gaining better understanding of clinical work whereas staff nurses and nurse managers described only limited gains in understanding the work of IT staff. Other identified themes were *training* and the *environment and infrastructure.*

Conclusion: Subjects reported HFCDs having positive impact upon workflow and helping staff achieve improved communication as well as improved patient care. The use of HFCDs resulted in changes in nursing tasks that required staff nurses and nurse managers to learn how to effectively use the technology. The implementation of HFCDs brought about organizational change in the ways clinicians and IT communicate within and across teams. In summary, HFCDs positively impact clinical and organizational communication but policies and procedures that support HFCDs are essential to success.

1.0 Background

Hands free communication devices (HFCDs) are distinguishable by three product traits: 1) The devices along with their software provide wireless verbal communication among health care staff by utilizing Voice-over Internet Protocol (VoIP) connected to a Wireless Local Area Network (WLAN), 2) each device weighs less than two ounces and is wearable by either clipping it to a lapel or a front pocket, or by hanging it around one's neck using a lanyard (see Figure 1). The result is that users' hands are free while they communicate using the wearable device, also known as a "badge," and 3) The HFCDs, in conjunction with the server software, provide basic voice control functions that, for example, enable users to pick up incoming calls or dictate call-handling instructions. The hands free communication devices (HFCDs) referred to throughout this paper were developed by Vocera Communications, Incorporated. The HFCDs and their accompanying software are a unique technology and are being used in approximately three hundred health care settings in the United States and Canada. [3] HFCDs are currently being implemented to improve the ways that clinicians, particularly nurses, communicate with one another in the clinical setting.

Figure 1. Promotional image of nurse wearing a Vocera badge. [4]

This thesis will first provide readers with background information about clinical communication, communication theory, computer-supported cooperative work theory, and organizational theory. In addition, it will describe Voice-over Internet Protocol (VoIP) standards and a basic technical overview of HFCDs. Second, the paper will discuss the methods that were used to collect data and the results that were produced using those methods. Third, a discussion section will compare how the results compare with previous research. Fourth, the researcher will suggest recommendations for the organizations that currently use HFCDs and also suggest future research. Lastly, the paper will end with a conclusion.

1.1 POOR COMMUNICATION LEADS TO POOR PATIENT OUTCOMES

> *Direct support of the communication between clinicians should substantially improve how our organizations acquire, present, and use information.*
>
> -Enrico Coiera
>
> *When Conversation is Better than Computation (2000)*

Results from 1995's Quality of Australian Health Care Study revealed that poor communication is a significant factor in the occurrence of adverse events. [5] Researchers in that study screened over 14,000 medical records and scored each case, on a scale from 1 – 6, using the criteria that mistakes in care management had led to adverse effects. They concluded that out of 14,210 cases, 2353 (16.6%) were associated with adverse events. Of those adverse events, 13.7% of cases resulted in permanent disability and 4.9% resulted in death. When asked to identify areas for improvement in preventing these adverse effects, the reviewers noted that improved communication would have helped prevent 11% of the cases with adverse events.

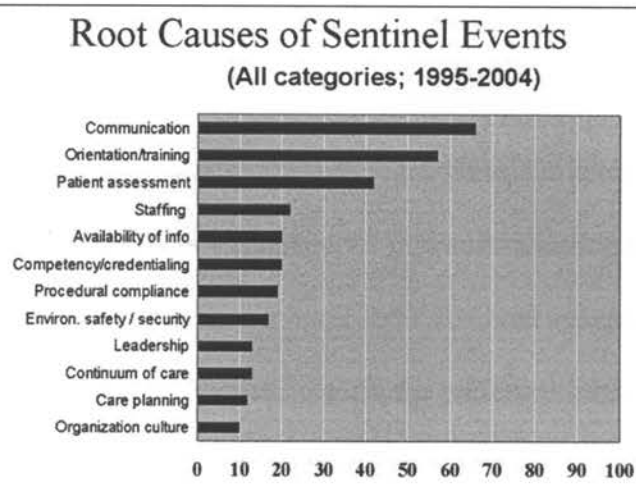
Sentinel events are unexpected occurrences in the delivery of health care that lead to serious injury or death. [6] JCAHO, a health care quality organization that gathers

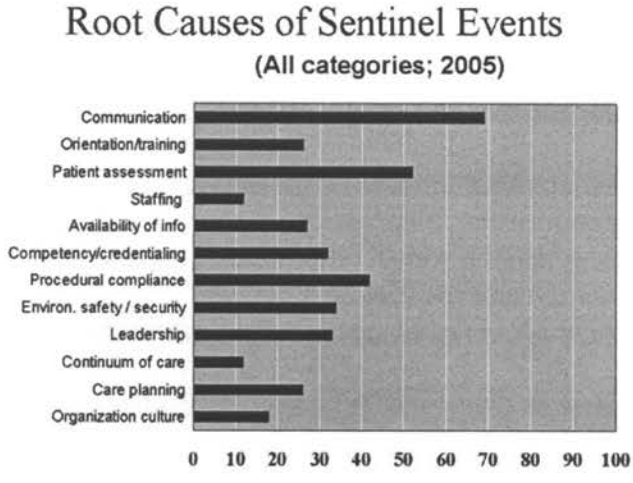
statistics from mostly self-reporting hospitals, complainants, and surveys, lists "poor communication" as the "root cause" in 70% of sentinel events. Poor communication has been the leading cause of sentinel events since 1995 (see Figures 2 and 3). [7] Subsequent publications have focused upon improved communication as an area in need of urgent attention. In the Institute of Medicine's landmark publication, *To Err is Human*, the authors estimated as many as 98,000 Americans a year die from medical errors in U.S hospitals. To address this, a recommendation made by the IOM was to improve the "human-system interface" by designing "better systems and processes," including, "improving communication and coordination within teams." [8]

The problem was deemed so urgent that JCAHO issued a sentinel alert event to health care organizations in 2002. JCAHO's Executive Director for Strategic Initiatives stated at that time, "'[i]f there were one aspect of health care delivery an organization could work on that would have the greatest impact on patient safety, it would be improving the effectiveness of communication on all levels – written, oral, electronic.'" [9]

To address the issue of communication errors, JCAHO has issued requirements as recently as 2006. Requirement 2E calls upon organizations to "improve the effectiveness of communication among caregivers" and to:

- Implement processes and procedures designed to improve the timeliness, completeness, and accuracy of staff-to-staff communication, including communication with and between resident and attending physicians.
- Implement face-to-face interdisciplinary change-of-shift debriefings.
- Take steps to reduce reliance on verbal orders and require a procedure of "read back" or verification when verbal orders are necessary. [10]





Figures 2 and 3. JCAHO Root Causes of Sentinel Events. [11]

1.2 CLINICIAN PATTERNS OF COMMUNICATION-BASED INFORMATION SEEKING

Coiera and Tombs's study of clinical communication in a teaching hospital revealed that clinicians were highly reliant on synchronous communication, that is, conversations that took place between people at the same time. [12] Clinicians were also highly mobile and therefore had trouble contacting one another in order to have those synchronous communications. This led to inefficiencies, as clinicians could not get their questions adequately answered or addressed. Clinicians dealt with tasks as they arose,

and before clinicians could check a task off their list, they needed to communicate that completion and required immediate receipt of that communication.

In a separate study, Coiera et al. shadowed nurses and doctors in an emergency department and found that subjects were engaged in communication events for 80% of their time. [13] Of their communication events, 89% involved synchronous communication. Of that, conversation was clearly the preferred method as clinicians spoke face-to-face 82% of the time compared to more "formal" resources such as computer information systems or medical literature.

From these and other studies, Coiera has argued that information systems within clinical settings must adequately support verbal communication, as it is the preferred channel for information exchange. Furthermore, having a better understanding of clinician communication behavior, Coiera argues, "should lead to substantial improvements in organizational efficiency and effectiveness as well as offering a genuine opportunity to improve patient care." [14]

The use of verbal communication plays a key role in the practice and delivery of health care. Conversation is used for disseminating directives, information, and knowledge. Conversation plays an integral role in decision making and problem solving, as well as reacting to the clinical environment, [15] and even reinforcing organizational culture. [16] It is so highly ingrained in the process of care delivery that when new technologies and sources of information are made available, clinicians continue to rely upon conversation.

Covell et al. tracked information needs within office practices and discovered the reliance that physicians have upon verbal communication. [17] Despite the availability of

print resources within the office, the authors discovered that physicians most often turned to other physicians and health professionals. Safran et al. reported that after the implementation of "knowledge-based medical records...face-to-face communication [was] still the predominant method for exchange of information between clinicians." [18] Tang et al. shadowed clinicians to investigate "information activities" and concluded that a "mechanism to communicate in a timely and efficient manner among health care team members" [19] was needed. Gorman and Helfand found that when information seeking, clinicians sought each other out for information 40% of the time. [20]

Reddy et al. observed a SICU patient-care team made up of residents, fellows, and nurses. [21] The researchers reported that patient care team members most often turned to one another for information. In addition, Reddy et al. were impressed by the number of "organizational questions" they observed. About 30% were questions that ranged from "policies and procedures to interdepartmental information." The researchers noted that without having answers to these organizational questions, the clinical team "would have difficulty providing appropriate care."

In nursing, Riley notes the critical function that verbal communication plays in establishing relationships with patients and coworkers. [22] Riley emphasizes the need to be able to encode and decode messages, use communication to develop trust, and use communication to convey empathy, humor, genuineness, and more. These are qualities not often ascribed to information systems. Apker et al. argues that the future of professional nursing relies upon "collaboration, credibility, compassion, and coordination," [16] highlighting that, "specific communicative behaviors associated with each skill set...exemplify nurse professionalism to members of health care teams." [16]

This is crucial as they view nurses as "central figures in team communication," and they, "build interdependence and engage in joint decision making." [16]

1.3 CLINICIAN PREFERENCE FOR RICH COMMUNICATION CHANNELS

The preference for synchronous communications can be explained by the desire for information rich channels of information exchange. [2] Face-to-face conversations and telephone communications are richer channels in that they allow immediate feedback. Immediate feedback lessens the chances for misunderstandings due to ambiguity. Conversely, a memo or a flyer uses a "lean information channel". While it may have the advantages of being posted or broadly distributed, the disadvantage is not providing people with immediate feedback.

Device	Strengths	Weaknesses
Pager [23, 24]	• Send alerts • Text messaging • Wireless	• No prioritization • Minimal context • Limited feedback • Delivery delays
Cell Phone [25, 26]	• Text messaging • Wireless • Synchronous or asynchronous	• Interference with medical devices • Bulky • Synchronous communication interrupts
Telephone [27]	• Familiarity • Synchronous and asynchronous	• Stationary • Synchronous communication interrupts • Travel distance to phone
Overhead page [28]	• Situational awareness	• Undifferentiated • Environmental noise
Planning board [12, 29]	• Temporal overview • One-many and many-many communication • Easy to manipulate	• Requires traveling to the board • May lack updated information

Table 1. Strengths and weaknesses of some common clinical communication technologies.

All messages use channels that fall upon a continuum somewhere between lean and rich. The channel, through which a message travels, must be appropriate to the type of message being conveyed. Daft developed the "model of channel richness" (see Figure 4) to illustrate the varying means of communication.

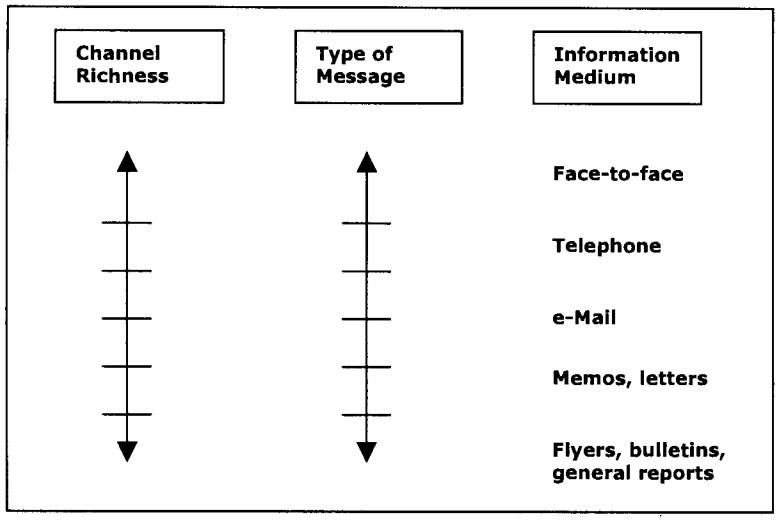


Figure 4. Daft's Model of Channel Richness. [2]

According to Daft and Lengel's theory, [2] media richness is a function of (1) the medium's capacity for immediate feedback, (2) the number of cues and channels available, (3) language variety, and (4) the degree to which intent is focused on the recipient. The greater social presence of a medium creates greater immediacy and warmth of communication, due to a greater number of channels.

The Shannon and Weaver model represents communication as a linear process, originating with a sender and ending with a receiver. [30] The only disruption that may be placed between sender and receiver is "noise" from an external source. The model, though, has flaws in that it assumes that communication travels only from sender to receiver and without any feedback between the two in the process. It also assumes that

noise is an external source. On the contrary, noise could be a presence that comes from either the sender or receiver, or both.

Schramm developed communication models built upon Shannon and Weaver, but attempted to account for the reciprocal nature of communication. [31] This "circular" model consists of a sender and a receiver each sending messages (either verbal or non-verbal) and their attempts to "encode" and "decode" messages from one another. An important distinction in the circular model is that the surrounding environment is considered to have an effect upon the way the messages are interpreted.

Schramm went on to develop the "shared-field of experience model." [31] This model takes into consideration not only the message, which requires encoding and decoding by both the sender and the receiver, but also the shared "field of experience" of each. The field of experience from each party denotes the level of context to which a party can attribute to the message. The greater the overlap between those exchanging a message, the greater the chance a message will be accurately communicated.

1.4 COMPUTER SUPPORTED COOPERATIVE WORK MODEL

Information is required to make decisions. The more complex the problem that requires a decision, the more difficult it is to find appropriate information. Richer channels of communication are appropriate for dealing with information seeking.

One might think of information seeking as a linear process in which a person asks a question and then seeks an answer. Taylor describes the process of information seeking in four stages: "visceral, an actual but unexpressed need for information; conscious, a within-brain description of the need; formalized, a formal statement of need; and compromised; the question as presented." [32] This is a complex internal process that

takes a person from recognizing he or she has a need, being able to identify exactly what is needed, and then being able to express that need.

Taylor's model describes an aspect of information seeking that encompasses the principal of "uncertainty." [1] Uncertainty refers to a data gathering process that is often facilitated by formal resources such as textbooks or electronic information systems. These resources can be used to gather information that addresses a recognized gap in knowledge to make a decision. For example, a person who might have a need to find current literature pertaining to treatment of diabetes may refer to PubMed and search for such literature. In that scenario, the person moved from the visceral, having an actual but unexpressed need for information, to the compromised, presenting their question to the information system. This process assumes an ordered, linear approach to information seeking. Or as Kulthau notes, "assimilating what is already known through a series of choices." [32]

In dynamic work environments where there is little time to formally determine information needs, people deal with issues of "equivocality." [1] Unlike uncertainty, equivocality refers to the ambiguity associated with more complex information seeking processes. These processes require a person to interpret a problem, define goals and strategies, and represent "decisions effectively to internal and external constituencies." [1] One could liken this to the process of a clinician interpreting a patient's symptoms and from that developing a differential diagnosis, developing a treatment plan, and then finding the most effective way of communicating that treatment plan to the patient as well as other professionals involved in that patient's care.

Equivocality, searching for relevant and disparate information to address an ambiguously defined information need, is only one aspect to be considered when placed within an organizational context. For knowledge workers to make effective decisions, they must conduct the equivocal information seeking process in the context and in competition with organizational politics, conflicting individual or organizational goals, and any deficiencies of communication. Given the many factors that go into decision making, Galegher and Kraut argue that "decision makers are essentially involved in a process of generating shared interpretations of the problem, and enacting solutions based on those interpretations. Thus, the processes involved are fundamentally social." [1] With this, the challenge becomes more than developing information systems that support clinical communication; rather, the challenge is developing a socio-technical culture that supports clinical communication.

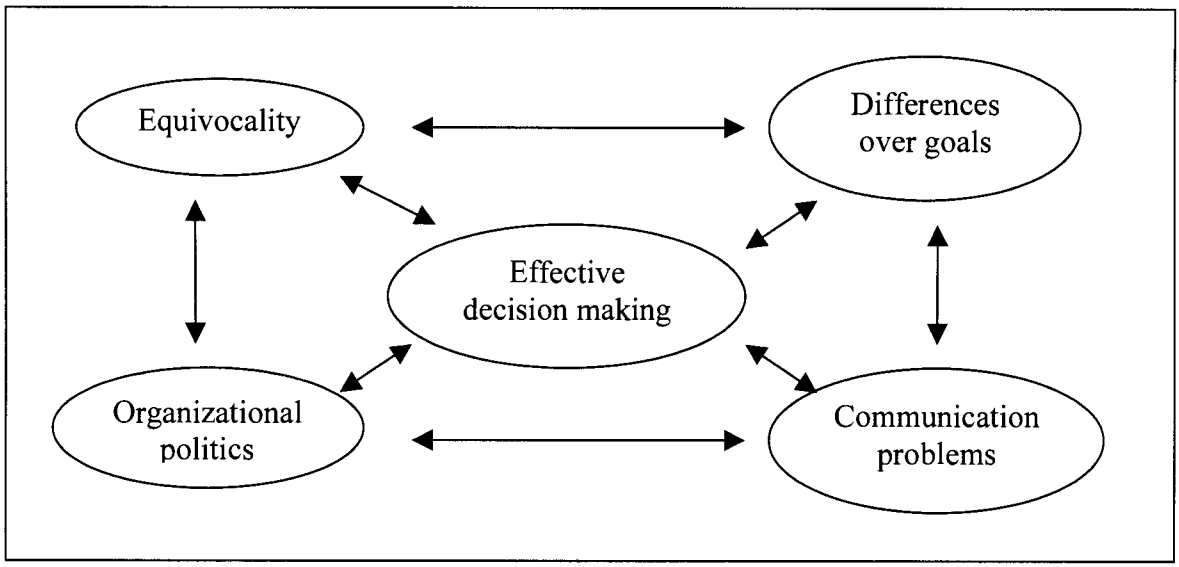


Figure 5. Effective Decision-making Model. [1]

Building interdependence and engaging in joint decision-making is crucial in many aspects of health care. As Gorman, Lavelle, and Ash note in "Order Creation and Communication in Health Care," patient needs can be "complex," and "acutely ill patients set in motion multifaceted, often simultaneous processes of thinking and acting by a self-assembling team of health professionals." Communication is the means to problem solve, plan, and "maintain and modify the kinds of common understandings that set up our possibilities for action." [33] Klein describes how naturalistic decision making (NDM) "focuses on how people use their knowledge and experience to assess complex and uncertain situations and take action in collaboration with contextual factors." [34] Increased cognitive loads interrupt the NDM process and can be adversely affected in an environment when clinicians are multi-tasking and taking in information from a variety of sources.

1.5 CULTURE OF INTERRUPTIONS NEGATIVELY IMPACTS PATIENT CARE

Poor communication in a dynamic and "event driven" [12] workspace increasingly leads to poor decision making. Problems most often arise and change in real-time, demanding clinicians make instant, mission-critical decisions, often without all the necessary or up-to-date information; even modifying treatment before post-treatment evaluation can be conducted. Within such an environment, with its associated time pressures, the amount of communication that goes on in the health care setting can be overwhelming.

Clinician bias towards synchronous communication [14] leads to a highly interruptible work environment. Reliance upon conversation within a highly dynamic and

"event driven" workspace often leads to "diversion of attention, forgetfulness, and errors." [12]

Researchers in the fields of computer and information sciences have written about interruptions that take place in business settings and have found that interruptions are "commonplace for a typical knowledge worker." [35] Cohen defines interruptions as "uncontrollable, unpredictable stressors that produce information overload, requiring additional decision-maker effort." [36] Interruptions also "require immediate attention" and require a person to take immediate action. [37] Interruptions are events that a person is not able to process on separate channels. Compare this to "distractions" which are low-level events that allow a person to perform different tasks simultaneously by operating on different channels; this process is more commonly known as multi-tasking. [35] For simple tasks, interruptions can cause "decision makers to focus their attention on relatively few information cues" which can actually cause an improvement in decision speed and accuracy. For complex tasks, though, interruptions slow decision speed and lower accuracy. [35, 38, 39] This has profound ramifications in the field of health care.

Interruptions account for the large amount of physician and nurse stress. Interruptions can take the form of person-to-person interruptions, or "technical interruptions" [15] such as noises from telephones or alarms. Nurses are more often impacted by interruptions than physicians and it is a cause for on-the-job stress and thereby a cause for attrition rates. [40] For nurses, often these interruptions come during the moments of direct patient care such as administering medication or attending to wounds. Hedburg and Larsson discovered that most interruptions by persons were for "information, instructions, and assistance." [15]

Paxton et al. reported nurses experience "48.5 interruptions per 100 consultations (n=3,081)." [41] Tucker observed eleven nurses and found that the five most frequent types of failures due to interruptions "involved medications, orders, supplies, staffing (having to do aids' housecleaning work), and equipment (deal with broken or missing equipment)." [40] Nurses were interrupted mid-task an average of eight times per eight-hour shift. Furthermore, interruptions abounded in the form of fragmented work [42] which impacted patient care strategies. As an example, one nurse was observed as switching among patients 74 times over an eight-hour shift. These nurses had to develop strategies to manage their time by using any one of three categories: 1) Partitioning care through regular status checks throughout a shift such as administering medications or checking vitals; 2) Interweaving care by moving between patients as opposed to providing care in a sequential manner; 3) Reprioritizing care by "continually adapt[ing]" tasks to meet the immediate needs of patients and staff. [40]

1.6 COMMUNICATION TECHNOLOGIES

A variety of communication technologies have been introduced into the clinical workspace in the attempt to improve communication among clinicians. Each technology exhibits strengths and weaknesses. Overhead pages can lead to desensitization and noise pollution affecting both clinician well being and patient health. [43, 44] Wireless phones can be carried and allow for direct and synchronous communication, yet wireless phones are not always allowed in health care spaces because their radio waves may interfere with medical equipment. [45, 46] Pagers allow the flexibility of wireless communication and alerts, but the delay in response time has been noted as a problem. [24]

Coiera developed a continuum, shown in Figure 6, in which some tasks are better addressed by promoting communication among people, and there are other tasks that are better addressed by information systems. In between the two there exists a "common ground" where the two may support each other.

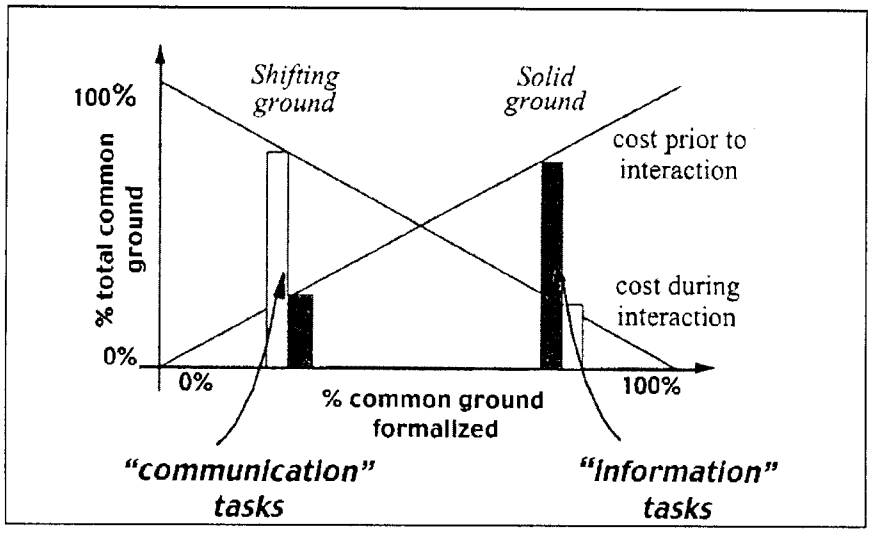


Figure 6. Communication tasks and information tasks. [14]

Coiera places "communication tasks" further to the left of the spectrum where common ground is less formalized. This represents task-oriented knowledge, which requires minimal formal training and coordination among people; they are the daily activities that need doing. Therefore less cost is borne out when common ground is less formalized. Coiera's model demonstrates that systems that support communication tasks, and systems that support information tasks, each have costs associated with them. Each system can exist in an information space; it's just that a system designer has to choose which is most apt for the task at hand.

That there are different forms of information that should influence the design of information systems has been a theme introduced by others as well. Forsythe found that

"physicians express a need for different types of information in the course of their daily work." [47] She argued that information could be divided into four categories: 1) Formal-general which is published and generalized information often found in textbooks or in MEDLINE, 2) Formal-specific which is the type of published, organization-centric information captured in policy and procedure manuals, 3) Informal-general describes "basic cultural knowledge [that] constitutes appropriate behavior with colleagues and with patients," 4) Informal-specific which refers to behavioral norms or rules that are specific to a particular group. [47] Forsythe's model, like Nonaka and Takaguchi's model of tacit and explicit knowledge, [48] highlights that information exists in multiple forms.

To support clinical communication, Coiera advocates using a technology that accounts for clinicians' synchronous bias and enables "information seeking." In addition, he argues the technology needs to allow for role-based contacts so that clinicians can contact one another based upon their professional role as well as their name. Finally, there needs to be some mechanism that allows clinicians to manage interruptions. [14]

When investigating the feasibility of cell phones for nurses in an inpatient setting, Taylor et al. found that nurses had specific requirements. [25] Through observations, interviews, and focus groups, the researchers found that nurses could not rely upon existing communication technologies. Overhead page messages were reported as garbled and inconsistent, and asynchronous technologies such as emails were not of great value because nurses lacked the time to sit down and go through messages. The authors went on to list "requirements for an ideal nursing communications device," some of which are:

- Smaller and lighter than most cell phones
- Wearable

- Wireless
- Allow user to call other staff by name or role (as opposed to extension number)
- Can receive calls "hands-free" via easy-to-hear speaker/microphone
- Interrupts gently when a call comes through

1.7 VOCERA OVERVIEW

> "Speech is the fundamental means of human communication."
> Clifford Nass and Scott Brave
> *Wired for Speech: Activating the Human-Computer Relationship*

Vocera is a "wireless voice communication system" [49, 50] developed by Vocera Communications, Inc. located in Cupertino, California. The company was founded in March of 2000 and began shipping product in 2002. [51] The technology is marketed to industries such as health care, libraries, and retail. The company states that Vocera technology is applicable in environments where the "workforce is highly mobile, geographically dispersed across a building or campus, and has ongoing, real-time communication needs." [3] As of August in 2006, healthcare implementations occurred in the United States and Canada, and the implementation sizes ranged from"75 users [to] over 4000 users." [51]

Vocera is a unique [52] hands free communication device (HFCD) that utilizes Voice over Internet Protocol (VoIP) together with a Wide Large Area Network (WLAN) to interconnect clinicians. The technology has received praise in the popular press for its ability to fulfill both synchronous and asynchronous voice communications, enable conversation-based information exchange, and allow staff to contact one another by speaking a person's name or organizational role. [3]

The technology is made up of two parts: HFCDs and the system software that resides on a server. HFCDs are 4.2 inches in length (10.6 centimeters) and 1.4 inches in width (3.5 centimeters). Each battery-powered badge weighs less than two ounces, and is worn by being clipped to a person's clothing by being hung around the neck using a lanyard. Furthermore, each badge is furnished with a call button, a microphone, and a speaker. Pushing the call button allows one to either initiate an outgoing call or to receive an incoming call; the microphone and speaker allows users to communicate back and forth with one another as if using a telephone. Optional headsets that plug in to the badges are also available. That the badge is wearable means that the conversation can take place while the wearer's hands are free.

The design of the badge is quite important. It has been described as simple and easy to use. Developed by Vocera and the design firm, IDEO, the badge design won an IDEA award from the International Designers Society of America (IDSA) in 2004. [53-55] Clinicians have touted the simplicity of the Vocera badge. Donald A. Norman in his book, "The Design of Everyday Things," describes "affordance" of a technology as the "perceived and actual properties of the thing," that is, an object's purpose is self-evident. [56] Ease of use is an important quality of a health care technology.

The other half of the Vocera technology is the system software. The software is standard Windows-based software that runs on a server and manages "voice and data applications." [57] The software stores user profiles, manages calls, and contains voice recognition software. The software resides only on the server(s) thereby allowing updates and preference controls to be centrally managed. [58]

Using VoIP and WLAN allows the voice-controlled communication badges and the system software to stay connected thereby enabling person-to-person contact throughout a building. The way Vocera works is that each clinician wears a device that wirelessly communicates to a server. The device can either be attached to a person's clothing, like a badge, or worn around the neck on a lanyard. The device is often compared to the "com" devices found on uniforms of characters from Star Trek. [55, 59, 60] When one clinician wishes to speak to another, she taps a button on the wearable device and then speaks the clinician's name or organizational role. The Vocera wireless device sends the spoken word as a signal to a central server, which then identifies the intended recipient. Once identified, the server sends a signal to the intended recipient whose device audibly asks if the call is to be received or not. The recipient verbally says "yes" or "no" in response to the prompt; if yes, the call is answered, if no, the call can be routed to voice mail or another person's badge.

The Vocera system enables multiple forms of communication. In addition to person-to-person communication, clinicians are able to broadcast messages to groups or roll over incoming messages directly to voice mail when a recipient is occupied. The Vocera system can also automatically transfer urgent calls among clinicians until a clinician responds, thereby ensuring an urgent message is received. The individual user or the group determines when and how these options are configured.

As of this writing, Vocera is a unique technology in that it combines VoIP technology with wireless and voice recognition functionality. The only other technology that is considered similar to Vocera is SpectraLink. SpectraLink also utilizes VoIP, but its devices are more akin to cell phones in that users call specific phone numbers to contact

one another, and users are able to exchange text messages. My initial research discovered one instance of clinicians using both Vocera and SpectraLink thereby providing clinicians with a spectrum of communication channels: HFCD, cell phones, and text messaging. [10]

1.8 WHAT ARE VOIP AND WLAN?

VoIP affords advantages to an organization in how it manages its voice communications systems and can alter the way in which information is shared among its workers. VoIP processes the voice into digital form and WLAN acts as the means of transmitting that voice signal to the VoIP application. VoIP was described by Kevin Werbach in the Harvard Business Journal as "the World Wide Web for voice." [61] This is because voice is digitized and sent between people in packets, say as an email is sent. New and customized applications can be developed to support more "intelligent and strategic uses [for] voice communications." An example noted is the use of Vocera at Rhode Island Hospital in Providence, where they've been able to link monitoring devices with the badges. When an alert goes off, "the system sends customized [calls] to the proper doctors or nurses." Whereas before an "undifferentiated call" would have gone out on an overhead page, the system can now send targeted messages to staff. As Werbach sees it, "the greatest potential of VoIP will come as companies design increasingly intelligent systems to link communications and business processes and improve the productivity of knowledge workers." [61]

WLAN has been in existence since 1940, but not until 1990 did the IEEE begin formulating a standard. The 802.11 standard was published seven years later and coordinated activity to run at 2.4 GHz. That standard proved not to be interoperable

enough for vendors such as Cisco, 3Com, and Nokia, who, under the auspices of their organization named the Wireless Ethernet Compatibility Alliance (WECA), furthered the standard to 802.11b. This revised standard, afterwards known more commonly as "Wi-Fi," proved to be more interoperable and has since become the de facto industry standard. [62]

Wi-Fi networks carry data to and from wireless devices using various methods of spread spectrum technology. "Spread spectrum spreads signal power over a wide band of frequency" [58] thereby squeezing more information into limited bandwidth. There are three ways that this is accomplished. First, frequency to 802.11b networks are able to carry data for 50 to 150 feet at different rates: 1 Mbs, 2 Mbs, 5.5. Mbs, and 11 Mbs. Newer standards have been, and are being, developed. Newer standards enable data transmission rates ten to twenty times more than 802.11b. There are two different kinds of networks, Basic Service Set and Extended Service Set networks.

The Vocera system is comprised of both hardware (badges and server) and software: "voice and data applications." [62] It enables users to communicate directly to one another over an 802.11b wireless network channel. Each HFCD is assigned a unique IP address and it must be registered with the system. A DHCP server assigns a dynamic IP address.

Utilizing the 802.11b channel has advantages beyond Vocera usability; it does not interfere with sensitive medical equipment such as heart monitors. Cell phone use in clinical settings, for instance, must be regulated for the signals can interfere with monitoring equipment. [45] This provides VoIP a significant advantage in the healthcare setting.

The Vocera badges are in constant communication with "beacons," pinging them at a default rate of 100 milliseconds. During the installation process, an audit must be conducted to make sure that this rate, or the desired rate, is maintained. Special attention must be made to areas perhaps not normally considered for wireless coverage: stairwells, bathrooms, and elevators, for users' conversations must be maintained regardless for physical presence. Failure to do so can result in negative impressions of the Vocera system. [63]

The Vocera badge is "highly directional." Because the badge is worn on the front of the body, close to where the user can speak into it, the signal is stronger 180 degrees forward and diminishes to the back of the individual. This fact must be, and is, taken into account when a wireless network is installed. As a user walks through the physical space, the badge automatically conducts a series of "hand-offs" [58] to maintain voice connectivity. Specific channels are used at specific distances to ensure connectivity (802.11b channel 1: 11mbs, 5.5 mbps, 2 mbps, and 1 mbps.) Approximately a dozen maximum communications can be maintained at a single access point. [53] Vocera notes, however, "the Vocera usage pattern is not similar to that of a conventional telephone. People often use telephones for sustained conversations; however, Vocera calls are typically brief." [52]

The Vocera system has the ability to be integrated into a facility's PBX phone system thereby enabling contact between users in a clinic and users outside a clinic. Once integrated, the Vocera badges can be used as if it were a traditional telephone except that phone calls can be made using voice commands.

Security for Vocera relies primarily upon its proprietary CODEC, which enables the device to encode and decode streaming digital data. [64] For a message to be deciphered, an interceptor must have access to the CODEC. Adding security layers upon the Vocera system may jeopardize the quality of the communication. Placing the Vocera server behind a firewall, for example, will add load to the signal and therefore slow the transmissions. [58]

1.9 CASE STUDIES

Vanderbilt University Medical Center, Nashville, TN

St. Jacques et al. compared Vocera HFCD technology against traditional pagers in an anesthesia unit at Vanderbilt University Medical Center (VUMC). [65] For four months, twelve anesthesiologists, twenty-two certified nurse anesthetists (CNRAs), eight circulating nurses, and six OR nurses used one of the two technologies. Two surveys were used to collect "system performance" and "user preference data" for each of the devices. To control for system performance, subjects were sent no more than two pages or Vocera voice queries each day and subject response times were recorded. The user feedback survey captured data related to categories such as: "simplicity of use, reliability, and efficiency" among others.

St. Jacques et al. reported that those with HFCD technology had response rates almost four times faster than those with pagers (30.2 seconds average, n=43 vs. 118.1 seconds average, n=30). The authors noted that this statistically significant result occurred "despite a statistically significant difference in the proportion of VoIP device users called during surgical cases compared to pager users." [65] The user preference data demonstrated that 70.6% of subjects would prefer to use the VoIP HFCD technology

although 97.1% rated pagers as more reliable than HFCD technology. Subjects also noted that environmental noises accidentally activated the HFCDs, and they noted their concern that HFCDs could broadcast private patient data into public spaces. The authors concluded that additional training could adequately address clinicians' concerns.

St. Agnes HealthCare, Baltimore/Washington, DC

Breslin et al. reported Vocera HFCDs were installed at St. Agnes HealthCare in May of 2003. [66] They compared two 32-bed units similar in size, physical space layout, staffing, and patient type. The first unit used only overhead pages, phones, and pagers, while the second unit used those technologies plus HFCDs. In both units, researchers "shadowed three registered nurses, and one unit secretary" for four days. In addition, researchers reviewed Vocera log files that tracked Vocera calls between nurses for those same four days. The researchers' goals were to model communication workflow for nurses with and without HFCDs, as well as collect survey data that would help to illustrate "specific impacts" of HFCDs.

Researchers found that it took up to one minute and forty-five seconds for nurses to make and complete traditional phone calls. Calls to an external department using Vocera HFCDs were "at least five times quicker than other methods." According to the authors' workflow model, HFCD calls took at most 55 seconds. Through the use of the survey, researchers reported that overhead paging was reduced by 94% and that 83% of nurses strongly agreed that the number of overhead pages was reduced. In addition, nurses who used HFCDs ranked them as their most preferred means for communication whereas nurses without HFCDs reported overhead pages as the most preferred. The authors concluded that Vocera HFCDs improved workflow and produced time savings.

William Beaumont Hospital, Royal Oak, MI

Kim Bonzheim, Director of Noninvasive Cardiology at William Beaumont Hospital in Royal Oak, Michigan, presented a case study of HFCDs used in a cardiac telemetry unit. [53] The presentation was conducted through HIMSS and hosted by Vocera Communication, Inc.

Bonzheim reported that prior to HFCDs being introduced into the unit, communication between telemetry techs and floor nurses was unreliable. In response to level 1–3 cardiac monitoring alarms, Bonzheim reported it took on average 9.45 minutes for an initiating call to go out from a tech to receiving confirmation from a floor nurse that an alert was completed. The success rate for this communication loop was 26%. After the implementation of HFCDs, the communication loop was closed in an average of 39 seconds. In addition, the reported communication loop success rate was 100%. Bonzheim attributed the unit's improvement to developing a better understanding of the "relationship between people and systems [and] understanding human behavior and developing interventions to eliminate errors." [53] In June of 2006, William Beaumont Hospital won ECRI's first annual Health Devices Achievement Award. [67]

1.10 ORGANIZATIONAL DESIGN

Kaplan argues "changes in communication directly affect changes in work." Information technology systems must fit the organizational culture to be "successfully" implemented as defined by the organization and by users. [68] This is achieved not necessarily based upon the capabilities of the system, which are certainly critical, but rather through the system's fit into the existing organizational culture. Past Computerized Provider Order Entry (CPOE) system failures, notably the rejection of CPOE at the

University of Virginia, [69] demonstrate how organizations must account for social, organizational, and political factors. Organizational objectives of improving communication may not be the same objectives of those on the floor. To ensure that multiple factors are accounted for when "developing a comprehensive evaluation plan," Kaplan advises following the "4 Cs: communication, care, control and context." [70]

Brennan et al. argue that nursing practice models are an important consideration for an information system implementation, and offered a meta-model which she termed the "Model of Nursing Practice Models" (MNPM). [71] An IT system must, for example, account for whether an organization has its nurses work within task-specific or user-centered units. Brennan et al. identified "11 factors that characterized" all nursing practice models. Some of those factors include continuity of care: the "consistency of assignment;" collaboration which includes issues such as "discharge transitions;" and communication such as "communication patterns" or effectiveness of communication at shift change. The authors discuss how MNPMs place a "greater-than-expected emphasis...on communication and interdisciplinary interaction than that evidenced in earlier writings...and may reflect changes in the contemporary practice environment."

Lorenzi et al. describe the differences between vertical and horizontal communication. [72] They argue that vertical communication is meant to maintain control and provide accountability whereas horizontal communication is used to "link together" work activities. Horizontal communication is where "performance gains are most notable when systems perform...at the process level." The two means of communication are "very different," yet both need to be aligned because a "key issue in

systems design is whether the proposed system will indeed enable the organizational changes that are required."

People accept change at different rates: some easily accept it, others view it as a challenge to overcome, and still others resist. [73] Danielsen found nurses reacted differently to the installation of CPOE. [74] Some reactions were based upon past experiences with CPOE systems, while other reactions were based upon how CPOE altered work relationships. Dykstra found the introduction of CPOE changed the way that clinicians developed and maintained work relationships and teams. [75] Findings by Danielsen and Dykstra show organizations need to acknowledge that introduction of a new technology into the health care workplace can impact an entire activity system. [76, 77]

Danielsen's and Dykstra's work demonstrates Lorenzi and Riley's argument that change is experienced differently at different levels: individual and organizational. [73] Building upon previous research that proposed a model of "first-order change", that is slight variations in a work process such as generating a new report, and a "second order change," which would be fundamentally altering the "system itself." Lorenzi and Riley extended this by arguing there are actually four types of change: operational, strategic, cultural, and political; and rather than there being first-order and second-order changes, they argued that a more suitable way of looking at a change as to whether it's a "microchange" (a difference in degrees) and a "macrochange" (a difference in kind). [73] For example, a system upgrade may be viewed as a microchange, whereas the introduction of an entirely new system would be considered a macrochange. To not account for the possibility that the changes themselves might be different, but that two

people can also view the same change differently, is to risk rejection of the change by the organization. The result is that what was an attempt to improve performance instead alienates portions of the organization, risks rejection of the system, and provides no evidence of improved system performance or perhaps even shows decreased system performance.

2.0 METHODS

2.1 PURPOSE OF STUDY

To describe the multiple perspectives of staff nurses, nurse managers, and IT staff in relation to the use of hands free communication devices (HFCDs) in hospitals. [78]

2.2 RESEARCH QUESTIONS

The central question of this study is how have HFCDs affected communication in health care organizations? From this, three subquestions arise:

1. How have HFCDs affected nurse, nurse manager, and IT staff communication?
2. How have HFCDs affected communication in the health care organization?
3. What were any unintended consequences associated with the implementation and use of HFCDs?

2.3 PRELIMINARY RESEARCH

Hands free communication device (HFCD) technology is relatively new to industry in general and health care organizations in particular. These devices enable healthcare workers to wirelessly contact and converse with one another, thereby supplementing more common communication technologies such as pagers, cell phones, or overhead pages. Whereas most research to this point has focused on time and motion studies of these devices, this study attempted to elicit subjective perspectives from key informants on the effect of HFCDs on communication in health care.

Preliminary data gathering was conducted by online literature searches (primarily MEDLINE, EBSCO Business Source Premier, Google Scholar, and Google). In addition, the researcher e-mailed, and telephoned hospital administrators, IT administrators, and nurses from organizations that had experience with HFCDs. The researcher found that

HFCDs affected organizational work groups differently. For example, IT staff had to account for network security threats, floor nurses found their relationships changed with tech staff, and nurse managers found themselves having to translate technical and organizational goals between IT staff and staff nurses. Altering the means by which these people communicated with one another affected organizational relationships in that these groups had more interactions with one another than before the HFCD implementation.

The purpose of this research is to capture the stories and opinions of each group so that it may be better understood how HFCDs affect communication from the perspectives of these three groups. Through my reporting the ways in which this technology affects communication, other organizations can learn of issues to consider before implementing HFCDs. Qualitatively gathering information from staff nurses, nurse managers, and IT staff will reveal the issues revolving around HFCD technology as it relates to interpersonal and organizational communication.

2.4 QUALITATIVE METHODS

Qualitative research methods provide researchers with ways to "explore social, political, and economic changes" without attributing predefined categorizations that might influence or skew interviewees' ultimate meaning. [79] Exploration is conducted through the use of fieldwork during which the researcher conducts interviews and observations, among other methods, in order to understand those changes. [80] Through interviews and observations, a researcher is able to record how subjects describe the culture around them "and the rules about how to operate in the world in which they live and work." [79]

New communication technologies may alter the way people interact within an organization. [24] For that reason, qualitative interviews can help uncover the changes that take place in those environments. This research technique has been used in similar studies that tried to capture opinions on changed information flow. Taylor et al. conducted focus groups and one-on-one interviews with nurses, nurse managers, and "operational assistants" in their effort to understand nurse communication needs. [25] Reddy et al. relied upon observation and qualitative research to understand technology's impact upon information flow in clinical settings. [21, 23, 24, 81] Focus groups are another useful means for gathering data from multiple interviewees although sometimes "group norms" can influence those with dissenting or alternate opinions from sharing their viewpoints. [82] To avoid such group influences and to encourage open expression of opinions, I selected interviews and observations as methods for gathering data.

HFCD implementations in hospitals can be site specific. Organizations may tailor HFCDs to function according to specific business rules, staff needs, or technical limitations. As a result, it becomes more difficult to control for variables such as organizational goals, staff acceptance, and technology requirements. Unlike quantitative research which through the empirical approach demands controls for any variability across samples, qualitative research operates under the assumption that each research environment is unique and the people that occupy that environment have particular world views. [83] Therefore, qualitative methods are suitable for this study.

2.5 LINSTONE'S FRAMEWORK OF MULTIPLE PERSPECTIVES

The Linstone framework was used to guide the design of this research in selecting staff nurses, nurse managers, and IT staff as the groups of study. Linstone suggests that

organizational issues are best understood through the adoption of multiple perspectives, each of which asks different questions and seeks different information from a well-described point of view.[84] He proposes three perspectives: 1) the technical perspective which evaluates the scientific and technology underpinnings of any problem, 2) the organizational perspective which is concerned with organizational goals and strategies, the corporate culture, and the social glue of myth and history that binds employees together in achieving those organizational goals, and 3) the personal perspective which elicits individual views of the system under consideration and focuses more on how the individual effects and is effected by the organization.

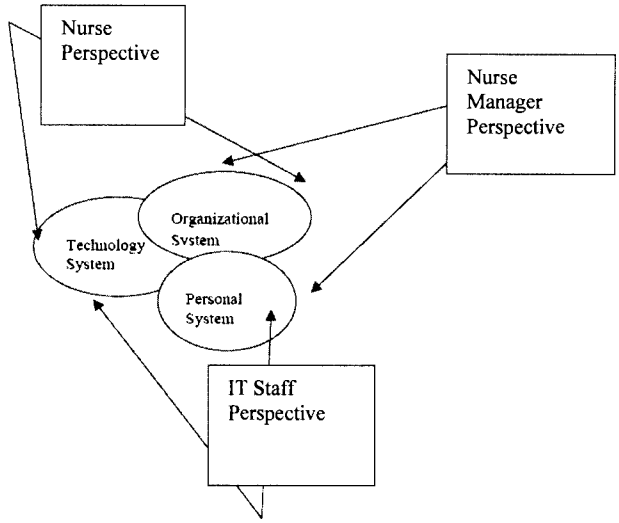


Figure 7: Multiple Perspectives Model. [78]

Linstone argues that most often, perceived problems are addressed from the "technical" perspective; that is, solutions to a problem can be found from developing quantifiable measures and linear methods. However, the technical perspective fails to account for unexpected occurrences that often take place in socio-technical systems.

Other viewpoints exist or even predominate within a complex socio-technical system such as a health care setting. [84]

Linstone advocates exploring perceptions based upon organizational and personal perspectives in addition to the technical perspective. Unlike the technical viewpoint, which adheres to quantifiable measures, the organizational and personal perspectives usually rely on more qualitative approaches to research. The organizational perspective tends to view situations from the context of the system: how a change affects working relationships and if that change is in line with organizational goals and strategies. The personal perspective looks at change differently, and tends to view change from the viewpoint of how it will affect an individual's goals and objectives. The three groups selected for this study represent Linstone's three perspectives: 1. IT staff as the technical viewpoint, 2. Nurse managers as the organizational viewpoint, 3. Staff nurses as the personal viewpoint.

The multiple perspectives framework has been used in the study of computerized provider order entry (CPOE). [78] Ash et al. have argued that this approach is an effective way to learn how users perceive the value of a new system and how that system meets their needs from multiple viewpoints. [78] The model provided a means for "offering a structure and format for reporting results" that helped to organize subjects' perceptions about a particular technology.

2.6 SETTINGS

The researcher interviewed and observed staff from two organizations: Hospital X and Hospital Y. Hospital X is an academic research center and Hospital Y is a community hospital. Each allowed the researcher to interview and observe users of

HFCDs within two different health care environments. These two institutions were selected because of their geographical proximity to the researcher and that they were the only two local health care organizations that were identified as using HFCDs.

At the time of this writing, Vocera HFCDs have been implemented in Hospital X facilities for under one year. The rollout was initiated as a new building, Building K, was opened to receive patients. Building K is a 325,000 square foot, 11-story facility that includes among others a nuroscience/otaryngology unit, a cardiac acute care unit, and two oncology units (see Figure 8). The design of the units in Building K is much different than those in which staff previously worked. The units in Building K are designed without central hubs or nursing stations and instead, have smaller nursing stations, or "pods," located nearer the patient rooms. The spread out floor plan is also different in that the building curves so that nurses at one end of the floor are unable to see nurses at the other end.

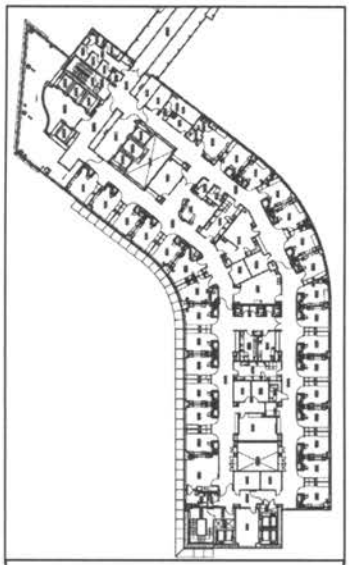


Figure 8: Building K at Hospital X

Hospital Y is the third largest health care organization [85] in the locality in terms of reported patients and by operating expenses. Its facilities include 483 licensed beds and 374 staffed beds. Hospital Y has units that have been using Vocera HFCDs since 2003 when it was first introduced as a pilot project. Recently, the use of HFCDs was expanded beyond surgical services and ancillary support staff to encompass more units. Hospital Y is planning to further expand its use of HFCDs after a newly constructed facility is complete.

2.7 STRATEGIES FOR TRUSTWORTHINESS

Triangulation is a method that tests for consistency of data through the use of multiple methods, sources, investigators, and perspectives. [86] Comparing and contrasting responses of different people given through the research process, concepts and issues can be identified consistently across groups. Patton lays out four categories of triangulation that "can contribute to verification and validation of qualitative analyses." [80] I will outline Patton's four categories and describe how my research will account for each category.

Methods triangulation; refers to discovering "consistency of findings generated by different data collection methods." This study accounts for different data collection methods by utilizing both interviews and observations.

Triangulation of sources; refers to discovering the "consistency of different data sources within the same method." This study accounts for different data sources by interviewing and observing staff at two different health care facilities.

Analyst triangulation; refers to "using multiple analysts to review findings." For this study, this researcher will develop themes from the data. An expert qualitative researcher will then provide an audit review to ensure the data and themes appear reasonable.

Theory/perspective triangulation; refers to relying on multiple perspectives or theories to interpret the data. This study will utilize the multiple perspectives model developed by Linstone. [80]

In addition to triangulation, member checking is used to assure that what subjects said is what they intended to mean. To carry out member checking, the researcher must go

back to the subject after the interview when themes have been developed, and confirm that those themes seem reasonable to the interviewee.

2.8 TRAINING

The researcher participated in a training seminar provided to nurses at Hospital X in relation to its Vocera hospital implementation. The training covered the basic design of the device, an explanation of the buttons and their purpose, and a demonstration of how the Vocera badges need to be worn around the neck. Each trainee, including the researcher, was taught how to log in to the Vocera system, set up a personal greeting, and use basic commands to initiate and receive Vocera calls to one another. Trainees were provided handout materials to take with them, which included PowerPoint slides, and a sheet that included Vocera commands and official names for units and job titles.

The researcher did not participate in training at Hospital Y. It was reported that Hospital Y used "super users" to lead training and retraining sessions. Super users were IT staff members that worked closely with nurses and were available to units for one-on-one assistance. In addition, Hospital Y made online tutorials available to staff.

2.9 SUBJECTS/SAMPLING

Subjects were identified with the help and guidance of executive sponsors, word of mouth, and suggestions for follow-up from the subjects themselves. This process is termed "snowball sampling" and is described by Atkinson and Flint as "identifying respondents who are then used to refer researchers on to other respondents." [87] The strengths of using this technique are that it can quickly identify subjects who are few in number. Also, being referred by a known party can lend credibility to the researcher. [87] The strength of snowball sampling could also be considered its greatest weakness, for

subjects are not randomly selected but instead selected based upon the recommendations of those already interviewed.[87] This could open the selection criteria to bias. To address bias, the researcher attempted to interview a spectrum of subjects, from different perspectives, and from different organizations. In addition, as required by IRB agreements, subjects were informed that they would be deidentified.

The researcher obtained names of prospective subjects from members of the thesis committee. In this project I spoke with nine members of IT staff, nine nurse managers, and eight staff nurses. The thesis committee suggested four of the five IT staff members and all four nurse managers at Hospital X. Five nurses managers from Hospital Y were suggested by a Hospital Y liaison identified using the snowball sample method. Specifically, the researcher directly contacted prospective subjects using email. He introduced the research project, providing a copy of the project overview, offered to follow up with additional information at the potential subject's request, and finally, requested the interview.

To identify staff nurses, the researcher emailed staff nurses and nurse managers who had already been interviewed. Those who were emailed were informed of the range of subjects desired for the research project based upon Rogers's five "adopter" categories: innovators, early adopters, early majority, late majority, and laggards. [88] Referring to Rogers was used to try and help people identify additional staff nurses who had a variety of opinions about HFCDs.

Those from all three groups whom I had the opportunity to interview are described in Table 2:

IT Staff	Nurse Manager Unit	Staff Nurses
Network Engineer	OR	Clinical Neurosciences
CIO	Clinical Neurosciences	Cardiac telemetry
Senior Manager of Infrastructure Engineering	Cardiac/Medical ICU (interim manager)	Cardiac telemetry
Telecom Systems Engineer	Cardiac/Vascular ICU	OR
Telecom Systems Engineer	Sterile Processing	OR
Computer Technician	Neurosurgery and ENT	Bedside/Charge in Cardiac/Medical ICU
Director of Technology	Cardio-thoracic and Vascular Surgery	Orthopedics and Neurology
CMIO	Orthopedics and Neurology	Orthopedics and Neurology
Senior Project Leader	Orthopedic Coordinator for Surgery	

Table 2. Types of Interviewees

2.10 INFORMED CONSENT OF RESEARCH SUBJECTS

Institutional Review Boards (IRBs) from both Hospital X and Hospital Y approved interviews and observations for this study. Prior to each interview, subjects were provided with an informed consent form notifying them of the purpose for the research project and their rights as participants in the project. Each interview subject signed the IRB paperwork.

Field observations were coordinated with the nurse managers of every unit that was observed. At Hospital Y, the nurse manager reviewed the observation notes to insure no patient data was collected. The Hospital Y nurse manager approved all notes from each of the three observation periods.

2.11 DATA COLLECTION

Subjects were interviewed in one-on-one sessions that took place in offices, conference rooms, and break rooms. Semi-structured interviews ensured that all subjects

were asked the same questions from the interview guide, though questions did deviate from the prepared list (see Appendix A). Each interview lasted from between 15 to 30 minutes depending upon the availability of the subject or whether the interview had run its course. Interviews were recorded and notes were made while the interview took place. Subjects were asked about their perceptions of what effects Vocera may or may not be having upon communication among staff across the organization. They were also asked what about HFCDs "surprised" them and if there were any other issues related to HFCDs that they thought were important. Subjects were remunerated for their time with either home baked goods or $5 Starbucks gift cards.

The researcher conducted observations three times of nursing staff using Vocera at Hospital X and then at Hospital Y. At Hospital X's Building K, two-hour long observation periods were conducted. Each observation was during a different shift: a morning shift, an afternoon shift, and a night shift. Each observation period took place on a different floor: Cardiac/Medical ICU, Cardiac/Vascular ICU, and Clinical Neurosciences. Each observation period included shadowing a nurse and also general observation of the nursing station. The role of the researcher was to be as unobtrusive as possible, but respond to questions that might be asked and comments that might be made by the subject or the staff. The researcher did ask questions of a subject if clarification was needed or the researcher was unsure why a certain action had been taken. Observations at Hospital Y were conducted in the Orthopedics and Neurology unit. Observations took place in one-hour increments and took place during day and night shifts. Observations included both the shadowing of nurses and the observation of the

nursing station. The researcher did not follow subjects into patient rooms. Observational notes were recorded using pen and paper and were typed out the following day.

The observations attempted to verify that what the nurses had discussed in interviews was carried out in practice. In addition, the observations helped the researcher understand what communication was like in the clinical space. The observations attempted to capture moments when communications came through not only the Vocera devices, but also other means such as phones, overhead pages, and other staff members. Observations about the clinical environment and the workflow were made.

2.12 DATA ANALYSIS

Recorded interviews were transcribed into Microsoft Word documents. The researcher then coded interviews into segments and organized those segments using Microsoft Excel (version 9.0). Then, a post-doctoral fellow adept at qualitative research reviewed and coded a portion of one of those interviews into segments. The researcher and the fellow then compared the results to see if the codes were consistent. Both the researcher and the fellow agreed the codes were consistent thereby providing greater trustworthiness of the researcher's codes.

After coding eight transcripts, the researcher presented the results to the thesis committee for review. The thesis committee felt that the sections the researcher had labeled, the "meaning units," were too inclusive and needed to be parsed further. The committee advised the researcher to organize meaning units in software other than Microsoft Excel because the amount of data was great.

The researcher imported the interview transcripts into QSR NVivo (version 7.0.274.0 SP3) qualitative research software. Within NVivo, each interview was coded according to

the Grounded Theory approach in which categories are developed using the data found within the transcripts themselves. Twenty-seven interviews and six observations were ultimately transcribed and uploaded the NVivo software. A total of 524 codes were developed.

To develop themes of the 524 codes, a card sort was conducted. Each code was printed from NVivo onto a separate piece of paper. Each code contained the name of the code assigned to the meaning unit, and the meaning unit itself. Using the card sorting process as laid out by Lincoln and Guba [89], the following was performed:

1. I selected the first code sheet and made that the first entry of the first category
2. I selected the second code sheet and made "a determination on tacit or intuitive grounds" whether it was similar to the first code sheet. It was not and so I created a second category.
3. I repeated the process, adding categories where the code sheet did not "intuitively" match the existing categories
4. After organizing ten cards, those cards that did not fit any categories were placed in a "miscellaneous pile."
5. After another fifteen code sheets were organized, I attempted to attribute definitions to each existing category.
6. I repeated steps three and four in an iterative process.
7. After categorizing all the code sheets, I reviewed the categories and reviewed the miscellaneous pile, looked over the categories for "overlap," and looked for "possible relationships" among categories.

8. I repeated the process of refining the categories, looking for relationships among categories, consolidating categories, and defining the categories until I believed the codes in each category reflected a concept repeatedly enough to consider the category as "saturated."

Member checks were conducted to improve the project's validity. Each interview was reviewed and summarized in a Microsoft Word document. The summarization captured subjects' responses according to each key question they were asked:

1. Why do you think Vocera might be something for Hospital X to implement?
2. What was communication like before Vocera?
3. What effects has Vocera had upon communication among staff?
4. What effects has Vocera had upon communication in the organization?
5. What about Vocera has surprised you?

The researcher attempted to reiterate the subjects' responses framed around the categories that were developed using the card sorting method. Subjects emailed back their approval or any changes they deemed necessary.

3.0 Results

The process of coding and categorizing generated five themes (See Table 3). The first theme, *communication access,* describes how users view HFCDs as providing fast and efficient communication thereby allowing users to provide and retrieve information with fewer interruptions to the workflow than before users had communicated with HFCDs. *Communication access* gave users feelings of connectedness and security which they felt translated into opportunities to retrieve help from fellow staff which ultimately translated into feelings of improved patient safety.

Subjects, though, reported that working with HFCDs required them to develop skills to *control* their devices and caused changes in workflow as well as requiring adjustments to work and personal relationships. *Control* could be linked to difficulties with the HFCDs themselves, such as the speech recognition functionality, and also the need or desire for training.

Training was the third theme, and users often referred to it in terms of helping users overcome difficulties with control. Subjects pointed to *training* as the way to improve the use of HFCD features as well as learning how to integrate HFCD-based tasks into clinical workflow.

The theme *organizational change* describes the role HFCDs have in helping the respective organizations meet particular patient and organizational strategies. In addition, subjects discussed how using and supporting HFCDs allowed them to interact and learn more about other functions of the organization previously foreign to them.

Environment and Infrastructure was a theme that was often referred to, particularly for those working in Hospital X's new Building K, where the difficulties and challenges

of learning to use HFCDs as they adjusted to a new work environment were great. Perhaps it is for this reason that more Hospital X subjects than Hospital Y subjects viewed using HFCDs as having to make a series of tradeoffs. Subjects provided a wide array of answers regarding what about HFCD technology and its implementation "surprised" them. Table 3 includes the themes that were derived from this study as well as their definitions.

Theme	Definition
Communication Access	The degree to which people are able to communicate with one another without interrupting tasks.
Control	The ability to manage the technical and social properties of HFCD communications in order to achieve safe and efficient work.
Training	The process or act of training, advocating, and encouraging learning in order to overcome user resistance to HFCDs and gain HFCD acceptance.
Organizational Change	Ways in which HFCDs may bring changes to interdepartmental communication and processes
Environment and Infrastructure	Issues relating with how building design and wireless architecture have an effect upon communication.

Table 3. The five themes derived from the study's data.

Each Theme and sub-Theme will be described below. Illustrative quotes are in italics and words or phrases added by the researcher for clarity are in brackets.

3.1 THEME 1: COMMUNICATION ACCESS

Subjects from all three groups of nurses, nurse managers, and IT staff described the pre-HFCD process of providing care as inefficient and fraught with interruptions to clinical workflow. The cause of the interruptive nature of clinical care was mobile workers' needs for access to information resources such as telephones, pagers, overhead pages that may or may not be heard, and fellow staff. One IT subject described the process as, *"[The] whole nightmare of trying to call, leave a message, voicemail...little*

yellow [and] little pink message[s]. Call y'know and get back and then you can't find the other person...[T]hat whole nightmare...the whole nightmare of communication access." Nurse Manager 10 described the process as having to do *"a lot of hurry up and wait."*

A nurse manager also described the process nurses worked with. *"So the nurses did have pagers and if they were in a patient room when we didn't want to use the overhead paging system because we're trying to decrease the noise, but if they were needed the unit secretary would have to type the text page, would have to go through the university wireless system which can take several minutes. If it's very busy, beep at the beds...the nurse gets the beep and then now what do they do? Well they have to either go find a telephone, or they stick their head out the hall and yell up or they come walking up to do that. So that can take, what I just described, even in the best scenario takes several minutes."* A nurse explained, *"Before Vocera you either had to be by a phone or you had to hear what was overhead paged to you...sometimes you don't hear that."* Continuing on the same point of looking for phones, an IT staff member described the process of communication this way, *"[Nurses'] communication [before HFCDs] was a lot like pagers. They got paged and then, you get paged you have to go find a phone or you carry that bulky phone around...you have to run around and look for a phone."*

Pagers, or beepers, were often cited as inefficient because of the delays between receiving a page and returning a call. As described by this nurse manager, *"if we were needed, we had an overhead paging system. Otherwise we had beepers and we would be beeped, and then we'd have to find a phone to respond to that. So it was slower...because of that delay."* A nurse manger commented upon the tedious nature of not having communication access. *"It was kind of tedious in the past cuz we had pagers and your*

pager would go off and you had to find a phone so somebody had to initiate the call to the pager and the person that received the page had to find a phone and call back to that person where they may or may not be busy." A nurse cited pagers as a cause of stress. *"[Pagers] just seemed to, was just extra added stress...one more thing you had to do."*

Accessing help from fellow staff sometimes required yelling down the hallway. One nurse manager recalled, *"Communication prior to this was you peeked your head out of your room and saw if there's somebody in the hall who could possibly help you,"* and also noted, "*Before [Vocera, nurses] would maybe just kind of stick their head out...the door and look for anyone to yell down to, 'Can you go get me this?' Which isn't the best way to communicate when you have family members walking up and down the halls."*

Locators too were a technology that was used for staff to help find one another with mixed results. *"We had an old locator that you could go up to the nursing station and find out where someone was working and then there was...a phone that you picked up and you called that nurse and it would be the closest speaker to that nurse...it was more cumbersome because you had to go further away to use it [the phone] and sometimes it [the phone call] would pick up the closest station and was not very close [to the intended nurse] so it was kind of a pain."* A few, though, recalled the multi-step process but still felt locators were an efficient way of communicating. One staff nurse put it this way, "*We had intercoms in all the rooms and we had locators on. So you, it would be a couple step process. You would go to the computer, find the person you're looking for, it'll tell you what room you're in, and you could call them in that room. And that was hands free as well. So you just come into the room and say, 'Hey...you got a phone call,' and I could*

say, 'Fine' and hang up. I thought that worked good. I liked it cuz you could see where people were so you could go talk to them."

But the process of having to walk to the nurses' station to make a communication, was a reason one IT administrator had for implementing HFCDs, *"I was looking for something to help the mobile worker to be able to not have to do all these starts and stops running back and forth between the nursing station and then providing patient care. The physician that calls into the central nursing desk, having to wait to find out who they need to speak with or get a phone call back or wait on hold to eliminate some of those barriers we had in communication."*

Messages were relayed among workers as described by this nurse manager. *"I'd come back from the ER and to the, generally to the front desk area where you and I met, and if I had phone calls then [name withheld] secretary would just tell me and, 'oh you had a call from,' or if there was staff looking she would tell me that so and so needed [me]."*

HFCDs were brought in to address the failings associated with the lack of communication access: searching for communication tools such as phones or notes, workflow interruptions due to searching for communication tools, delayed responses associated with technologies such as pagers and voicemail, locating staff, and relying on relayed information. Subjects overwhelmingly gave supportive responses when discussing HFCDs and how they address communication access. One manager stated how she thought HFCDs fit into the clinical workflow. *"No matter what your role is whether you're a bedside nurse or nurse manager what it helps you do are your minute to minute tasks. Anything that's more long-range, it's done over email or telephone but as far as moving your work day done and moving along from task A to task B you're getting*

task A done. That's what we use this [Vocera] for." Nurses, nurse managers, and IT staff felt that HFCDs have been integrated into clinical workflow and that nurses have become dependent upon the technology.

Increased communication access allowed staff to focus more on the communications rather than finding the appropriate communication tools. IT 05 commented, *"It's sort of removing your focus of attention on the medium to actually be able to focus on the content... you're really being able to con[centrate]...to focus your attention. The medium fades into the background where it should be."*

3.1.1 COMMUNICATION ACCESS – FINDING A PHONE

HFCDs address the difficulty nurses had with finding phones. As one nurse manager described it, *"Having to make the phone calls, it interrupted the smoothness...you always had to stop what you were doing and go find a phone. With Vocera you just answer the phone, it's hanging around your neck. So that's been really nice and it works just about everywhere in the hospital including the elevators."* Having a phone around the neck reduced the amount of walking to get to a phone, *"[HFCDs] increased the ability to communicate. Make it more seamless, cuz some place[s] of the hospital I go I have to walk a ways to get to a phone. Down in the tunnel, there's places where there's no phone access and I'd spend time running up and down elevators and things like that."* Similarly, another nurse manager noted, *"it's nice to be able to be working out in an area and call sterile supply, or supply and distribution and you don't have to go find a phone. You can continue working and call directly"*

Ready access to communication via an HFCD made nurses feel they save time. One nurse manager describes it thusly, *"It just makes it a lot easier to have to not look for a*

phone because you have the [badge] around your neck and that saves a lot of time." Another nurse manager related communication access to time savings but also felt the HFCD allowed awareness of other staff, "*I think it comes, the time savings to the nurse...being paged directly to your Vocera where you didn't have to go find a telephone, or stop take your pager off access the message...Time savings and just being aware of where everybody is at all times."*

An additional benefit of HFCDs as one nurse manager put it is that users did not have to remember phone numbers. *"[HFCDs] just saves a lot more time than trying to remember phone numbers all the time cuz you just have to remember certain names, we certainly connect with a lot of people regularly who have Vocera.*

A nurse manager gave an example of about how many times she would have been drawn away from work to find a phone had she not been wearing an HFCD. *"[I]n two weeks I had 480 phone calls on my Vocera...that tells you how many pages I was getting and trying to find a phone and doing that kind of thing. So it's really made that a lot easier."*

The use of HFCDs did not eliminate the need for traditional communication technologies such as telephones. In fact, the telephones were observed to be used more heavily than were HFCDs. Observations revealed HFCDs did not supplant other communication methods but more accurately, they supplemented other communication methods. Nurses continued to wear telemetry pagers, occasional overhead pages were delivered, and telephone calls, particularly from outside sources, still came into the clinical environment and were handled by clinical staff, and staff still walked the halls looking for each other without making HFCD calls. Comments that were made after

concluding one observation period, *"I came away with a better understanding that Vocera is 'just another [communication] tool.'"*

3.1.2 COMMUNICATION ACCESS – IMMEDIACY

Concepts that subjects often used revolved around immediacy of communication, quickness of communication, or the instant nature of HFCD communication. A nurse manger described the value of having "real-time" information. *"I think it is has provided the staff the ability to have real-time information given to them. It's not like we're leaving a message on a machine somewhere or writing them a note that they may or may not see. I mean we can talk to them at most times and they can multi-task or be doing other things but still hearing the message about the next patient or...the next day for that matter...real-time information can be relayed."*

Other nurse managers discussed similar opinions of HFCDs effects. NM02 stated, *"[Vocera's] pretty reliable and very, when it works, very expeditious in really allowing us to get that information very quickly."* Another said, *"the good thing about that was the staff could get a hold of me immediately, by calling you can call on the telephone, get into the Vocera system and then ask for me and you'll get me immediately."* A third nurse manager related its effect upon staff communication, *"I do know that my staff enjoys communicating with the OR [Operating Room] much more quickly and efficiently using the Vocera method."* And a fourth nurse manager related the immediacy afforded help that might not have been available before HFCDs. *"[Staff] feel[s] they'll get an immediate answer and that the help is there where before it was, 'Well maybe she'll call maybe she won't, I hope the page went through.' They know right away."*

NM02 explained how immediate access affected the ability of staff to care for patients. *"If the plan of care needs to change we need another type of a medication, the patient's pain is out of control, instead of having to go through a phone system trying to find a physician...that can take many, many minutes, having immediate access through Vocera gets the patient really what thing...they need."*

A nurse manager described how she did not know an issue of communication access existed until she started using HFCDs. *"I wasn't aware there were any issues...this will work so I can respond immediately. That also tells me if I need to come right away. So the response time must've been an issue somewhere."*

Nurses too appreciated the immediacy HFCDs provided. *"I think that where before they would kinda say, 'Yeah, I know what I'm doing," and, 'Yeah, I got what I need and we'll just start the case and see what happens'... [Vocera] opens up an avenue of being able to contact somebody immediately versus trying to stop what you're doing and again that slow motion of calling and waiting and you get the response you feel like you're wasting time."* Another nurse commented upon the directness of communication and how it allowed nurses to feel they were accomplishing work. *"It was a pain [with beepers]. Once we went to Vocera though it was so nice because...when I was on the floor...[the] unit secretary could just call me right there and we could get things taken care of...[Y]ou seen those commercials? 'We cut out the middle man.' That's how I always thought once we started using Vocera is I just seem to cut out... the middle man."*

Immediate communication that is associated with HFCDs also had an effect upon those in IT. IT 03 pointed out that staff responded to questions faster than if they used cell phones. *"[Q]uestions tend to get asked and answered immediately with those people*

that have it. So, we may say, 'Well, what's happening with this?' And if you're talking to somebody with a Vocera badge and they don't know but somebody else does, they tend to just call that person and get the answer. Where even with a cell phone... they don't pick up the...phone and call immediately." IT 04 commented that having HFCDs helped to quickly resolve IT issues a nurse might be having, *"[L]ast week we had a trouble ticket. Instead of picking up the phone and paging the person and wait[ing] for them to call me back, I called her on her Vocera badge, we talked about the problem, resolved the problem and done."*

3.1.3 COMMUNICATION ACCESS – BREVITY

The nature of these communications was brief and reflected users' need for immediate information. The length of observed HFCD communications were often less than thirty seconds in length and always less than one minute in length. IT 02 explained that, *"the vast majority of calls are less than 45 seconds."* HFCD communications were directed at locating and finding fellow staff as well as materials such as patient charts. Requests for lifting help, or informing nurses that transportation had arrived on the unit were types of calls witnessed by the researcher. HFCD calls were often directed to nurses to inform them that calls had come into the unit from an outside telephone line: these observed telephone calls were most often from the family of the patient or ancillary services.

Subjects described their frustration when HFCD calls lasted longer than an implicitly desired length of time. SN 03 explained, *"I guess what drives me nuts is the one guy who...stutters and he doesn't know what he's going to say before he calls. And so there's a lot of hemming and hawing and I don't like that in front of the other patients. [It]*

makes us all feel like we don't know what we're doing. If somebody was to call and say, 'Hey, they need tea in Room 4," I say, "Thanks, bye." I hang up and I'll get to it eventually." To SN 03, the perceived indecisiveness of the caller not only delayed the transmission of the message thereby delaying the recipient's ability to return the task at hand, but it also could have poorly reflected upon the staff in the eyes of the patient. SN 05 explained that "*keeping [communications] short and sweet and to the point*" were necessary to communicate effectively with HFCDs.

3.1.3 COMMUNICATION ACCESS – DIRECTNESS

Communication access also allowed staff to gain efficiency by reaching one another directly. A nurse manager described the benefit, "*I can talk to them directly and they can tell me what they need.*" Another nurse manager described the benefit of being able to reach staff directly while she was away from home. *"[W]hen I'm at home and I need to talk to her directly and I don't want to bug the unit secretary and bug her to find her I just dial [extension] and ask for her by name and get her wherever she is...I just call them directly and try to cut out the middle man and go directly to the source."*

A third nurse manager noted that HFCDs made it easier to provide direct answers to questions. *"[HFCDs] made [work] a lot easier because...I get a direct answer to a question, or I'm able to answer a question directly which I think has been very helpful in that there's none of that running around and fire drills."* A staff nurse described how direct communication benefited her, *"[direct communication with Vocera] means, more efficiency, of course. And just making my day easier. Making it flow better."*

3.1.4 COMMUNICATION ACCESS – STREAMLINING

An IT administrator related an example of how HFCDs streamlined the patient care process. *"I was standing outside a set of elevators while a nursing unit was taking a discharge patient out to the car only to realize they had gone off without the patient's paper post-op instructions. So she called using her Vocera badge saying, 'I'm with patient so and so, they don't have their post-op instructions will someone bring them back down for us to the front desk?' So instead of having to stop, go back upstairs, or stop [and] wait for someone else to go down while [they] made a phone call [and then] waited for them to come down, it just streamlined that process so everything could keep moving forward in absence of that one piece of information."*

A nurse manager related another example of streamlined work because of HFCDs. *"[I]f they're tied up they can't answer the phone. If they're doing a prep and have sterile gloves on or something like that then other people get involved and you have this, who's on first thing. So it's been really helpful for that."*

A nurse noted that HFCDs allowed him to be better prepared. *"[Vocera has] helped me quite a bit if I've done something or I'm doing something that I'm not sure of. I can always call somebody...at the front desk that has some experience and then talk to them while I'm doing something and can kinda, 'get this,' or 'be prepared for it,' you might do this instead of what you're thinking and so have something else in the room."* And as a result, *"I'm able to do better, be a better nurse and accomplish more in my duty that they assign me that day."* Nurse Manager 09 also lauded the device for helping her be prepared. *"[T]hey can be in their rooms and I can say something like, 'We need to do this for that case, is there anything you need me to do to facilitate that?' It's right there and*

tell them ahead of time. 'Dr. Gray is coming in and he's got...a visitor with him. The visitor wears size 7 and a half gloves and they have been privileged to work here for one day'... they have that heads up somebody's coming."

3.1.5 COMMUNICATION ACCESS – LOCATING OR FINDING

HFCDs have had an impact on how staff was able to locate one another and equipment. Nurse Manager 07 explained, *"I think also a way for physicians and other people, ward clerks, where their nurses were at all times. If, so, a doctor called to the desk and he needed to Mr. Jones's nurse it wasn't a matter of that ward clerk physically getting up and then going from room to room search...paging overhead she could just without leaving her station, she could locate where that nurse was."*

Staff Nurse 01 concurred with the nurse manager by stating simply, *"I just think it's easier to find people,"* and, *"I feel like now I can almost always get a hold of people when I'm looking for them."* Staff Nurse 03 explained how HFCDs were used when locating others. *"If I wanna talk to somebody about something I'll call them and ask them where they are and then I'll go see them. So that's how I use Vocera. I use Vocera as much to find out where people are as I do to exchange information. 'Where you at?' 'I'm over here.' 'I'm on my way, ok.' We'll have a talk."*

Unlike other nurses, Staff Nurse 06 did not find HFCDs a useful way to locate other staff members, *"I don't know who's near me...I don't know. No nurse, I may need a nurse [to] co-sign on a medication. So I'll just keep on going through [Vocera]. Find this one, find that one, find this one, find that one. That's a problem. The size of the unit I think too. But if you have a locator system it's, 'Oh!' That nurse is right around the*

corner I'll go grab her. [Vocera] doesn't tell me where somebody is. It's like, that nurse could be at the front desk."

3.1.6 COMMUNICATION ACCESS – OBTAINING HELP

Communication as described by the subjects: instant communication, direct communication, streamlined communication, and knowing where others are located; all contributed to feelings that staff could obtain help. One nurse manager stated, *"If there's an emergency I can break through to them I have the ability to do that... It's great when I need somebody, I can hold this button down and call everybody and say, 'I need help down here right now,' and everybody's gonna come running"* and, *"They [nurse staff] can be in an isolation room and if they're missing a piece of equipment or something they can call out of the room to have someone bring it to them as opposed to having to ungown, wash up, go back out, regown which is a huge time factor,"* as well as, *"you can be tied up in a room with a patient and need help and you don't have to leave your patient."*

A nurse manager expressed surprise at how HFCDs allowed her to access help. *"I think the convenience [of HFCDs surprised me]. It's a very convenient tool because of the time factor that is saved. You save time. And, for example, if you're in an emergency, in cardiac you can get into situations a little bit where it's nice to be able to punch a button and call for help or call a specific individual. You don't have to leave what you're doing and that's been good."*

Another nurse manager is able to prioritize help. *"[Vocera] makes them a little more secure knowing that there's somebody to support them...I'll be there, and or get 24 other interruptions. I usually get back at least within a time period. And I'll usually ask them,*

'How urgent is this? Do you need me to come right now?' and they'll say, 'No.' and then I can go in 5 minutes instead of dropping what I'm doing. I think [nurses] feel more supported with Vocera than they did before and it makes their rooms go smoother and they're less stressful."

Staff nurses also commented upon how HFCDs can access help. One staff nurse noted, *"If you're having an emergency situation it's kind of nice if everybody knows what's happening."* Another staff nurse stated, *"[Vocera] also gives me some comfort in that I can reach somebody quickly if I needed help."* In addition, having access to help through HFCDs can be of value to new nurses. *"When you're first starting out especially in nursing and you're doing something you've never done before, usually even when you have a preceptor you kind of have kind of an idea what you're doing...you have a person standing there behind you so you're a little bit more at ease trying something knowing that if you've done, doing something wrong that somebody's there to help you, correct you or whatever. With Vocera being so close if you find yourself in a situation that you're not sure of you can actually call somebody and ask them the question right when you're doing it and kind of maybe walk through it, I think for me it would give me a little more reassurance that I have somebody with me while I'm doing it rather than me trying to figure something out that I'm not used to or not understanding or feeling uncomfortable in doing."*

3.1.7 COMMUNICATION ACCESS – DEPENDENCE

Communication access by way of HFCDs caused staff to become dependent upon the technology. IT Staff 06 described, *"[T]hat's how important that device became...they're dependent on it. I mean we're real dependent on it now...especially surgery. I mean they,*

that thing goes down, you talk about screaming...[I]t's almost like it's so important to them they forgot normal communication, it's down, but they forget like OK I need to go to a phone. Or I need to now get a pager...it's now like [Vocera's] down."

IT Staff 03 recalls, *"we had a downtime a month ago or so and we had a problem and got lots and lots of feedback about how that really messed things up for them. Well that says to me that they've built it into their process such that it was hard to go back to their old processes that they were using not 8 months ago, right? We were told when we were implementing it by our vendor...that the first week they'd hate it, the second week they would get used to it, and the third week they would kill you if you took it away from them. And that's really the kind of process we saw people go through."* IT Staff 02 remembered, *"[T]he Vocera system went down for like half an hour and we heard about it like crazy...they just can't live without it, they're having to walk and find people, and they've really incorporated it into their lives and the way they're doing things. So that was pretty telling for me."*

IT Staff 07 told another story of staff dependence upon HFCDs. *"I've offered to take it away from them, 'No no no no, that's not what we meant!' 'Oh, so you're not that unhappy?' 'Oh no!'"*

Nurse Manager 01 related an example, *"not too long ago, the Vocera on my unit went down for some reason and they had to go back to the beepers, and this was like for an eight hour period, ten hour period...I came in the next morning and it was like, 'Oh my God Vocera went down'...it was horrible and it was a miracle they lived through the night and just horrible horrible horrible, and the first thing I said to them was, 'now you realize how valuable Vocera is for you. Because before all I heard was you all complain*

about it... '[N]ow you know how valuable it is.'" Similarly, Nurse Manager 03 stated, *"It's something you're used to having and you get almost immediate dependence on it if they don't have it. It's like, 'well what do I do?'* And Nurse Manager 04 noted the time HFCDs showed their popularity, *"We also ran out of [HFCD badges]. So by 3 o'clock, the people that came on at 3 o'clock didn't always have, there weren't always Voceras for them to pick up. And that, and then we realized how much we immediately had depended on them."* According to Nurse Manager 04, HFCDs had become the primary communication tool. "*[HFCDs] became basically our main communication tool...that was the main way we had to communicate."*

IT 03 explained that nurses in outside departments were already asking IT when they can have access to HFCDs. "*We're able to move forward with more areas. I mean the pressure to move forward [with HFCDs] was tremendous and the pressure to do areas that weren't identified in the project is also tremendous right now. So people are hearing about [HFCDs]. They're latching onto the technology and they're saying, 'it really can help us.'"* When asked if IT 03 thought that information about HFCDs was being spread by word of mouth among nurses, IT 03 responded, "*Absolutely. Absolutely. No question about it."*

3.2 THEME 2: CONTROL

"Control" was a term used by two subjects, a nurse and a nurse manager. Their description of the theme described difficulties that many others were dealing with or trying to overcome. I define "control" as the ability to manage the technical and social properties of HFCD communications in order to achieve safe and efficient work. Social control refers to individual users being able to manage the social aspects of the

technology such as frequent interruptions from others, prioritizing conflicting communications, relying upon a common etiquette, and adhering to patient confidentiality requirements. Technical control includes the ability to use the speech recognition features, utilize breakthrough functionality, and appropriately use the "do not disturb" function.

3.2.1 SOCIAL CONTROL

Not having control of the HFCD device was described by Nurse Manager 02 this way, "*[W]hen I first started using [Vocera] I would forget to put it on cover, and it would go off, and it would hear me say something and think that I was responding to it, and then the person would start talking to me. It was just like, 'I hate this thing! Shut up!' But once I realized, 'Wait a minute...it's just a piece of equipment that I had to learn to control to help me.' And I think the staff has finally got that and it does take a little while to realize that you need to control it so you can use it as a tool you don't let it control you.*" Nurse 04 described a similar outlook, "*I think you'll learn more after use after taking more control over it; not answering every call, screen better I guess would be the best word for it, so that you're able to accomplish what you need to do and still be able to help other people. Because you can put it on hold or tell them, 'I'll call you back in a minute or something.'*" In addition, Nurse 04 stated, "*Being able to take control, because it becomes second nature you just turn it on and it you just go, you could be in some really awkward situations when it goes off and you forget that you can put it on hold or something.*"

Staff nurse 04 described how after a period of time the HFCD became a subconscious tool. *"It's now...to the point where I don't realize I've got it on until it goes off. So...and*

that took probably about six months for me for to realize that I wasn't even paying attention it was there until it went off." But when compared to other communication tools, those tools seemed to be perceived as more controllable. *"There's not much out there other than Vocera, phone, or the beeper. So, I think I can control the beeper pretty well, I can turn that sucker off pretty quick, not answer the phone, that I got control over [that]."*

3.2.2 SOCIAL CONTROL – INTERRUPTIONS

The strength of HFCDs, instantly and directly being able to access staff, was also a cause for complaint as described by IT Staff 03, *"We found that in fact the nurses felt they were interrupted more times with Vocera than they were without Vocera. Ok, that may be true because now people are communicating nurse-to-nurse more and so yeah, the patient experience is that this nurse is getting these interrupting calls and the nursing staff was concerned about that. That's something we've got to try and address and figure out is there something we can do about that or can't we."*

Interviews with nurses and nurse managers indeed backed up what IT Staff 03 had heard. Staff Nurse 02 stated, *"We had locators that, whoever could tell where we were. [I]n some ways, they could hit the room you were in to say you have a phone call, it just didn't seem we were getting as many interruptions as we do now...people are constantly telling you everything where before it was just a phone call, 'Patient in room 2 needs to see you when you're done,' they were very brief and short."* Staff Nurse 02 also described that HFCDs interrupt while working with patients, *"When you're...discussing something with a patient to be able to just truly have that time with the patient and not have these constant interruptions."*

Staff Nurse 03 discussed the possibility of getting interrupted during a care conference. *"I can be talking with somebody about losing their limb for instance and their family and it's a pretty intense conversation and anybody can call me and they're in the room and so I'm forced to acknowledge them, talk to them...It's a weird business, nursing, cuz you can, it can be really intimate at times where it's totally not appropriate to say, 'excuse me I have to take this' but you have to."*

Staff Nurse 03 described the feeling of getting interrupted with the HFCD. *"It's annoying [when interrupted]. It's like, 'Jesus Christ, stop calling me! I know!' [I]t can be frustrating. It can be like, 'Now what? Stop!' Especially if...the patient's not that sick... So it can be frustrating."* And the rate of interruptions made Staff Nurse 03 begin to think that many of the calls were not worth answering. *"I could be doing something that I don't want to be disturbed in, and this thing doesn't know that and it just I mean how could it, is just a machine but it like keeps bug[ging]... it's like crying wolf and, 'I'm not going to take this call.'"*

Staff Nurse 04 described the interruptions as an invasion of personal space. *"[S]ometimes you'll get a call from [other nurses] and so it's like an invasion of what you're trying to do...for your job in your room and what you're doing with your doctor and then try and have to figure out somebody else in another room...I think there's some invasion I guess on your time or on your space...as to what you're doing, as to have to answer other people's questions or problems."*

Staff Nurse 06 expressed her dislike for HFCDs and described being unable to escape calls she did not want to receive. *"I hate Vocera. I'll just tell you that right now. I hate it. From the moment I start my day. I think it raises my blood pressure. It raises my anxiety*

level. It's frustrating. It's hard to get a hold of people. It doesn't always work. And like I said, I go into patients' rooms and I don't always remember to hit the 'Do not bother' [Vocera button] so I'll just go in there and somebody'll say 'Can you talk to?' and I'll hit the 'No' and often times they'll just cut through anyways. So when I say, 'No' they... break through. [I'm] not a fan."

Nurse Manager 09 questioned how effective the use of HFCDs is on the patient floor. *"I have a feeling that probably, and this is just because I've worked on the floors, I don't think I'd want to use it inside a patient's room...I know that they use it on the floors but our patients are [anesthetized]. So when we're using them generally speaking, [the patients are] out. And I know some of the conversations I've had, 'We need to have such and such in here right away,' and I don't know I would want the patient whose room I'm in to know there was something kinda urgent going on somewhere else."*

Nurse Manager 01 had to address the issue of people turning off their badges due to perceived interruptions by referring to the computer system. *"[P]eople are always on do not disturb...because of the interruptions."*

While on observation, a nurse volunteered to me that she had a "love - hate relationship with [HFCDs]." In her opinion, HFCDs made nurses too accessible and she experienced many interruptions particularly in the morning shift. I asked her why she did not use the "Do Not Disturb" function on the HFCD and she replied with the following process:

1. She explained to me that nurses don't put it on 'do not disturb' because it's so important to get information about all their patients.
2. The additional information from calls requires nurses to know how to prioritize more, requires a skill.

3. The interruptions affect/disturb the nurse-patient relationship.
4. Thinking about it, she stated, "it changes the psychology of nursing."

Staff Nurse 03 also alluded to this conflict of wanting to turn off the badge but feeling unable to do so. *"It's like the phone you can't turn the ringer off, you can but you also can't. You can put it on standby but then you don't take it off standby and...maybe it's not natural to us."*

3.2.3 SOCIAL CONTROL – CONFLICTING COMMUNICATION CHANNELS

Users often described the difficulty with HFCDs in that they sometimes found themselves in situations where they were in one mode of communication, say on a telephone, when an HFCD call came in. The user had to switch mental channels or move between mental channels to handle the conflicting modes of communications.

Nurse Manager 07 described a scenario. *"If I'm on a call trying to get or relay information, and then to have another call come in...you get this beep and it breaks up the conversation that you're having...[S]o then it's not very beneficial because now not only you have a garbled conversation with somebody else, somebody else is waiting for you on the line, so it can be kinda irritating, not irritating, inconvenient in that way. I suppose there might be some way you can put other calls on hold but I don't know. I mean, or, maybe there's a function that you can allow it to not have a second call interrupt your first one with that beep."*

Staff Nurse 02 describes a similar scenario. *"You're talking to somebody here and somebody else is coming up and they don't know that you're listening to this person. And so you've got all of these communications coming at you and you're just like [expresses frustration], 'I can only talk to one of you at a time.' And that's happened quite a bit too*

is that someone's talking to you so you look like you're just standing there and a doctor starts coming up and starts talking to you and you're like 'wait a minute!'"

Nurse Manager 09 described a communication error that occurred when she received a second call on her HFCD. The nurse manager found herself unable to navigate between calls. *"The only negative thing I can say about it is if you get two [Vocera] calls with it. I'm talking [with one person] and I get...a Vocera call from someone else. The Vocera blips, and so you can't get either conversation. You can't, cuz it overrides the person you're talking to until you stop...hang on, take the other call, and then you can proceed with the other call you originated."*

3.2.4 SOCIAL CONTROL – PATIENT CONFIDENTIALITY

Controlling for patient confidentiality was a primary concern for users of HFCDs because of the chance that patient information might be broadcast over the speaker at inopportune times. Staff Nurse 06 noted that staff might use a patient's name during a call. *"I think there's potential for it being a HIPAA violation. If somebody uses a patient's name, most people don't, but it's happened. 'Your patient, Mrs. Smith, needs you.' It's a HIPAA violation."* Nurse Manager 02 explained, *"From a clinical point of view, patient confidentiality is very important. And it's just the more technology we have to throw voice from one area to another and to, the more we try to do expediently. We have to be very careful with who's hearing this data and information I'm putting across."*

Nurse Manager 07 noted that confidentiality extends to vendors as well as patients. *"With a vendor for instance in my office, I wouldn't necessarily want them to hear some of the conversations that I might have with other vendors or regarding other patients."*

She went on that the organization viewed *"patient confidentiality [as] a big issue. It's...something we take pretty seriously."*

Nurse Manager 05 recommended, as many others did, the need to move sensitive HFCD calls to a phone when privacy is not attainable. *"One thing I will say is a drawback is if you have to have a private conversation with somebody it's best that you talk on a phone cuz you don't have the confidence of anonymity. Vocera is a loudspeaker essentially. So if someone had called me now and you're in the room and they had a concern about you, well you would be hearing it also or somebody else for that matter and that's something that you don't want to hear, other folks to hear. So that probably would be a concern at this time but you have to have to be, let's say, like a telephone you have to have good phone etiquette, you have to have good Vocera etiquette in a way too."*

3.2.5 SOCIAL CONTROL – ETIQUETTE

Another theme that subjects often referred to was the absence of, or the need for, common communication etiquette. This was perhaps more pronounced among subjects at Hospital X where the HFCD system had been in use for less than one year compared to the four years at Hospital Y. The theme of HFCD etiquette is comprised of concepts such as the use of inappropriate names or nicknames, a desire for commonly shared communication protocols, and a need to maintain professionalism in communication.

The circumstance of staff making "inappropriate" comments about other staff through the HFCDs was a mistake people made. Nurse Manager 02 recalled when she received a call from a colleague, *"[Someone] upstairs called me one time when I was at the front desk and was really upset with one of her staff members. She thought I was in my office and she just started goin off and I ripped [the badge] off [my neck]...running to my*

office... 'Be quiet! Just a second I'm not in my office!' [Y] ou always have to be careful with your conversations."

IT Staff 01 told a similar story of people who did not follow HFCD protocol by hanging up after a conversation was complete. *"Some people are forgetting to hang up so their other person that they called, just to be curious, isn't hanging up either. So they're actually listening in on everything else afterwards. And we had a couple incidences, [one] where this nurse thought she was done with her conversation and she wasn't, she didn't hang up, and so she's just speaking negatively about another nurse. Well it got back very fast."* IT Staff 07 also mentioned "etiquette" was a consideration when evaluating the first HFCD implementation. *"When it comes to standards and naming conventions and how you implement things, we had to kinda back up the bus a little bit and clean up some of the early work that was done under the pilot, because some of the naming conventions is the example that comes to mind, it was the discovery of certain kinds of standards that we need to have in place. A real simple example of that is the etiquette pieces of it. What are our standard as a health policy, our health system that we want to take around? How our employees and staff are expected to use this?"*

Staff Nurse 06 felt HFCDs changed communication in that people had gotten ruder with one another. *"I think [HFCDs have] affected how we communicate with one another. I think we've gotten rude with each other. I mean there's no etiquette. Some people just hang up...or some people have actually been kinda rude on it, 'whaddya want now?!?'...[T]hat kinda thing. 'Oh I'm sorry I'm in a patient's room um...I needed something.' So I think in that respect people are not as professional, can be not as professional with it...[M]y boss breaks in, she'll just break in sometimes in the morning. I*

think there needs to be a code, a code of ethics, a code, a standard on how to use Vocera appropriately...what's acceptable and what's not acceptable use and I think it needs to be monitored."

Names play an important function with HFCDs for they are the primary identifiers that people use for finding and connecting with one another. Users have the ability to make changes to their names or to assign nicknames to theirs or others' names. Subjects reported this as a cause for concern as well or conversely a way to boost morale. IT Staff 01 saw nicknames as a cause for concern. *"Every three days or so...I'm learning of these cute names, or things that they shouldn't be doing...I was training someone last week. As practice...we have to have them interact in class and I have them play with Vocera and call people in their department and...as soon as he got logged in...it says, 'you have a message from 'Boom Boom.'...[T]hose 'Boom Booms' and 'Bush Man,' I don't know...completely inappropriate. I mean I'm glad they're having fun with it, boosting morale but..."*

Nurse Manger 08 described a similar experience and feeling she had to explain to staff the proper use of names, *"Reminding them what the tool was for and how it should [and] should not be used. And that's taking care of the problem. At least I don't, I don't call anyone anymore that has put an inappropriate name on their response when you call them. It might've been immature on my part but if I got a message from someone, 'will you talk to,' one person had 'Smash' on theirs, sounded like 3 or 4 people were saying 'Smash.' Well that resulted because she ran her nose into a door. And I didn't know who it was so I wouldn't answer that. I just thought it was someone playing and um, that's*

been taken care of. I just told her when I found out who it was, 'you know I'm not going to answer that. If you want me, I have to know...that it's you [who is] calling.'"

Staff Nurse 05 saw the ability to change names as a way for staff to make the job more fun. *"I think it helps with morale too because you can record your name and so people will do that in funny ways and it's just that...some things aren't just so cookie cutter I guess. It just makes it more fun."* Staff Nurse 01 recalled how nicknames can make for an awkward moment when a call comes through at a sensitive time, *"[P]eople make their names sound funny or whatever and that's really fun...then when you're in the middle of a care conference and you forget to put it on 'Do Not Disturb' and someone's name comes across sounding silly, it's kinda awkward."*

Nurse Manager 03 sees the issue of nicknames as having more serious repercussions for the organization. *"It's not always an appropriate name...it could be a nickname...they sign their agreement for use. They're not supposed to be doing this but there's no really good way of policing that, to make sure that people are using it appropriately and it could end up potentially offending somebody or, just something that I don't think anybody had thought of...For example, one of our female RNs, a different gentleman, her name isn't Betty however he changed her name to Betty because that's what you call a cute snowboarder girl. And it's just not an appropriate use and she was offended by it...I mean I feel...there is some liability issues with it...that could potentially [be] looked at as harassment, potentially so...[I]f it's just left up to the managers to hold them accountable it's hard because I can't literally police everyone on the unit when they're using the Vocera especially when they can change it like instantaneously. Like, they can change it today, and they can change it back to something else tomorrow."*

3.3 TECHNICAL CONTROL

The usability of the HFCDs is critically important upon staff communication. The criteria for the subtheme of technical control are the concepts: speech recognition, use of commands, usability, and dropped calls. Some subjects touted the ease of use and speech recognition technology, others criticized its failings, and others still fell somewhere in between.

3.3.1 TECHNICAL CONTROL – SPEECH RECOGNITION

IT Staff 02 felt the HFCDs have a robust speech recognition capability. *"You have to say the exact syllables in the correct sequence and then from there it's remarkable how well it does with different accents, different pitches of voice, different speeds of voice, uh everybody wants to go like, let's just say a number, 49064, [snapping fingers] they'll go, '4 [pause] 9 [pause] 0 [pause]' you don't have to do that you just go 49064 and it picks it up. It's just amazing."* Similarly, IT 04 registered surprise at HFCDs' ability to recognize accents. *"[T]hey can even speak, say it's Spanish, they can even speak those commands in Spanish so it will understand them the next time they try to make a call. So I think that's been the nicest surprise out of everything, how easy it is to actually use for such a diverse population."*

With that, though, IT 02 believed the speech recognition needed to improve further to be even more sensitive to accents and to understand different phrases for the same command. *"I think that one of the largest frustrations is the lack of artificial intelligence built into it. Finally we're not having to type in a very specific 10-digit number to reach someone else, instead we're using words. That's great, but there is a frustration level if you can't remember the exact words. Although Vocera will respond to 'yeah' or 'yes' the*

word 'call' has to be the word 'call'. You can't say 'phone Robin Smith' you have to say 'call Robin Smith.' The learning, the specific syllables to say has caused some frustration and I think where this things needs to go in the future is to accept a lighter range of syllables and add some level of artificial intelligence..."

Nurse Manager 05 described how work on the system helped his team overcome problems with accents. *"A challenge we had initially with the technology is that I have a very diverse staff, very culturally diverse staff, a number of people are English as a second language, ESL folks, and their accents are quite thick. And Vocera could not always recognize their names. So that took some time where we had to work with them to speak really slowly because Vocera would keep asking us to repeat the name. So we worked with a number of my folks who where English is not a primary language and they've seemed to have made some enhancements into the Vocera system where it can be more recognizable to more dialects, accents, things like that too. It also lets you spell your name also which helps out some people in certain cases too but that seems to be a help at this point too. So I think at least from my point of view they've addressed the issues that we've experienced quite promptly."*

Staff Nurse 02 was one of many who described the frustration when her HFCD misunderstood her commands. *"You're trying to call a manager, you're trying to call...[then Vocera asks], 'Did you mean?' So [nurses are] constantly trying to determine, especially with people's accents and names that you can't pronounce, it's very difficult to get a hold of somebody because you're not pronouncing it the way that Vocera understands it."* She noted that she had difficulty getting to identify the names when she attempted to pronounce names of foreign countries and cultures. "*On our floor we've got*

tons of people from the eastern bloc and Africa, from Japan, so some of their names are difficult to say. And then when you've got...this computer trying to understand, you crucify their name[s]."

Staff Nurse 06 complained that when she took the time to "train" the HFCD it still did not recognize her commands. "*If you don't pronounce somebody's name properly or you try and learn a name, I've tried to do that with certain people that have...uncommon names, and it'll take me 10 times to say their name. It's like, "Ok after each beep say the name." Say the name, say the name, say the name, say the name. Ten times. And then it goes, 'I'm sorry see your administrator. We did not get that.' That's that variation, sounds similar to another variation, 'See your administrator.'"*

Nurses claimed a wide range of success for the speech recognition. Staff Nurse 09 believed the HFCD speech recognition worked 95% of the time. "*I think the more people get on it [the HFCD system] and the more similarity in names the easier [they system] is confused. You know, if you have like a 'Scott Brown' and a 'Bill Brown' and a 'Jim Brown' then she has to go through all the Browns sometimes if you don't, if she doesn't get it the first time. But most of the time it works really well, I'd say 95% of the time it works really well."*

A staff nurse from the observation period estimated the speech recognition worked one-third of the time and later said it worked one-half of the time. The observation described her experience this way, "*The nurse sits down at the pod and pulls out a binder with patient charts. She initiates a Vocera call, "call Pharmacy." It fails to understand, asking if she meant a particular person. She says, 'no' waits for the Vocera to prompt her and she says, 'call pharmacy.' Again the system asks if she meant to call a particular*

person and again she says, 'no' and waits for the prompt. 'Call pharmacy' she says and the system asks if she meant a particular person. Visibly frustrated she cuts off the Vocera and calls [on the phone]. The phone call gets through in under 5 seconds. I notice she's wearing the Vocera badge as instructed and clearly stated 'pharmacy' when she commanded the device." The researcher's personal note stated, "*That was frustrating to hear. It was painful to hear even though the episode could be measured in seconds."*

3.3.2 TECHNICAL CONTROL – EASE OF USE

Many subjects appreciated the ability to make a call at the push of a button and described HFCDs as user friendly. Nurse Manager 01 stated, *"About the Vocera product itself, uh, I don't really know, I mean I think it's fairly easy to use. It's definitely user friendly sometimes I think it aggravates, but like my computer it's usually me that's the problem and not Vocera. If you're not giving it the correct commands cuz you have to be very specific in your commands"* Nurse Manager 09 added, *"what's surprised me about Vocera? Actually how easy it is to use, it really is."*

IT Staff 07 referred to the push button functionality as its ease of use. *"It's such a simple device and it's a what I consider a single transaction type of technology. [I]t's pushing a button the size of a dime. I mean how simple can that be?"* Staff nurse 04 found it simple as well, *"Push a button and go."* Finally Staff Nurse 05 concluded, *"it's really user friendly so there isn't much of a curve."*

Unrelated to the push button, a staff nurse brought up an issue regarding the screen size on the back of the badge to one nurse manager's attention. The nurse manager had to provide repeated reminders and explanations that for the HFCD to work properly it needed to be worn close to the staff nurse's chin. The staff nurse, though, repeatedly did

not wear the HFCD close to the chin and so was unable to get the speech recognition function properly. After repeated reminders the nurse manager concluded that the staff nurse was attempting to sabotage the device. That conclusion changed when the nurse manager noted a difference in her own eyesight that prevented her from easily seeing text on the HFCD's small display screen. After that, the nurse manager concluded that the staff nurse may have actually been wearing the badge in an "inappropriate" place because when an HFCD call came in, the badge could more easily be held at a further distance from the eyes thereby making the display text readable.

3.3 THEME: TRAINING

Training was noted by many as an important part of being able to effectively use, and therefore communicate, with HFCDs. The theme training is defined as the process or act of training, advocating, and encouraging learning so to gain HFCD acceptance.

IT Staff 06 considered training the most important factor for effective communication with HFCDs. *"Training. I think that's the biggest thing. Getting them [the users] trained right...the correct way to use it things like that and stuff. Little shortcuts, little things like that. I think the biggest thing is, you, the folks using it train effectively how they use that device. What you can do what you can't do, things like that."* IT subjects often reported the need for user training and many report that people's perceptions of HFCDs change after training. IT Staff 01 explained, *"[T]they don't want to come to training, they finally come to training, I force them, I mean we say it's mandatory and they['ve]...just gotten off their shift after 12 hours, that's 7:30 in the morning. Some of them are showing up on overtime which they don't like. But I try, after they see the functionality, and how much*

time it can save them light bulb goes off and like, 'Oh I could do this with it or I could do that with it or,' they're realizing the benefits. So that's really neat to see that so quickly."

Subjects had varying accounts of what was learned and not learned at training. Nurse Manager 07 remembered learning basic call functions. *"I remember I went to a training course where the Vocera people were there and it was basically about explaining how to use the system but it seems to me something about just knowing where you're at or who you're speaking to and who else can hear you."* Nurse Manager 09 remembered training included basics as well. *"I think it [training] was pretty basic. We were shown how to log in, how to record our voice, our names so that when you are called they will get that message back, "'[That person] is not available to take your call, can you...' and it's your voice. We were shown how to...do things like call wall phones...Pretty basic stuff."* Staff Nurse 04 thought it would be important for training to include information about starting calls with questions, *"Nothing was said about what you do when you make a call to somebody. But now they're teaching them the first words out of their mouth is, "Is this a good time?' So I think the first question is clarify that the other person can talk to you before you say anything."* Staff Nurse 05 mentioned that training could have included more hands on experience. *"[M]aybe people who needed more hands on they could actually make the phone calls or... instead of just hearing about it they could actually have people calling each other using the product."*

Nurse Manager 03 noted that HFCDs represented a learning curve for users. *"Yeah it [Vocera] was a huge, huge learning curve...There's a lot of learning curve and getting used to the system."* That learning curve extended to IT staff as well. IT Staff 04 explained, *"I think we're still in a learning curve because all of those things require*

somebody to do something. I have to add myself to that group in order to receive that call and we're still in a training curve in getting people to do those kind of things. And it'll come and I think it's already sparking a lot of conversation."

Actual usage was reported as an important factor in learning how to use HFCDs. Employees at Hospital X were given training three weeks before they actually used the devices. Subjects repeatedly stated the gap between training and usage was unhelpful and that retraining was needed. *"When you're trained on a piece of equipment you really don't get it until you start using it. And then after you get it...especially in three months period, you should go back and...retrain because there are so many things that you missed, because the technology was so new."* Nurse Manager 01 reported the effect of the gap between training and use results in staff not using the full functionality of HFCDs. *"That's one thing I'm trying to get into my staff's head when they call a physician they can call the physician directly back to the Vocera. [T]hey're not really using that and we really need to start using that because they'll say; one of the biggest complaints is when they call, 'oh I have to wait by the phone.' 'Well, no you don't'...[I]t just hasn't clicked. And that's why we need to go back for retraining."* IT Staff 03 concurred, *"We kind of threw them a curve and said here's all this new technology, 'Please go [at]tend classes.' But then they didn't use it for a week to two weeks, and now all of the sudden you've got all of these changes and you're trying to adjust to all of those. And obviously that's tough. I mean that would be tough on anybody. And so I think we've looked at, and I think what we've learned is, is you really have to go back and refresh that training sometimes. And so we came back and we've done some training refreshing."*

Some nurse managers reported having to advocate on behalf of the HFCD system to staff after HFCDs were implemented. Nurse Manager 01 described her experience. *"[C]onstant training...and constant going back and saying... 'it can't do this it can do this it can do this.' And also being a manager is very much being a cheerleader. Y'know and saying this is helping...it's just constant reinforcement of how to use a tool, that you have to use the tool... that's part of your job, that you're using it properly, and that being a cheerleader."* Nurse Manager 02 added, *"You also kind of feel a little bit like a sales rep which has been hard. I know we've all said that. 'Man, I feel like a sales rep for this thing'...[Y]ou want Hospital X's investment to be well utilized, you want the staff to appreciate [Vocera], so you're positive and you're trying to sell it and that's been, sometimes it feels kinda weird. Cuz you feel like a Vocera sales rep."* IT 07 felt she had underestimated the difficulty of gaining HFCD acceptance among end users. *"The level of commitment you need to have for the ownership in it at the end user level was a little bit more than I anticipated."*

IT Staff 08 described his experience with advocating HFCDs. *"People still are curious about and I guess they're really saying, 'why do we need it?'... I'll just use the example, my parents, I remember for many years, 'I don't need a microwave.' Y'know and then it was, 'why would I ever stop at that ATM machine?' My parents are saying that but now they can't imagine being without it. That kinda type of stuff that you see with new technology. Y'know you walk out and you tell a nurse, 'You can get a hold of Joe anytime you need to.' 'Well why do I need to do that? Why don't I just call them on the overhead.' 'Well you could, but what if he's not near the overhead speaker he doesn't hear it.' So...that sorta thing I find interesting."*

Nurse Manager 03 described some nurses being more accepting of HFCD technology. *"We have different levels of accountability between our nurses some people are accountable and realize they need to absorb all the information and read their email and we have others who don't...they come here, they do their job...[S]ome people are more into technology than others, some people are more accountable than others...so it just it takes a lot of repetitive and then once people start to get it then even go back another month or two months later and repeat the whole thing all over again."*

In counterpoint, Staff Nurse 06 explained her perspective on staying updated with HFCDs. *"We get reminders on the email about Vocera updates. I'm gonna spend my break reading about updates on Vocera? Cuz I can't check my email when I'm out on the unit. I can only check my email when I'm on break. I'm not going to spend my lunch hour reading five different updates on Vocera. So y'know management doesn't take the time to actually talk to you about, 'Well you know there's some new...' It would take 10 minutes to come into the staff room and say, "...[L]et's go over some new techniques on Vocera. Any questions?" I just delete [the emails]. Don't have time for them."*

3.4 THEME: ORGANIZATIONAL CHANGE

Organizational Change refers to issues relating to how HFCD affects communication among and between people across an organization. Concepts related to this theme are: understanding other departments' work, having to resolve organizational issues of authority and responsibility, and achieving goals of the organization.

IT staff subjects related how working on HFCD projects enabled them to see clinical care workflow and better understand the work of nurses. IT Staff 01 explained, *"I'm hiding in my world which is IT. I wasn't really aware of that [clinicians finding and*

wasting time]. I mean I know of other problems that they had, but [this] was quite interesting to see." And it had impact upon her perception of clinical work, *"[I]t's made me more sympathetic to what [nurses] go through, having to see what kinda of things that they're under and so much responsibility."*

IT Staff 01's experience led her to better understand clinical communication and how it differs from IT communication. *"IT technology is our world, and because we're not in patient care it's expected of us to check e-mail constantly or be responsive to it. And it's interesting to see other areas where patient care is their number one focus and that [e-mail is] not a priority. And so just seeing different things just helped me realize why some [nurses] act a certain way."*

IT Staff 02 described his experience of going out on the floor to install HFCD wireless access points. *"When we were first going out and hanging the wireless access points in the ceiling, I'm walking through areas where...there's patients pushing IV bottles around and when you're working for a hospital you realize, holy cow! We're not making toasters here, this is really important stuff going on every single day... Now I was hanging up one access point outside this room and this lady comes out and says, 'yes he's here,' it was one of the birthing rooms. 'Yes he's here, he was born 10 minutes ago.' I thought, ahh that was kind of an exciting little moment there because I remember when I went through that with my daughter being born and uh it really drove home the fact that we are not making toasters here, this is good important stuff. So I've really wanted Vocera to work and work really well and not be an albatross around people's necks, to be a communication tool that makes their lives easier."*

wasting time]. I mean I know of other problems that they had, but [this] was quite interesting to see." And it had impact upon her perception of clinical work, *"[I]t's made me more sympathetic to what [nurses] go through, having to see what kinda of things that they're under and so much responsibility."*

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Some IT staff reported no difference in their dealings with or how they support nurses' communications. IT Staff 06 observed, *"[Immediate communication between clinical and IT] doesn't have a big impact on IT, on us."* IT Staff 07 decided, *"clinicians and IT? Ummm...I don't know that it has a direct relationship there other than we again are a supporting body to the clinical environment. So for us it's one more piece of equipment deployed."*

IT Staff 08 at first answered that HFCDs are just *"one more piece of technology,"* but later revised his answer. *"[N]ow I actually visit a nurse wing if there's a problem whereas before...[w]e never really did have to go out to the environments and then interface in that way, but with this technology there's a direct correlation to, 'hey this is brand new stuff so we as the engineers do interface with the end user during its original deployment.'"* The effect it has upon his work? He answered, *"Me personally I guess...you kinda always realize that health care is going on out there but when you're not out in the field so to speak you don't really see how the nurses interact and how more day-to-day workflow goes...it's sort of an eye opener... from my viewpoint if somebody's badge doesn't work...I used to think, 'We have 5000 badges out there. If one badge doesn't work how is that a big problem?' But when you go out on the floor and that one person is, 'got that badge.' Right? It kinda makes you think, 'well...to them that is probably the most important thing to them right now.' So...it kinda opens up your eyes a little bit."*

Staff nurses reported very little interaction with IT or other departments for that matter. Staff Nurse 03 reported what many expressed, *"I haven't noticed much communication to tell you the truth aside from just the floor."*

Nurse managers reported more communications with IT as well as with other departments. Nurse Manager 01 related what communications with IT brought, *"Well I think they [IT] learned from us about workflow and about how we communicate with each other and that type of thing... I learned more about servers, having a backup server, and... just how technology works...databases and how to build them and what can interface with what and all those types of things."* Nurse Manager 02 described her relationship with IT as one that now gives her more *"allies out there."* She also explained, *"[B]efore [IT] was...a telephone number I called for the help desk and we've developed a really, very good relationship with our [IT] partners on this project. And I of course use them for other things now because I know who to ask and who they are instead of just a help desk number."*

Nurse Manager 05 described how he relied upon a departmental "super user" to help resolve HFCD issues. *"There's this one gentleman, our IS coordinator for surgery who I was connecting with routinely and his predecessor routinely via phone and now carries Vocera. So we talk as much as we did before."*

Nurse Manager 07 described HFCDs providing access to outside departments. *"I might even have more communication with outside departments and some of the other managers, but it has allowed me to have quicker communication with other departments."* As did Nurse Manager 09, *"[I]f [my coworker]...is over at [another facility] I can Vocera her and get her [there]. So that's really nice."*

A challenge of implementing HFCDs is that authority and responsibility need to be assigned to appropriate departments. IT Staff 05 described the challenge. *"I think the project didn't contemplate that that impact post-live... there's so much attention to*

making sure it was successful at live but then two weeks later when a badge goes dead who do they call? And that was absolutely, it wasn't necessarily an unintended consequence but it was...an unforeseen issue that had to be mediated and resolved."

Nurse Manager 02 described the result of unclear communication roles and responsibilities. *"Clinical engineering does the nurse call and [IT] does [Vocera]. Oh man, that has been really hard and really frustrating...All I'll know is that nurses aren't getting their [Vocera calls]. So there's a bed piece and it's got the piece that plugs into the wall, and then from the wall through wireless to Vocera is the nurse call interface. And then once it goes to Vocera then have Vocera handle it is yet another department, [IT], that has been my most difficult thing to maneuver through this. If we just had Vocera to go up with, it would've been much, much, much smoother."*

The implementation and integration of a patient-nurse call system at Hospital X did not meet the needs of nurses who demand immediate call and answer functionality. The system is set up so that when a patient calls a nurse from the bed, the patient's call is sent as a notification to the assigned nurse's HFCD. The nurse may then use the HFCD to call back to the patient. To do so, the HFCD must find an outside phone line, dial a number and call the patient's pillow speaker through which the nurse and patient are able to converse. Subjects described the communication loop from nurse to patient as taking too long, 45 seconds to a minute, to be considered effective. (Figure 9) In addition, the HUC may have also received a call from the patient in which case the HUC attempts to call the nurse. The HUC's call may not get through because the nurse already is attempting to call the patient, in which case, the HUC leaves a message on the HFCD. Rather than make the phone call back to the patient, nurses walk to the room to ask the patient how they can be

of help. Delays in the communication loop between the patient and nurse caused the nurse to revert to the communication access workflow prior to the HFCD implementation. Therefore, for HFCD systems to be considered successful, calls should provide fast throughput to intended call recipients.

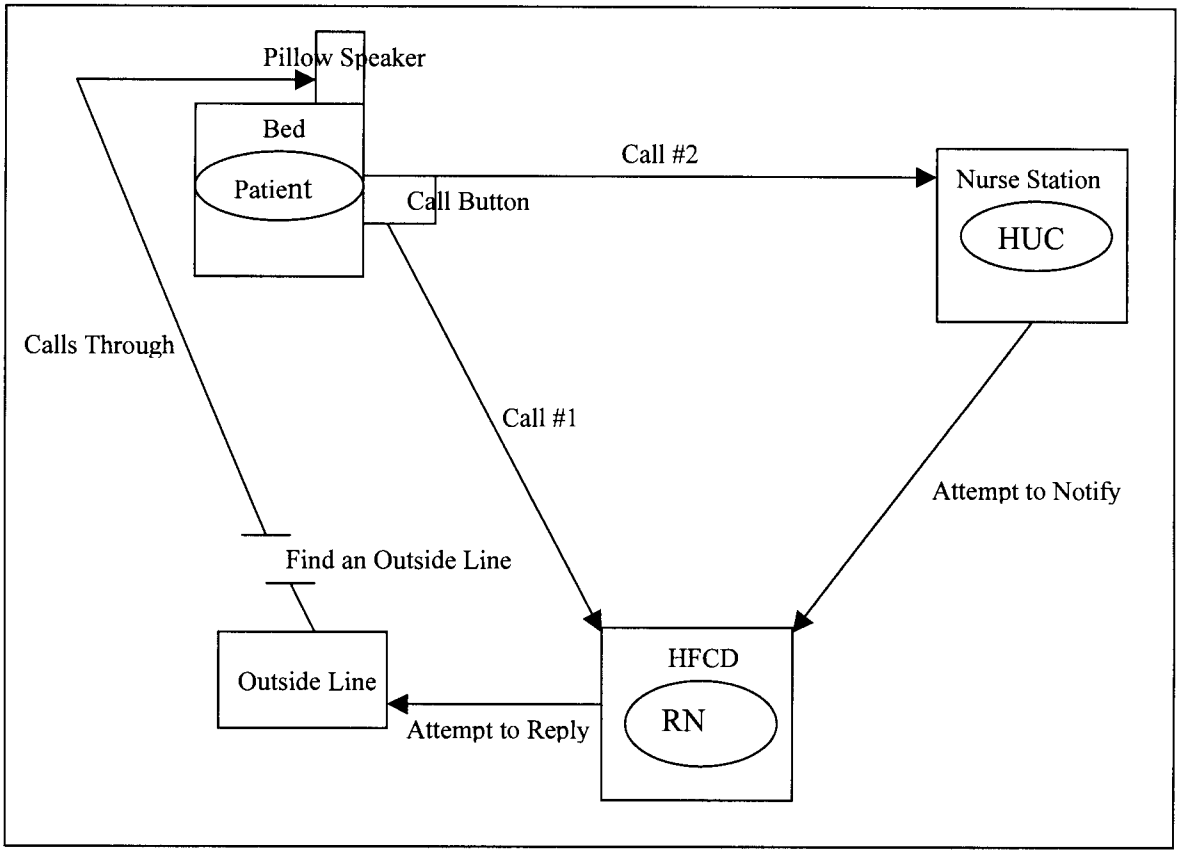

Figure 10. Nurse Patient-Call System. Patient to nurse communication loop was reported by clinical staff as being too lengthy and convoluted to be effective.

IT 05 talked about this challenge from the IT perspective and noted that the *"congruence of voice and data,"* brought together by HFCDs, represented a particular challenge for assigning departmental responsibility and authority. *"[I]t has been a surprise because the word I was going to use is Vocera sort of 'snuck up' on us that way. And how it manifested itself is to whom do they call? Is it a phone and they call our communications department? Or is it an IP device and they call our network the network*

group? I think we solved that I do believe they call telecom but...all the deployment was through the network people because it was IP-based and telecommunications."

Some subjects believed that the ability for staff to communicate across departments, as well as have communication access, could bring about significant staffing changes and even elimination of health unit coordinators (HUCs) or unit secretaries. IT 05 explained, "*[Vocera can] dramatically, I think, transformatively [change communication on an organizational scale]... Even the term secretary...whose role is...managing the paper and communication process of that unit. Well, if you're going paperless to an electronic health record and you have the easy communication...do you need those people? Or if you still need those people are there other things they can do to add value to the clinical team and not having to track down a physician or nurse?"* NM 10 described that as they move into a new building, the HFCD system will be integrated into the nurse-call system. As patients would then be able to communicate directly with nurses, and nurses being able to communicate directly with each other, NM 10 questioned whether the roles of HUCs would be needed. "*When we move to the tower in this unit and the orthopedic unit will have our call system hooked up to the Vocera. That would just be awesome. Cuz right now what happens is you have a call system, it the intercom is at the nurse's station, the HUC or the charge nurse will ask what the patient needs and then communicate with the nurse. Where when we have it hooked up to Vocera I see us losing that whole piece where you know immediately the patient needs you and be able to communicate with them...they're [HUCs] not going to be in one centralized station and eventually we may not need them...if we don't need them to do that anymore then probably it's not a job we need to have or it will change significantly."*

3.5 THEME: ENVIRONMENT & INFRASTRUCTURE

The physical and wireless architecture impacted workflow and also impacted the quality of HFCD communications. For particularly Hospital X subjects, a considerable factor in their experience with HFCDs was moving into and getting acclimated with their new building, Building K. The Environment & Infrastructure theme describes issues relating with how building design and wireless architecture have an effect upon communication.

Hospital X subjects previously worked in units within Building Z. IT Staff 02 described the previous communication patterns as, *"For a whole lot of communication they did there were either people located in the central hub area having discussions, now they can have those same discussions with their unit secretaries, their nurse managers and things like that without leaving the bedsides."* To provide a contrast, Staff Nurse 02 preferred the previous unit, *"There was a lot more relaxed, easier connection I think [in the old unit]."* Opinions of the unit in Building Z were mixed, some thought it made for a better workplace while others found it too "claustrophobic."

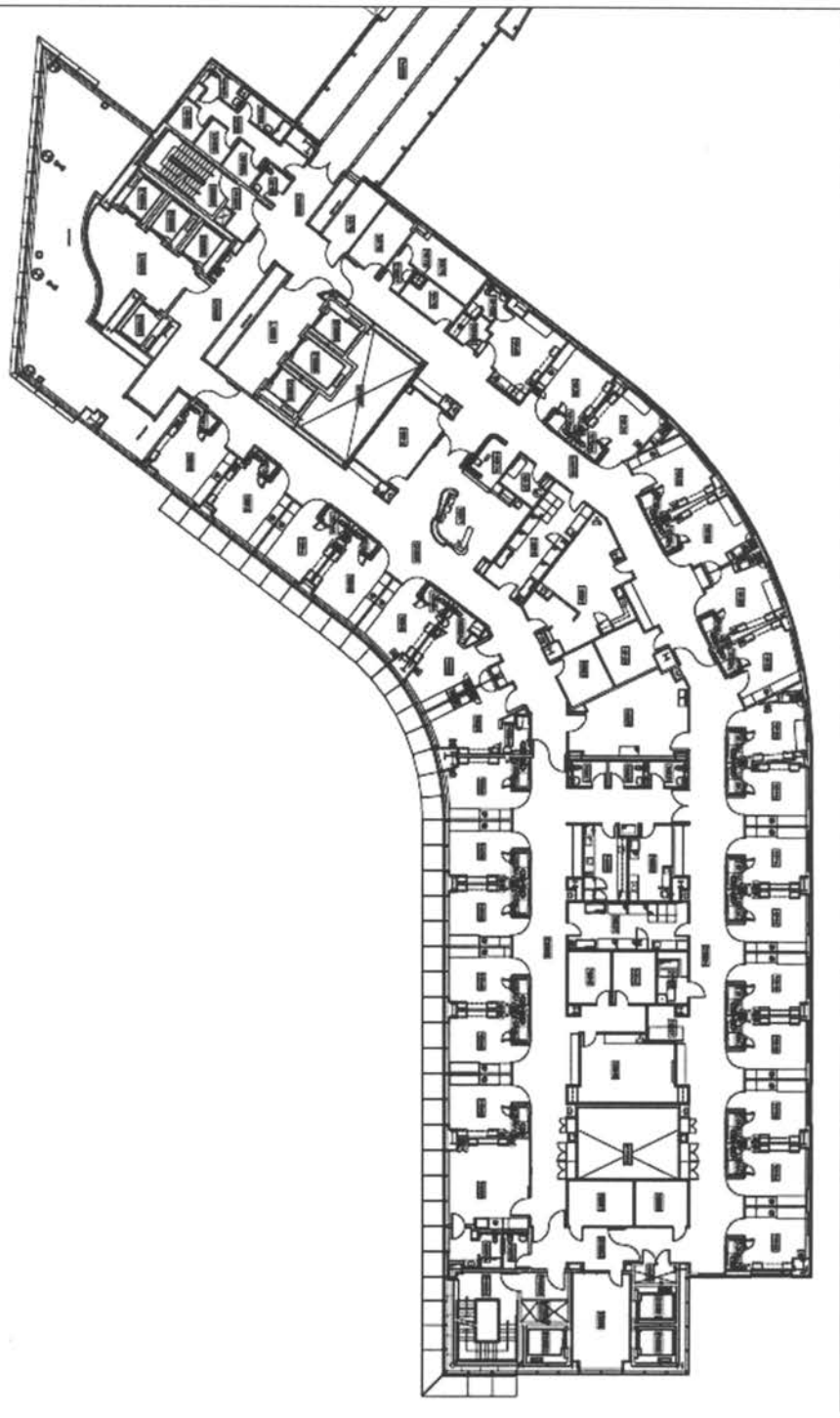

Figure 9: Floor plan of Building K
The floor plan curves so that nurses at one end of the building can't see nurses at the other end of the building.

Hospital X subjects made many observations about the new Building K and how it changed their work and communication." *If you look at [Building K] it's designed completely different than Building Z... At [Building K] it's very spread out, you have pods around the floors so you may have one or nurses go back to that pod but you don't have the whole team go back to a central location very often because they don't need to. So they're spread out, it's a longer walk to get to certain things, they tend to communicate differently."* IT Staff 01 added, *"especially in [Building K] because the units are huge. They are very huge and so it takes so much time to find someone and Vocera was their way to reduce all that waste of time and improve productivity."*

Staff nurses agreed that the new building significantly impacted their work. Staff Nurse 02 explained, *"We're really spread out and again just because of the size I think that makes a difference,"* and Staff Nurse 03 said, *"We're so spread out our old floor used to be, had a central location where you could see the nurses station from everywhere...Now that we're spread out we've really decentralized...we spread out to different computers where we do charting and whatever which I think is great cuz I prefer to spend time at the patients' rooms anyways, I think everybody does."*

Nurse Manager 01 contemplated how moving into the building without HFCDs would affect staff, *"If we didn't have this technology when we came up in this building I do not know how the staff would've responded, because the build[ing]...is so large."* And Nurse Manager 04 explained that when surgical supplies got moved down a floor, staff saw HFCDs as an asset. *"Then when we opened that department with all those supplies moved down to the 5th floor...I think the staff realized right away that it [HFCDs] really would help them because there was, they were going huge change with their supplies*

being on a different floor and this whole new building, we were much further apart from each other now, nobody felt very tucked in."

IT Staff 05 commented that the building's design could actually support wireless communications, *"The configuration of [Hospital X] I think also facilitated a better wireless. Had there been more walls, more concrete, more interference it would have plagued a wireless infrastructure."* Considerations of space were of a concern at the Hospital Y site as well. *"I'll find out then if I have any more hidden little areas...But there's nothing I can do about it...like some of the issues we had was the nurses would go into...a big shower where they take some patients and try to use [Vocera] and...the reflection off the walls. Where they were talking they'd get that reflection and it didn't work well and Vocera came in helped us out on that and they just decided, 'oh it's your walls, y'know, this room here'" So they got the message like, 'Ok when I talk I need to go out and talk and not be inside and talk.' [C]uz there's no way that even if I put an access point in there still there would be reflections on that type of wall...[A]nd plus, do you want to put a $1500 access point there, and how often do you bring patients there? The shower? And how often do you use it?"*

4.0 Discussion

Interviews and observations generated five themes around the effects that hands free communication devices had upon communication. Those themes revealed that HFCDs positively impacted clinical and organizational communication; but additional policies, procedures, and technological advances were necessary for HFCDs to be successful.

This qualitative study furthers knowledge about HFCDs by capturing opinions from staff nurses, nurse managers, and IT staff. Twenty-seven interviews and six observations across two health care organizations provided a depth of data that helped gain insight into the effects HFCDs have upon communication as well as how they can bring about organizational change. This is the first study of its kind that investigated HFCDs.

4.1 COMMUNICATION ACCESS

Observations and interviews bear out users' preference for using HFCDs to supplement existing clinical voice communication technologies. Hands free communication devices (HFCDs) reduced the need users had for looking for phones or other information communication technologies (ICTs). HFCDs tapped into the preference nurses and other clinicians had for rich communication channels. The HFCDs' wireless capability provided users with flexibility that was necessary to carry out clinical work.

As most responded in interviews, HFCDs provided users with improved "communication access." Improved communication access reduced the amount of wait time between messages, and increased the likelihood that messages were promptly acknowledged and responded to. Faster turnaround times between messages were described as beneficial and more useful than pagers. Reddy et al. explained that pagers were limited due to "missing feedback mechanisms." [23] The subjects in this study

believed having immediate and direct responses from others provided them feedback that was helpful and beneficial.

Users discussed appreciating the ability to hear voices through the HFCDs. Again, Reddy et al. described pagers as not having the ability to convey a sense of call priority thereby resulting in "missing context." [23] Users described HFCDs providing more context to clinical communications. The sound of a person's voice on a speaker helped users determine the level of priority that should be attributed to a specific communication. Increased context was also beneficial for a number of communication tasks: obtaining answers to patient-related questions, querying staff members about their current location in the workplace, contacting ancillary staff, or for contacting people outside the unit such as vendors.

Subjects reported pre-HFCD workflow as highly interruptive. The highly interruptive environment caused nurses to step away from patients to issue or receive communications. The process of trying to communicate with one another using common technologies such as pagers and telephones were considered time consuming, frustrating, stressful, and inefficient.

Previous solutions for a lack of communication access was to have information technologies scattered across the workplace. This placed additional difficulties in finding information. Users had to walk to wall phones or to a central nursing station to issue and receive communications. Staff nurses and nurse managers described how sometimes to ask for help, they would at times yell down clinic hallways to get one another's attention. This was described as undesirable, for yelling made the care environment less pleasant for patients and visitors alike.

IT subjects also described the interruptive nature of the clinical environment. Many IT workers reported not having much exposure to clinical workflow prior to HFCD implementations. They expressed surprise that clinical workflow was as fluid and interruption-driven as they had come to learn.

The nature of communication in clinical settings described by Coiera and Tombs as well as Coiera et al. described the scenarios as explained by the subjects and witnessed in observations in this study. As Coiera and Tombs described, nurses and nurse managers were highly mobile, highly reliant on synchronous communication channels, and asked questions as issues arose. [12] The clinical environment was an interruptive environment in which clinicians often underestimated the impact their questions had upon others. [13]

The types of questions people asked through their HFCDs were where others were located, informing others that a phone call was on hold, notifying them that an ancillary service such as transportation had arrived at the unit, or that visitors were requesting to see a patient. Many of these types of questions relate to what Reddy et al. described as organizational questions. These types of questions relate to questions and information required for the coordination of patient care. Reddy et al. described this as the "glue" considered essential for effective patient care.

Many subjects discussed how nurses and nurse managers had become reliant upon HFCD technology and thought it would not be beneficial to return to previous means of communication. Nurse managers explained that during times when the HFCD system went down, the staff complained that they did not have rapid communication access. The relatively short time that staff came to depend upon HFCDs could be the result of a relatively rapid "adoption rate." [88] Rogers explains that as more users adopt an

innovation, the innovation reaches a "critical mass" at which point the innovation becomes "self-sustaining."

4.2 CONTROL

The ability of subjects to access and correctly use the voice commands of the devices was a common issue brought to the attention of the researcher. Although subjects from all three groups acknowledged the frustration associated with verbal commands not being understood by the HFCDs, the intensity of opinion was not equally shared across the groups. IT staff and nurse managers believed the voice recognition technology worked sufficiently whereas opinions from the nurses were more mixed. Staff nurses reported that HFCDs had difficulties with accents. The difficulty of accents extended from the wearer who had an accent, to the wearer without an accent who attempted to contact someone with a name they found difficult to pronounce.

Nurses complained of the frustration they felt when the device did not understand their voice commands. Anecdotally, the rate at which the device did not understand user commands varied between 33% and 95%. Most subjects described the frustration they felt when the device did not understand the verbal commands. Some staff nurses explained the voice recognition technology did not meet their expectations.

A challenge associated with the use of HFCDs was the ability of users to issue verbal commands, role names, and personal names within the specified order required by HFCD technology. HFCDs were unable to function if there was any deviation from the prescribed command structure.

A case of a nurse that was attempting to contact the pharmacy department provides a useful case study. The nurse wanted to contact the pharmacy and so issued the command

to "call pharmacy." Unbeknownst to her, or perhaps she had forgotten, was that there were five pharmacies from which to choose. It was up to her to specify which exact pharmacy she intended to contact. The HFCD provided her no feedback by requesting she specify which pharmacy she intended to contact. Instead the HFCD was unable to carry out her command. After repeated tries, the nurse used a telephone to carry out her communication.

As an HFCD communication network grows, and the number of contacts grows, the demands upon users to issue correct personal names, roles, and departments will become more burdensome. Rogers offers the equation n(n-1)/2 to calculate the number of possible links that exist within a communication network. As an example, a health care organization that has 1500 users linked by HFCDs can expect a possible 1,124,250 links in its communication network. As HFCD networks are expanded it will be increasingly difficult for users to remember the large number of commands, units, roles, and personal names. Some form of support either in the form of training, communication mediators such as operators or unit secretaries, or improvements in the technology will be required to support clinical HFCD users.

Some described HFCDs as nothing more than a speakerphone worn around one's neck. Collectively, interviews and observations revealed that HFCDs actually required changes in the way communications were made and tasks were carried out. Staff nurses and nurse managers reported to varying degrees that HFCDs required them to shift their thinking about the tasks. Described by some as developing a sense of control over the HFCDs, some pointed to training or retraining as a solution while others pointed to increasing the technological capabilities of the device as another solution, or both. The

implementation of HFCDs is not a benign change. Rather, it requires users to rethink the way they communicate with one another and carry out clinical tasks.

Referring back to Coiera's work, one aspect of clinical communication was interruptions that clinicians imposed on each other. As more nurses, nurse managers, and even IT staff were connected and "always on" with HFCDs, the need to learn how to "control" the device became important. Previous studies focused on the ability to provide users with improved communication access through HFCDs, but few described the issues pertaining to how users have to learn to use HFCDs, learn to rely on HFCDs, and learn to integrate HFCDs into their workflow. Subjects in this study referred to this process as control. Control is made up of two subthemes: social control and technical control. Nurses described that the interruptions negatively affected their work and got in the way of delivering effective patient care. They described difficulty returning to the task at hand after being interrupted by their HFCDs.

The ability to use the functionality of the HFCDs and the ability to integrate them into clinical workflow had not been thoroughly investigated. St. Jacques et al. found that users experienced moments when the HFCDs were set off by environmental noise. In addition, St. Jacques et al. reported that users felt the HFCDs were less "reliable" than pagers, but that additional training might have helped reduce such incidents. The authors did not explain how training could have specifically addressed the device turning on or its unreliability when compared to pagers.

The subjects in this research described having to learn how to use the devices. Even more than having to learn how to use the devices, the users explained needing to learn how to perform work while wearing HFCDs. One subject went as far as to say that the

device "changed the psychology of nursing." Many users, regardless of their enthusiasm for or skepticism about the technology, described having to go through a learning process with HFCDs.

Groups differed as to their perceptions of control over HFCDs. All IT subjects believed that HFCDs were a positive technological addition to clinical workflow, particularly since they addressed communication access. Nurse managers also uniformly agreed that users, the organization, and patients benefited from staff utilizing HFCDs. Nurse managers, though, related experiences of their own learning how to balance HFCDs with clinical work. Staff nurses, though, were more mixed in their opinion about HFCDs, some holding off opinions about the technology for the time being, waiting to see if the technology's speech recognition improved or if it could be better integrated into their personal work habits.

The difference in perceptions of the utility from each of the groups perhaps demonstrates different understandings of clinical work and communication. From IT's perspective, HFCDs improve clinical communication and workflow because communication access was improved. Nurses and nurse managers may have seen more of a tradeoff than did IT staff; while nurses and nurse managers may have saved time having to locate phones or one another, they also saw that HFCDs changed the tasks of their work and therefore required adjustments to those tasks. Those adjustments include: learning how to handle or manage HFCD interruptions, manage conflicting communication channels, protect patient confidentiality, and develop HFCD etiquette.

Nurses described the feeling of not being able to place the HFCD on "Do Not Disturb." IT staff often touted the ability to halt incoming calls during times when the

user wanted to remain unavailable. Nurses, though, felt that the decision to do so was more complicated. Nurses expressed feelings that although they could technically place the HFCDs on hold, the desire to always be open to receive information about their patients prevented them from putting the devices on hold. This then opened up nurses to a vicious cycle of feeling interrupted but having little control over being able to limit interruptions.

Interruptions in the form of voice calls were a particular problem and were particularly an issue that newer users at Hospital X were still learning to manage. The phrase "getting control" over the HFCD device was referred to as a process that users were either learning how to overcome or was a process that they had to go through. A nurse manager who described herself as an *"enthusiastic"* user of HFCDs described her surprise at how *"frustrated"* she got when trying to work using an HFCD. That process meant going through a mental understanding that the device can be turned on and off, and that she could use its functionality to handle calls as she saw fit. Her advice to new users was to not become "enslaved" by the device. Others, more so nurses and nurse managers than IT staff, of trying to overcome interruptions and gaining control of HFCDs, told similar stories.

Donald A. Norman, who has written extensively on usability, developed the model of activity comprised of a "gulf of execution" and a "gulf of evaluation." Each gulf must be overcome for users to use an artifact and carry out an intended task. To cross each gulf, devices such as HFCDs must assist users by providing appropriate feedback mechanisms or design. Without feedback from the HFCD to make a correct command, a user will be unable to cross either the gulf of execution or the gulf of evaluation. [90]

In the use of HFCDs, it appears users would benefit from improved design of the speech recognition capabilities so that the system better supports users in their commands.

4.3 TRAINING

Training and continued training were thought to be important ways for users to better internalize the processes required for using HFCDs. Training was conducted at Hospital X as HFCDs were rolled out. Users were introduced to the device and taught how to use the basic functionality. IT staff reported going into the clinics for follow-up training if HFCD reports detailed a particular person having difficulties using an HFCD. Updates and other information were sent to staff in e-mails. One nurse complained that time limitations prevented her from reading e-mail updates unless she devoted time during her break or lunch to do so. She felt personalized training should have been made available during staff meetings or at other dedicated times. Hospital Y provided continued training in the form of "super users," IT staff who worked closely with nurses and were available to units for one-on-one assistance. In addition, online tutorials were made available to staff.

Nurse managers reported having to make efforts to advocate heavily for staff to use the devices. IT staff described encouraging nurse buy-in of the technology, and that clinical staff had to be convinced to use the technology. For nurse managers, the effort made them feel as if they had to sell the technology to their staffs and others. They had to evangelize the technology, explain to staff how an HFCD call is routed, and that if a call did not reach the intended audience, it may not have been the fault of HFCD technology

but rather the underlying wireless infrastructure. Nurse managers also described having to promote HFCD technology to visiting hospital administrators who came to learn more about HFCDs. For IT staff, training and advocacy had to be ongoing. Identifying users that were having difficulty using the technology and retraining was considered an important job function of IT staff. In addition, IT staff reported it was important to explain to clinical staff how and why wireless architecture works, or at times does not work. Training, retraining, and continual advocacy of HFCD technology was important in order to reach a "critical mass" [88] of support among users. IT staff and nurse managers felt that critical mass was being achieved in that word of mouth was causing interest in HFCD technology among those groups without HFCDs.

4.4 ORGANIZATIONAL CHANGE

The implementation, use, and support of HFCDs brought about change in relationships between departments. IT staff reported their experiences working on the clinic floors, installing equipment and supporting HFCDs, gave them a better sense of the work being conducted in the clinic. Seeing work being conducted in the clinic and observing clinical workflow first-hand made some IT staff members describe newfound empathy for the work nurse managers and nurses perform. Before the implementation of HFCDs, IT staff described how they were unaware why it took a long time for nurses to answer phones and emails. After HFCDs were installed, IT staff explained they knew more about why those delays occurred.

Nurse managers and nurses, though, did not describe as much as a change in relationship with IT. Some nurse managers, who were involved with the HFCD installation at Hospital X, felt that they did learn more about technology such as servers

and networking. One nurse manager described appreciating IT more and that she felt she had, "more allies out there" now that she had personal relationships with IT. One nurse pointed out that he thought IT was "great" and that they would come out "in a moment's notice" when an issue arose with HFCDs.

Some subjects described they saw HFCDs changing the organization in that because staff that were in direct communication with one another, it may eliminate the need for, or significantly alter the roles of, health unit secretaries (HUCs).

One IT subject described the IT challenge of supporting HFCDs. As HFCDs were a "congruence" of "voice and data," traditional organizational responsibility and authority for telecom and applications required modification. This posed a particular challenge for nurse managers when multiple technologies were integrated into the nurse-patient call system. One nurse manager explained the difficulty associated with not knowing whom to call should the system fail. As the workings are all hidden from clinical staff, the nurse manager described having to make multiple calls in order to find help when the nurse-patient call system fails. Nurse managers explained that HFCD failures or down times created skepticism about HFCDs among staff nurses. Skepticism had to be actively addressed by nurse managers in one-on-one and group settings.

4.5 ENVIRONMENT AND INFRASTRUCTURE

Subjects felt that HFCDs were valuable in allowing clinical staff to remain in contact with one another when the physical environment made it otherwise difficult to do so. In Building K where nurses were distributed across large floor spaces, it was reported that HFCDs allowed them to find one another, retrieve help, feel secure that they could receive help, and contact one another. HFCDs were described as being helpful for

combating any "isolation feelings" that users might have had from working on such large clinic floors.

Still, the devices did not preclude people from still walking the floors to find one another to communicate. Users described using HFCDs solely as a locator device so that once a caller contacted a receiver and discovered where the receiver was located, the caller would walk to the location to have a face-to-face discussion. It was not discovered what types of conversations would lend themselves to face-to-face discussions as the researcher did not investigate why, but this could be done in future research.

Subjects described that the physical makeup of the building had impact upon the installation of HFCD technology, and conversely, HFCD technology had impact upon the physical makeup of the building. IT staff explained that wireless access had to be made available in previously unthought-of of physical areas such as elevators, stairwells, and even shower rooms. As users moved from area to area, they expected their communications to move with them and not to have any drops in signal. IT staff noted that ancillary staff who moved from unit to unit where HFCD communications were supported in one but not the other, developed negative impressions of HFCD technology due to the drops in service. The drops in service, though, were only because the wireless architecture hadn't been extended across the entire facility and therefore weren't caused by an HFCD shortcoming. IT staff described with some frustration how users expected HFCD communications to occur without any drops in coverage whereas users might have been more forgiving with their own personal experiences with failures of cell phone drops.

Just as IT staff needed to tailor the wireless infrastructure to meet the needs of the building, it was described that the building itself needed to be tailored to meet the needs of the wireless infrastructure. One subject explained that Building K's architecture was designed with open hallways, fewer walls and less concrete so to lessen the chance of wireless signals being interrupted.

An impact of having users physically distributed on clinic floors could be related to feelings of increased interruptions. Mark et al. [42] suggest that unlike workers who are "co-located" and who then are "more aware of natural breaking points before interrupting others," distributed workers do not have the same awareness. Because distributed workers do not have the same awareness, they may feel that interruptions are more "disruptive" than "beneficial." [42] One explanation for the frustrations at interruptions described by physically distributed users could be that HFCD calls not only occur frequently but also do so without context to the distributed user's workflow.

4.6 LIMITATIONS

A number of factors are considered limitations for this research project. First, the researcher interviewed and observed subjects from two health care facilities based upon their geographical proximity to the researcher and their use of HFCDs. As such, this study should not be considered generalizable to other healthcare organizations. However, qualitative studies can be "transferable." That is, results from qualitative studies should be looked at as providing applicable results if the context of the second site is considered "congruent" to the first site. [91]

In addition, the researcher consulted with another researcher to verify that coding during analysis was independently verified. Still, all of the coding was conducted by the researcher and thus may have reduced the trustworthiness of the codes.

Time was also a limitation in that observations were limited to a maximum of two hours per session. Observation times also differed in that sessions lasted for two hours in Hospital X while observation sessions in Hospital Y lasted for only one hour in length. Additional observation time in both sites may have revealed different work patterns and uses of HFCD technology not made apparent to the researcher.

The study group represented a wide spectrum of units and users. Although this provided a broad variety of opinions, it can also be stated that there might have been significant differences in the way that HFCDs are used within each unit, i.e. HFCD use in OR suites as opposed to HFCD use on patient floors. In addition, users in Hospital Y had as many as two years additional experience using HFCDs than did users from Hospital X.

Finally, the researcher had an opportunity to attend a training session at Hospital X but did not have an opportunity to attend a training session at Hospital Y. At Hospital X, trainees were given demonstrations regarding the physical design of HFCDs, how to use functions such as calling, messaging, and recording greetings, and were provided with handouts that covered address book names, groups, as well as PowerPoint slides about the training session. The researcher was unable to confirm what exact training materials and lessons were provided for users at Hospital Y.

5.0 IMPLICATIONS

The research revealed that the implementation and use of hands free communication devices (HFCDs) had specific implications for staff nurses, nurse managers, and IT staff. This section will cover apparent impacts HFCDs had to each of the three groups. In addition, implications for future research will be described.

5.1 IMPLICATIONS FOR STAFF NURSES

The implementation of HFCDs enabled users to contact one another for issues of communication access: fast access to a phone, ability to locate staff, and ability to access help. The individual user that had communication access to others, though, was also made accessible to others. Users, then, were made susceptible to interruptions. It was important for users to develop control of the HFCDs by taking advantage of its functionality, i.e. the Do Not Disturb button.

The ability to effectively integrate the functionality of the device into clinical workflow occurred at different rates for different people. The primary reason was that wearing an instant communication device, whether it was an HFCD or some other technology, changed the work of nursing. Nurses described needing to learn how to integrate the technology into their workflow, prioritize calls, turn the HFCD off when they do not want to be disturbed, and to turn the HFCD back on when the nurse was ready for contact. Integrating the technology into clinical workflow was to develop a new skill. Like other skills, integrating HFCDs took time and effort. Users should expect support, training, and improvements to the technology in order to help integrate HFCD technology into their workflow.

The use of HFCDs was just as much a social device as a communication device. Users used HFCDs not as much as a telephone but more like instant messaging. As such, HFCDs should be thought of not as a speakerphone that one wears around one's neck, but rather as a mobile computing device; where instead of a keyboard and mouse as input devices, one's voice is used, and instead of a monitor to provide feedback a microphone and speaker is used. The instant nature of HFCD communication meant that etiquette needed to be considered and developed when using HFCDS. To address patient confidentiality, users might begin each HFCD call with the phrase, "Is now a good time to talk?"

Clinicians have been shown to underestimate the impact of their interruptions upon others. To lessen the impact of interruptions, staff might consider before making an HFCD call if the need for information requires an immediate response from the intended recipient. Finally, the use of nicknames should not be used for it can have an effect upon other people inside and outside the department being able to access the user. Also, nicknames might not be considered appropriate in a professional setting.

5.2 IMPLICATIONS FOR NURSE MANAGERS

Nurse mangers, more than staff nurses, uniformly saw HFCDs as a benefit to users, the organization, and patients alike. Nurse managers felt they were able to provide better support to their staffs, issue messages to staff, and receive support from other nurse managers. Nurse managers too described balancing the challenges of communication access with the challenges of control over HFCDs.

All nurse managers believed that HFCDs ultimately benefited patient care, or at least, none of the nurse managers felt that HFCDs detracted from patient care. They felt it was

beneficial for their teams to be able to have communication access and that HFCDs provided that. For their own parts, nurse managers used HFCDs for a wide variety of calls such as preparing surgical suites, or posing questions to other nurse managers. HFCD calls also pertained to issues such as labor contracts, broadcasting messages to staff to ask if any would like to work additional hours, or lastly to communicate with vendors and asking questions about equipment.

Nurse managers described how HFCDs fit into the model of clinical care more from a system point of view rather than a task point of view. They saw themselves as issuing directives, encouraging usage, and advocating HFCD use among their staff. They also pushed to have staff receive continual training and support to integrate HFCDs. These actions were taken in part to overcome what some saw as user resistance. A mix of advocacy, encouragement, and punishment were used to get users to wear, log in, and communicate with HFCDs.

Nurse managers had to deal with staff nurses who applied nicknames, sometimes-inappropriate nicknames, to HFCDs. In such cases there was variability as to how individual cases were handled. Some nurse managers chose to address the issue with individual staff, other nurse managers chose to address the issue when reports were due, others still looked to the organization to provide them with guidance but found it lacking.

HFCDs' integration with nurse-call systems was of interest to nurse managers, for they felt the system could greatly improve patient responsiveness. Two issues arose out of one unit's experience with the system. First, the communication loop from the patient to the nurse and back to the patient took too much time for the system to be considered effective. Second, when a problem with the nurse-call system occurred, it was difficult

for the nurse manager to know which department was responsible for fixing the problem. HFCDs represent a confluence of information and communication technologies and therefore do not hold to traditional models of IT and Telecom support.

5.3 IMPLICATIONS FOR INFORMATION TECHNOLOGY STAFF

Subjects that worked within the Information Technology (IT) teams uniformly perceived HFCDs as having a positive impact upon clinical care. They most often described HFCDs as addressing, and overcoming, the challenges of communication access. Although IT staff saw the need for training and support, they did not mention the problems associated with control as much as the nurses or nurse managers did. IT staff attributed most user-related issues to a lack of, or a need for, training rather than noting that HFCDs' interruption rates, conflicting communication channels, or etiquette changed clinical tasks.

IT subjects expectedly described issues revolving around the technology of HFCDs. They pointed out that despite the relative newness of the technology, it works and that it has generated excitement among nurses. For that reason IT saw it as a "good project" to work on. IT staff, though, described how they had to overcome barriers to implementation such as HFCD badges that fell apart, or dropped calls. Technical breakdowns or system failures had significant impact upon clinical staff, as they described they had become dependent upon HFCDs. Technical issues were still being addressed but IT staff for the most part were impressed with HFCD technology.

IT staff also saw their roles as trainers, and to assist clinical staff with questions about usability, like improving the voice recognition rate and insuring that the wireless network was working. To support the users, IT staff employed methods such as employing an IT

"super user" that directly addressed clinicians' HFCD issues, providing access to online training materials, providing one-on-one help to those having difficulty using the badges, as well as sending out weekly e-mails that provided tips on using HFCDs. One organization opened up a help desk to directly address HFCD questions but reported the help desk was underutilized.

IT staff interaction with clinical staff helped IT workers to better understand clinical workflow. IT subjects reported that the experience helped them understand the issues and challenges that nurses deal with in providing patient care and that from the experience they empathized more with clinicians.

HFCDs are an information and communication technology that bring together voice and data. As such, authority and responsibility traditionally shared between computer support and telecom needed to be recalibrated. Users reported having difficulty knowing whom to call if and when the HFCD system went down.

5.4 IMPLICATIONS OF LINSTONE'S FRAMEWORK

Linstone's framework helped to uncover multiple perspectives related to the use of HFCDs. Those perspectives provided a rich understanding of how HFCD technology's effects could be viewed differently, or similarly, through technical, organizational, and personal viewpoints. The result was that HFCDs could be described as having strengths that were to be noted and weaknesses that needed to be improved upon.

5.5 IMPLICATIONS FOR FUTURE RESEARCH

Valuable technical research would revolve around developing effective voice-controlled user interfaces. Much like the development of user interfaces for the web, based upon human-computer interface research and the advocacy of designers such as

Jakob Nielsen who over time developed certain best design practices for web sites, voice-controlled user interfaces may have particular design challenges. Understanding how menus and specific HFCD commands could be made more efficient could help users to better find those that they intend to call. In addition, if data sources begin to be integrated into HFCD functions, a more robust and efficient voice-controlled user interface, one that can help users verbally navigate through staff, commands, and perhaps even patient information, will be considered essential. More robust command and vocabulary needs associated with HFCDs could perhaps be developed through learning the formal and informal languages and metaphors of clinical care.

HFCDs also pose an interesting subject for social issues in clinical care. One such example was that some users explained younger nurses were more tech-savvy and were consequently more eager to use HFCDs than older nurses. Interviews bore this out to some degree, although nurses who were not comfortable using cell phones also described discomfort with HFCDs. A younger nurse described her HFCD as not much different than her cell phone. A nurse manager described those who more often logged in to the HFCD system without having to be reminded were more "accountable" than other nurses. As a new technology is introduced into the workspace, some users embrace the technology faster than do others and therefore may gain more recognition from management or more power from mastering a new technology that others have not. Studying the dynamic among work relationships since the introduction of HFCDs could inform organizations of how technological changes can impact staff perceptions of work.

An additional area of research that would be valuable for understanding the impact of HFCDs would be to analyze patient-satisfaction rates of those whose nurses wear

HFCDs. Nurses described one of the reasons for their discomfort with HFCDs was its possible imposition on patients. Collecting data from patients about HFCD calls in the patient room, as well as opinions as to the quality of nursing care when nurses wear HFCDs would be of value to staff and administrators alike.

Finally, one IT staff member argued that an all-at-once implementation, or "big bang" implementation, of HFCDs would be preferable to a piecemeal effort. In this study, Hospital Y underwent a gradual HFCD implementation after the institution completed a pilot project. Hospital X, on the other hand, rolled out HFCDs on a per building basis. Debates continue and research is still needed to reveal the best strategy for implementing CPOE systems: big bang or piecemeal. Research on HFCDs could also look into similar strategies to inform healthcare institutions how best to move forward on an HFCD implementation if they choose to do so.

6.0 Conclusion

The hands free communication device (HFCD) is a wearable information and communication technology that provides users with wireless access to communication. HFCDs represent congruence in information communication technology. Wireless voice and data enable clinicians and IT staff to program specific call functions and communicate based upon names and organizational roles.

This study has shown that HFCDs play a positive role in delivering patient care. They reduce the need for nurse managers and nurses to spend a significant amount of their time searching for communication tools and waiting for responses from one another. HFCDs help clinical staff locate one another as well as locate information and materials they need to conduct their work. HFCDs streamline work processes. HFCDs have already become an integral part of the way nurses deliver patient care.

The introduction of HFCDs, though, changed workflow and work patterns that required clinical staff to make adjustments in their processes. Nurses perceived an increase in interruptions that at times negatively affected their ability to provide patient care. Also, despite having the technological ability to limit HFCD interruptions, nurses expressed reluctance to do so out of concern they might miss calls related to their patients. In addition, nurses expressed frustration when there was not an agreed upon HFCD communication etiquette. These challenges required users to develop skills that would help them better cope with the changes brought about by HFCDs.

Subjects pointed to training and retraining as necessary parts of HFCD implementations and use. Training was described as helping users learn to operate HFCDs and integrate HFCDs into clinical workflow.

In addition to clinical staff, IT staff also described changes brought about by HFCDs. IT subjects described how HFCDs allowed them to more quickly access clinical staff and answer their questions. IT staff also described that after working on the HFCD project they better understood clinical workflow and that they had gained greater respect not only for nurses but also for the healthcare organizations' missions.

Finally, the physical environments and supporting architectures impacted the ability of HFCD users to communicate. The environment and architecture, both physical and technological, influenced the quality and reliability of HFCD calls.

Subjects described becoming reliant upon HFCD technology in the course of their daily work. HFCDs positively impacted clinical communication. Users described receiving organizational support in the form of training and retraining as critical to helping them adjust to the changes to work flow brought about by HFCDS.

HFCDs provide benefits and bring about changes to communication that with the support of a healthcare organization enable users to take advantage of this information and communication technology.

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APPENDIX A

Interview Guide #1

Setup

- Introduce self and explain purpose of research
- State the time and date
- State the interviewees ID number

Background

What is your position and will you tell me a little bit about your professional experience?

History

How long have you been using Vocera?

How did you first hear about Vocera?

Why did you think it might be something for OHSU to implement?

Problem Gap

What was communication like before Vocera?

Vocera's Impact

What effects has Vocera had upon communication among staff?

What effects has Vocera had upon communication in the organization?

Unintended Consequences

What about Vocera has surprised you? For example floor noise, broadcasting of sensitive patient data?