Effects of Computerized Physician Order Entry on Communication: A Qualitative Study

A THESIS

by:

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Table of Contents

Table of Illustrations

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Abstract

Introduction

Computerized Physician Order Entry (CPOE) is a good thing for several reasons. It is expected that CPOE will improve patient safety by supporting clinical decision support at the point of care. It is also expected to reduce costs by reducing redundancy in documentation and ordering. To obtain these effects CPOE is often deployed in a group of applications including the Electronic Medical Record (EMR) and Computer Decision Support (CDS).

Although expected to have beneficial effects, CPOE is not a benign change. It alters workflows, hierarchical and social relationships, transforming the organization in the process. Communication is both changed and a mechanism or substrate for change. As interpersonal and business relationships change, social and reporting relationships change the contents, contexts, effects and channels of communication.

This thesis will consider communication theories in relation to CPOE. Communication theory can provide a fuller understanding of how communication processes are affected by CPOE and how these communication processes in turn affect information transfer and the success of CPOE. Further, these understandings can help predict where and how problems may occur and also how some of them may be addressed.

This thesis will also describe findings relating to the effects of communication process change beyond those explained by communication theory that are important to understanding CPOE's effects on communication.

Methods

A multidisciplinary team has been collecting data on the success factors for implementation of CPOE as well as the unintended consequences of CPOE. Over the past five years site visits have been made to twelve hospitals and clinics, nine of which are the subjects of this thesis. Communication is one of the cross cutting themes of these success factors and has been a focus in observations. The author has participated in these studies as well as performed individual observations with a more in-depth focus on communication effects. A grounded theory (GT) approach has been used throughout.

Results

The "open coding" method of GT identified communication's central importance in CPOE processes and themes regarding how CPOE influences communication. We found effects on team functions and interpersonal relationships, on development of alternative and/or redundant communication channels, and on changes in clinician-patient communication among others. Further iterations of data collection and analysis expanded and refined themes as well as providing further detail to the themes. Full reanalysis in the GT "constant comparison" tradition led to the current formulation of five overarching themes with multiple sub themes.

The data were also analyzed for fit with existing communication theories. The best fits were with the Osgood-Schramm communication-channel model, the Osgood-Schramm shared-field-of-experience model, and the Daft communication-bandwidth model.

Discussion

CPOE's introduction to an institution changes the roles of existing communication channels. It is a powerful communication channel itself and causes a reordering of the

communication channel hierarchy that may cause multiple problems or perhaps provide solutions. In this study, locations in which CPOE replaced rich, broadband channels experienced multiple problems due to the replacement. Isolation and separation led to insecurity and misunderstanding. Where CPOE represented an additional channel instead of replacing channels some institutions found increased or more efficient connections. Maintenance of quality and workflow leads to the preservation of some communication channels and new roles for other media, such as paper. Technology can perhaps mitigate some problems.

The ubiquity, or near omnipresence of electronic systems, CPOE and the EMR leads to mixed effects, most of which are positive. Although some historical communication channels are diminished, new, very powerful channels are introduced, in some ways allowing a closer "message to channel" fit. Conversants can electronically be virtually "on the same page." This "virtual mode" of communication can produce not only a "distributed cognition" or awareness but also a "distributed action" in which tasks that formerly were done in contiguous locations can now be completed by widely separated actors.

Situation awareness has been impaired as a result of today's regulatory climate but emerged as improved through the effects of CPOE and associated electronic systems. Improvement could be expected across a wide range, from individual clinicians to medical units and even institutions.

Computers, CPOE, and other electronic systems reach into the medical encounter, including the exam room, changing the nature of the medical evaluation.

Conclusions

CPOE / EMR is a transformational, disruptive innovation that changes multiple processes. Systems, including technical and social aspects, are seen to be affected.

Preservation of multiple channels is necessary for continued efficiency and safety. In the traditional paper world paper-based processes did not represent the sole communication medium but was supplemented by verbal and other channels. In the CPOE world some of these channels should be allowed to persist to compensate for the shortcomings of electronic communications.

Paper persists in all locations but its role has changed. After being the archival form of the patient chart for decades it is becoming an evanescent medium of communication, a role for which it is eminently qualified.

Plan to be surprised; be prepared to alter course; be sensitive to the changes occurring in your organization. There is, indeed, a "deep intertwinement between technological and human elements"[1] of the networks that will be transformed by the implementation of EMR/CPOE systems. One network does not change without reciprocal changes in the others. Be aware and detect and address the "fallout," the unintended consequences of implementation.

Introduction

This study explores the effects that the introduction of Computerized Physician Order Entry (CPOE) and the Electronic Medical Record (EMR) has on communications in inpatient and outpatient health care settings.

Background:

There has been an increasing focus on medical error prevention and on improving the overall quality of medical care including government bodies such as Health and Human Services and the state of California; payors, best exemplified by the Leapfrog Group; and in the medical literature. Systems-based remedies such as decision support, evidence-based medicine, EMR, and CPOE have been favored as solutions and are currently receiving the most attention.

Implementing EMR/CPOE systems, however, is a risky proposition with many attempts ending in failure, including the recent, well-publicized recall of CPOE at Cedars Sinai in Los Angeles.[2] Electronic systems are all too often implemented without full understanding of the existing sociotechnical system and subsystems that are being transfigured in the process. New technologies bring change to nursing and ancillary departments as well as to every physician who writes an order. Electronic systems alter job descriptions, workflows, and reporting relationships. They may even affect even how workers view "the work." The unintended consequences of introducing the technology, including those affecting communication, are often underestimated and may lead to failure. [3-4]

CPOE, the focus of this study, will be defined as a computer application providers use to enter orders directly for medications, diagnostic tests, and ancillary services. Note,

however, that some quoted sources define "CPOE" as "computerized *provider* order entry." "EMR" will refer more broadly to the full suite of clinical applications. Results reporting, i.e. laboratory values, xray reports, etc may or may not be included in the EMR. Clinical Decision Support (CDS), defined as an application or applications that supply information to support ordering decisions, has integrated into the EMR/CPOE system. The EMR and CPOE seemed more easily separable just a few years ago but the distinction has blurred as these systems became more integrated. Note that CDS further blurs the distinction by occupying space on the interface between the EMR and CPOE, using data from the former to inform the latter. The goal of much medical communication is formulating a plan and issuing orders, so information transmission and gathering is an integral part of order entry. For these reasons, our discussion of communication in CPOE will involve information transfer in the EMR as well as ancillary communication systems.

CPOE/EMR as Quality of Care Innovation

Error reduction has been the reason behind the increased interest in CPOE/EMR. Prescribing errors are the most frequent source of medical error and morbidity. [5-8] Failure to get medication and patient information right is an important problem. [9] CPOE is widely seen as an essential technology to reduce prescribing errors. [10-14] [15]

CPOE is being implemented on the basis of improving order legibility, prescriber identification, faster order routing with faster order execution, error reduction, and decision support. CPOE needs three conditions to reach its full potential. First, it must be present at the point and time of care. [12] [13-16] Second, it needs to be combined with decision support. Nebeker recently reinforced the need for decision support to realize the

potential of CPOE on medical error. [17] 3) it must reach into the hospital room and clinic exam room. Aydin and Forsythe stressed that, "... if the EMR is to be of maximum use to the physician, he/she must be comfortable enough with the system to use it in the patient's presence." [18] Communication processes are central to care delivery, team function and the overall success of CPOE.

CPOE/EMR Can Cause Error

That CPOE can cause new errors has been well documented. [3-4-12-19] Although these particular articles do not deal with communication issues as direct cause of error, a common mechanism of error is through changes in communication or reporting processes that reduce redundancy and cause closer "coupling" of events. Coupling is a mechanical or engineering term meaning there is little slack or buffer between two items. In the context of medication ordering, the "buffer" is in fact often a pharmacist or nurse. Removing that "buffer" means there are fewer "redundant" accuracy checks, i.e. "people checks," on orders between the time they are submitted and executed.

CPOE can cause new kinds of errors through interfering with communication while at the same time remedying other issues. In one study of 805 incidents, poor communication among health-care providers, between provider and patient, and patient misunderstanding accounted for over half of the errors.[20] In other research, Coiera concluded that, "the communication space is apparently the largest part of the health system's information space. It contains a substantial proportion of the health system information 'pathology' but is usually ignored in our informatics thinking." [21]

Both Communication and the Organization are Deeply Affected by CPOE/EMR

In previous work in the inpatient setting, we demonstrated that CPOE causes a disruption across a broad spectrum of communication channels. Communication within the multifunctional medical team appeared to have suffered the most through substitution of impersonal electronic communication, i.e. CPOE, for more personal phone and face-to-face contact. We also identified how lack of understanding of a communication channel and how message recipients act on those messages can lead to overconfidence and dangerous assumptions. Communication can affect the CPOE implementation process as well, especially in the "hectic environments" of the emergency room, intensive care units, and code situations.[22]

Communication with patients is one area deeply affected by the introduction of technology. "Doctor initiated and 'medical' content of consultations increased at the expense of a reduction in patient initiated and 'social' content." [23] Although EMR / CPOE using physicians clarify information with patients more than their non EMR / CPOE counterparts, they show a trend toward accomplishing fewer patient centered tasks such as outlining the patient's agenda and exploring psychosocial / emotional issues.[24] Using the terminal is distracting to patient and clinician and diverts attention from the patient. [25]

When new technologies and associated organizational changes hit an established system there are reverberations as the change propagates. Technology pushes cycles of transformation and adaptation. [26] Systems are expected to respond to interventions such as CPOE with compensatory changes in both technical and human segments.[27] CPOE /

EMR implementation should be considered a *transformational* intervention that initiates profound changes in an institution and individuals. As Berg put it, "...when seen as a process of organizational development, [patient care information system] implementations can be intended strategically to transform the organization, and the technology can be allowed to grow along, gradually becoming part and parcel of the basic organizational work routines."[28]

The pattern of communication itself may change if the electronic system enters the conversation as a participant in what then becomes a triadic conversation. [29] [25] At the core of this perspective is that significant changes in communication channels and patterns should be seen across role identities.

Alterations in communication practices may vary dependant on setting. It is important to examine communication across the continuum of care, inpatient, outpatient, and during care transitions.

The study of communication theories and models has expanded since its origins in just the early 1900s. Some of these communication models can help us understand the process and interpersonal changes induced by the implementation of CPOE.

Communication Models

This thesis deals with organizational and interpersonal effects of communication and how these can enhance or impair organizational effectiveness, and both working and personal relationships. Models of communication are necessary however, to frame and organize these effects.

Communication became a topic of interest and investigation in the nineteenth century and has produced many theories dealing with the transmission, content, and structure of

messages. The word "communication" comes from the Latin root *communis,* "common." In communication, we endeavor to establish "commonness" with someone. That is, we try to share information, an idea or an attitude. For this work, communication is a process that involves transmission of information with intent to influence action. Communication does not happen, however, until the message is received and understood. This working definition includes communication of factual or data information as well as directional information such as plans or commands. "Information and communication are deeply intertwined. This also holds true technologically, as the distinction between information and communication systems rapidly disappears."[30]

Communication is crucial to medical care and CPOE. There are several existing communication models that apply to these processes, each of which can help understand problems and where things might go wrong. Presented here are the models found most useful along with some background information on each. The watershed Shannon and Weaver model is provided as background. We will then discuss two models developed by Schramm of channels and understanding and a third model by Daft on channel richness.

Shannon & Weaver

Shannon and Weaver's model [31-32] forms the basis for many modern communication models. Figure 1 is my rendition of their model. The model is a combination of engineering and mathematics that reflects their backgrounds. It is really a mathematical model that deals with the technical aspects of transmitting information and with "noise" in the communication process. Of note is that message content, meaning, and effectiveness are not considered; only the fidelity of the received to the transmitted message is important.

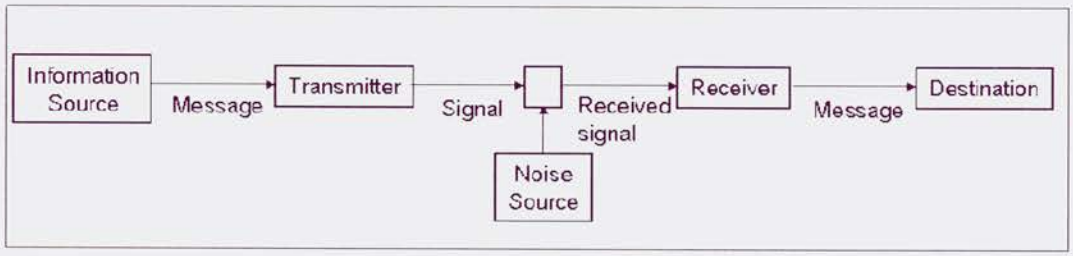

Figure 1. Shannon and Weaver Communication Model

Shannon and Weaver's intent was to describe the theoretical limits of how much information could be transmitted through a channel and the impact of noise on that transmission. An important note is that communication in this model is linear and unidirectional, from information source to destination. If there is a problem in transmission, an errant message may be received, or perhaps no message at all. In this model, the information source is unaware of such problems.

Schramm Models

Subsequent authors have extended the Shannon and Weaver mathematical model by including sociological and behavioral considerations to produce models of communication with a more human component. Schramm with input from Osgood proposed two distinctly different models each with a very different perspective on communication. One is based on the Shannon and Weaver model describing communication channels and interferences; and the other a model of requirements for common experience among communicants to understand messages.

Schramm "Circular" Model: Channels and Noises

Schramm proposed a model of communication in which sender and receiver are participants with symmetric roles in communication in a "closed-loop" of communication. [33] The author's rendition of the Schramm "circular model" is illustrated in Figure 2.

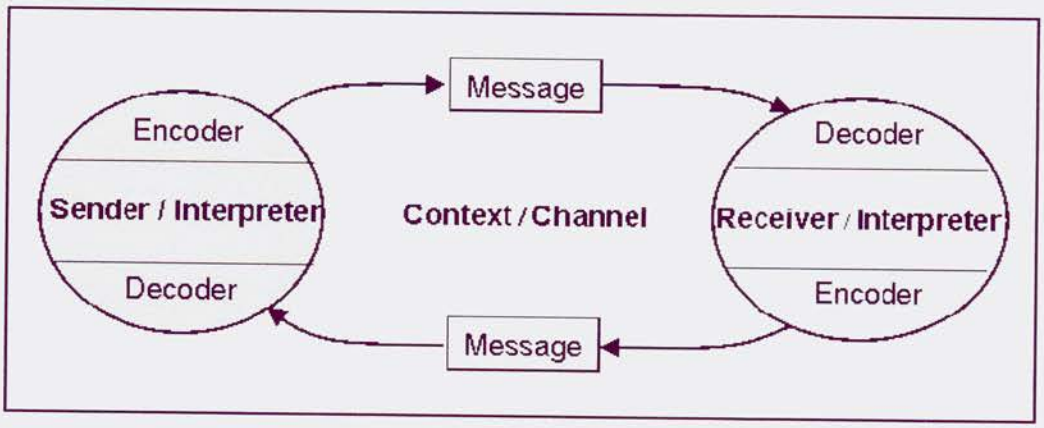

Figure 2. Schramm "Circular" Communication Model

In this model the sender continually interprets her surroundings. She does not just observe her environment but is actively engaged in a process of interpreting the conditions and making sense of them. At times there will arise thoughts, instructions, etc. that she wishes to send to someone else. These become "messages." At the other end of the message, the receiver must interpret the received message, not just decode it and make sense of the information.

"Encoding" and "decoding" are seen to be activities simultaneously maintained by both sender and receiver. Once the sender has formulated an idea to be transmitted it must be "encoded." "Encoding" a message is putting the idea into a form compatible with the chosen communication medium and understandable to the receiver and requires some skill. This means that for messages containing questions for example, the message must be constructed to make the question visible. To be informative, the message must be composed such that the reason for the communication and the content is recognizable. "Decoding" is the receiver's process of extracting information from the message. Just as in encoding, decoding requires skill on the part of the receiver to understand the information encoded in the message and the context in which it was sent.

The "channel" is the medium through which the message is transmitted to the receiver and is chosen by the sender. Whether a hand signal or more complex medium, it must be appropriate to the message and appropriate to the receiver's capabilities. It is important to note that the introduction of electronic media changes the menu of available channels primarily by providing new channels. Secondarily, other channels may seem less attractive, more difficult to use, or even obsolete.

Although not explicitly labeled in Figure 2, there are potential disruptions to the message introduced by the channel. Anything that impedes a transmitted message from getting through is defined as "noise." Noise includes the familiar types of physical noise such as static on the radio, "snow" on the television picture, and cell phones cutting in and out. Physical noise would also include smudging or blurring of printed words.

A form of noise separable from physical noise is "semantic noise" This form occurs when there are mismatches in encoding/decoding such that the sender cannot fully encode the message or receiver cannot fully decode it. Distraction is a significant and familiar source of noise in which attention is diverted toward a peripheral stimulus and away from the message. Another type of noise, code/context noise arises when the sender uses language unfamiliar to the receiver. This is not limited only to cases of difference in national language but, more subtly, when the jargon of the sender is different from that of the receiver. The receiver's attitude toward the sender may be noise if it leads the receiver to mistrust or misunderstand the message.

"Closing the loop," i.e. supplying "feedback," is sending a message back to the sender that the message was, at least, received and perhaps even understood. Lack of feedback in a channel can have serious implications for the use of that channel. A channel without a

"feedback" or "loop-closure" feature may be regarded by potential users as being unreliable or unpredictable.

Schramm "Shared Field" Model: The Shared Field of Experience

Although the Schramm Circular Model describes the interaction of messages and disruptions to communication it says little about how human factors affect message communication. Schramm noted the positive importance of the communicants' shared history, common language, background, and culture, as well as the negative importance in their absence. From these commonalities he developed the concept of the shared field of experience. (See author's rendition in Figure 3) Schramm contended that correct message interpretation depended on the sender and receiver sharing portions of their histories, backgrounds, their fields of experience appropriate to the message. The common ground concept often used by other authors is synonymous.[33] "Common ground refers to the knowledge shared by two communicating agents." [34] "For a conversation to occur, agents have to share knowledge about language as well as knowledge about the subject under discussion." [21]

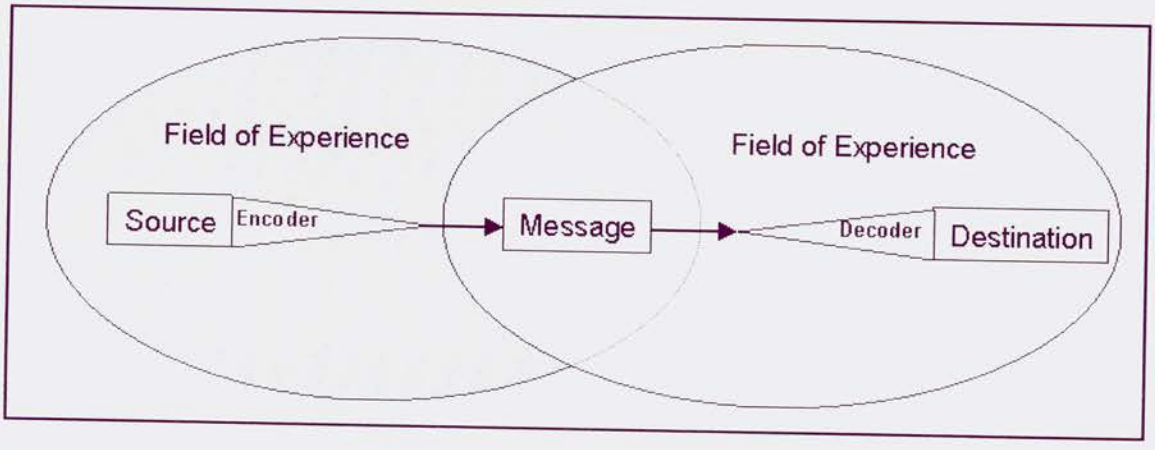

Figure 3. Schramm Shared-Field of Experience Model

Daft Model of Channel Richness

People usually have several communication media available to them, at least potentially, for example, face-to-face contact, telephone, email, and letters. All of these media are capable of communicating information, but importantly, at varying rates of transmission or bandwidths and with differing levels of synchronicity. Bandwidth is the amount of data or information that can be passed along a communications channel in a given period of time and varies greatly by individual channel. Channel bandwidth available for communication includes the substance or text of the message, and if available, also includes expressions or inflections of the communicants and non-verbal channels such as eye contact, posturing, and the oft-described "body language." The concept of channel "richness" is related to bandwidth but at a somewhat "higher, more functional level" by describing effects of communication, not just the amount of data transported. As described by Daft and Lengel, "Information richness is defined as the ability of information to change understanding within a time interval. Communication transactions that can overcome different frames of reference or clarify ambiguous issues to change understanding in a timely manner are considered rich."[35] Messages consisting of "text only," like email are considered less "rich" than telephone messages, for example. Face-to-face communication is generally considered to have the "broadest bandwidth" for information transfer among persons. Figure 4 is the author's rendition of Daft's model of channel richness.

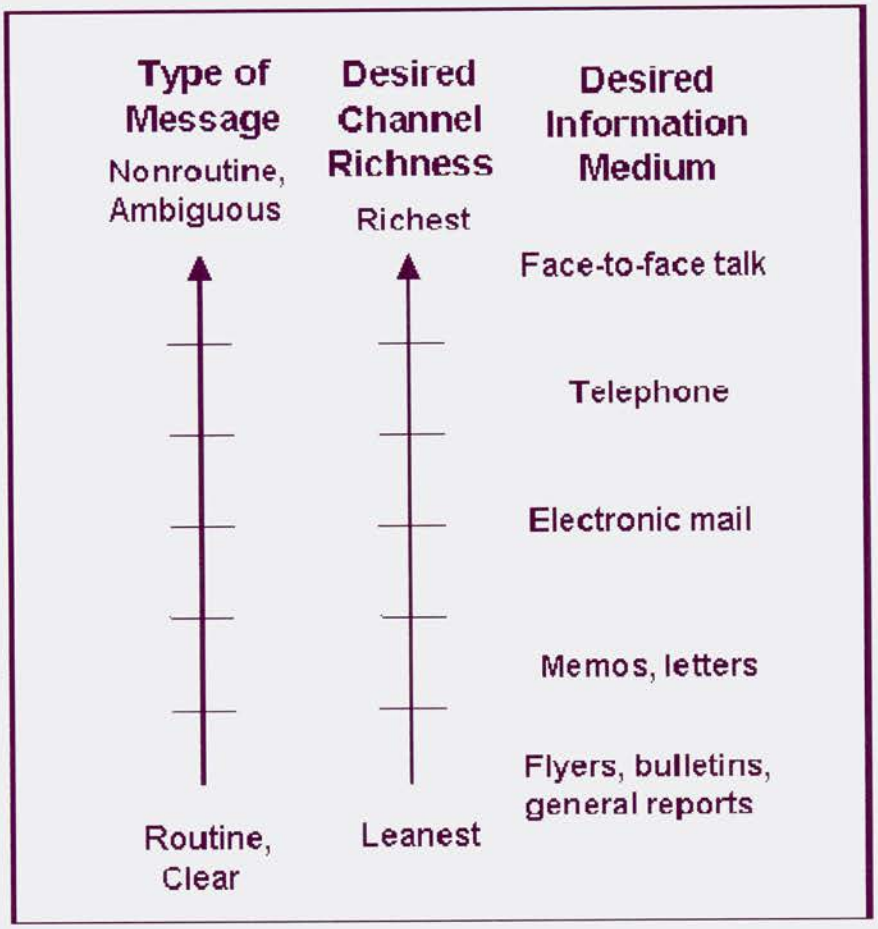

Figure 4. Daft Model of Channel Richness

Strauss and McGrath in their study of groups assigned to computer-mediated or face-to-face situations found that, "The results indicated that face-to-face modes are superior to computer-mediated discussions when productivity is a priority or when the time available to perform tasks is at a premium, especially for highly interdependent tasks."[36] "There is a continuum of social context cues underlying communication media" [35] "Social context cues help parties regulate interaction, express information, and monitor feedback from others. A reduction in cues such as eye contact, head nods, and voice inflection creates disruptions in the flow of communication" [36] Carlson, et al demonstrated that senders choose the channel/medium appropriate to the message. [37]

Technology allows information delivery through a more widely distributed network enhancing reliability. The technology that enables persons to do knowledge tasks remotely potentially does so through narrower communication channels, at least for electronic systems currently available.

Channel richness is also affected by the synchronicity of the channel. Face-to-face and telephone conversations are both highly synchronous and require simultaneous engagement of both ends of the conversation. All conversants must be simultaneously available and able to make the connection. Telephone tag is an all-too-familiar exercise in trying to find an opportunity to be synchronous. Synchronicity is important in some communication, especially the "give-and-take" conversations in which ideas are interchanged and plans formulated through the interchange. At times a need for social interaction may make synchronous communication preferable. At other times, simultaneity may be just a "nicety" that possibly costs the communicants much time.

Synchronous communication is seen introducing semantic noise through interruptions and task-switching. "Interruption of people is problematic because people have cognitive limitations that restrict their ability to work during interruptions." [38] Even in aviation, with its admirable safety record, context switching has led to the loss of commercial aircraft. [39] In this case, pilots preparing to take off were distracted from their pre-flight checklist and never returned to finish it. They took off with the flaps in the wrong setting and crashed shortly after take-off.

Physicians seem to show a bias in favor of disruptive, synchronous communications channels such as phone calls, pages and impromptu meetings leading to inefficiency and error. [40] [41] Affirmation of task completion is important and may be obtained through

synchronous communication. In a study of medical, nursing, and clerical staff at hospitals in the US and the UK, Coiera found that "There seemed to be pressure in such an event-driven environment to deal with events when they arose. In order to feel that a task involving communication could be 'ticked off the list,' subjects needed an acknowledgment of receipt of message from the other party. Acknowledgment was possible with synchronous channels but not with the available asynchronous channels." [30]

Purpose of This Study

The purpose of this study was to elucidate communication changes induced in hospitals and clinics by the introduction of CPOE/EMR.

Research Questions

What are the effects of CPOE/EMR implementation on communication and communication dependent processes? Can communication theory explain at least some of these effects?

Methods

Purpose of Research

As will be developed in this section, this study represents an extension of previous work done by the Physician Order Entry Team at Oregon Health & Science University or POET. The initial purpose of this research was to describe the success factors of CPOE and the study has resulted in several published works. For the POET the focus has been on success factors and unintended consequences, not directly on communication effects. I carried out independent investigation of communication using team-gathered and independently- gathered data. The purpose was to provide insight into the process

changes in communication in hospitals and clinics brought about by CPOE introduction. I selected qualitative methods as the most appropriate to acquire and analyze data for this purpose.

Qualitative Methods

Qualitative research "lends itself to developing knowledge in poorly understood, or complex, areas of health care." [42] Processes and workflows involved in medical work are, in fact, highly complex and interconnected. Additionally, medical workflows and communication are unstable in locations undergoing the transformation from paper-based to electronic-based systems for record-keeping and provider ordering. We chose a qualitative design for this study because it allows focus on complex processes and contexts as well as on the actions and intents of participants. The qualitative design facilitates study at varying depths appropriate to understanding individual communication effects.

Overview of Study/Chronology, Including Communication Study Research

Between the start of the POET work five years ago and up to the time this study was conceived last year, the POET team had visited seven health care systems' hospitals and clinics. A chronology of data collection that outlines the author's role is given in Figure 5.

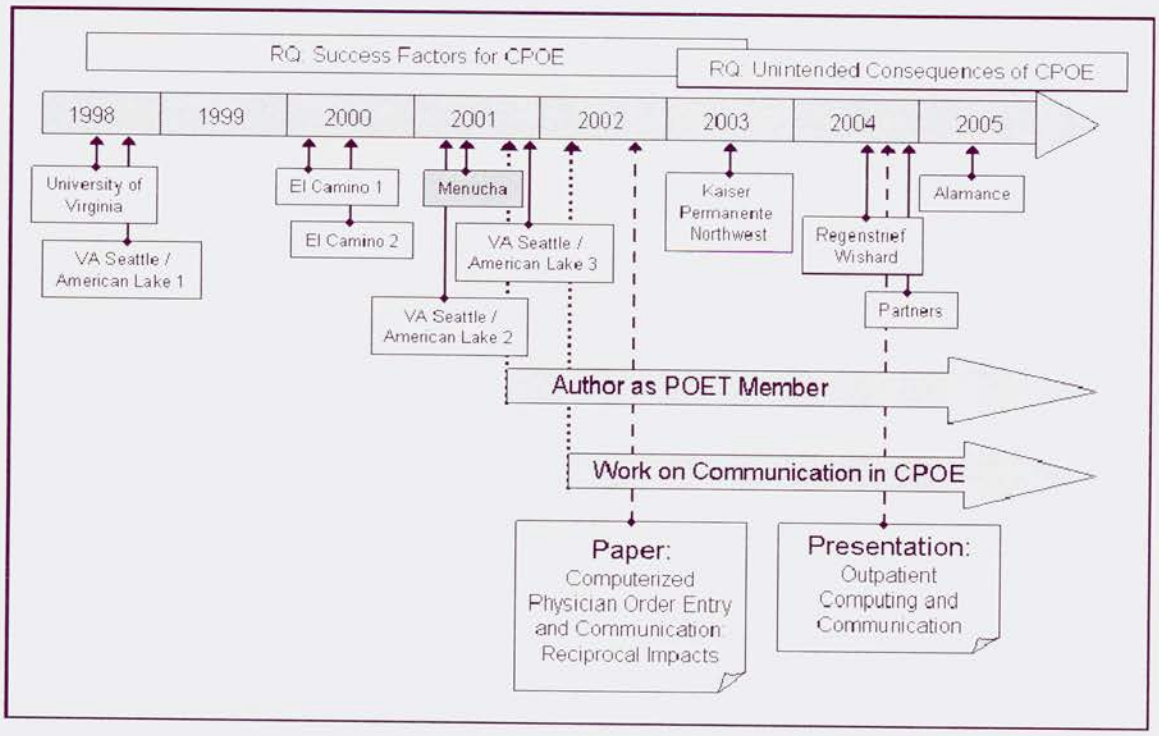

Figure 5. Chronology of Data Collection and Publications

Data Collection Team

Data collection for this thesis was carried out in association with the POET research efforts that began in 1998 and continues to the present. Although POET personnel have changed through the years, the team has been multidisciplinary throughout its existence including librarians, physicians, informaticians, a pharmacist, and trained informatics graduate students.

Menucha

In 1998 the POET began its study of success factors using broad-based ethnographic techniques to investigate the success factors for CPOE. In May of 2001 the POET hosted the first "Menucha Conference" in Portland. That conference brought together thirteen experts in the field of CPOE from around the world to identify requirements for a successful CPOE implementation. That conference also developed a list of potential

CPOE study sites "based on geography, type of organization, ownership and date of installation." [43]

Phase 1

In the POET's first two years the team visited the University of Virginia, the VA Puget Sound Health Care System (VAPSHCS) sites in Seattle and American Lake, Washington and the El Camino Hospital in Mountain View, California. Analysis of those visits was in progress when the author joined the POET. The author then read and independently coded data previously analyzed by the group to become familiar with the study and also became a participant in POET analysis sessions. The author participated in the last two site visits to the VAPSHCS in December 2001 and January of 2002, both as observer and as a POET "trainee."

This initial group of visits in 1998 through 2001 is referenced as the "Phase 1" studies in Figure 5 because they were the first set of site visits focusing primarily on inpatient facilities. Transcripts and field notes of this phase were analyzed through 2002. It was during this period that the author uncovered the strong relationship between CPOE implementation and communication. This was felt to be a "cross-cutting" theme that influenced success factors but was not a success factor itself per se and was not explored in depth by the POET. The author continued independent work in this area resulting in a paper in the fall of 2002.[22]

Phase 2

In Phase 2 the POET's attention was shifted to outpatient implementation and the clinics of Kaiser Permanente Northwest (KPNW) became the focus of study through 2003. Located in the same city as POET, Kaiser was visited over a longer period than in

Phase 1. Throughout Phase 2 the author continued independent coding and analysis of his own fieldnotes as well as the POET documents for communication related themes. This ongoing analysis resulted in a presentation. [44] Two research questions were being investigated by the POET during this phase. There was continued work on success factors for CPOE, this time in the outpatient arena. The POET also looked to the future and the importance of understanding the ramifications of CPOE implementation and a new research question, "the unintended consequences of CPOE."

Phase 3

The POET is now in the midst of a new research direction studying the unintended consequences of CPOE. It has made three site visits with research questions relating to infusion levels of CPOE, relationships to unintended consequences and preventive strategies. Data from two of those visits were coded and analyzed by the author for communication related themes and results are included in this thesis.

Sample/Unit of analysis

The institution is the unit of analysis for this study.

Site Selection

Site selection was purposive based on geography, type of organization, ownership, and date of installation to obtain a broad cross-section of excellent sites. [45] The characteristics of study sites are shown in Table 1.

	Geography	Type of Organization	Ownership	Date of installation	Date(s) Visited
University of Virginia	Eastern	Teaching	State supported	1989 homegrown	August 1998
Veteran's Affairs Puget Sound	Western	Teaching	Federally supported	1998 homegrown	Sept-Dec '98 May-June '01 Dec '01-Jan '02
El Camino Hospital	Western	Private	Private	1966 homegrown	August 2000
Kaiser Permanente Northwest	Western	HMO	Not for profit	1995 commercial	May–Sept 2003
Wishard/ Regenstrief	Midwest	Teaching	Not for profit	1972 homegrown	August 2004
Partners Healthcare	Eastern	Teaching	Private	1989 homegrown	October 2004

Table 1. Characteristics of the Sites Selected

Informant selection

On-site Contact

A crucial key to success in field work in qualitative research is "getting in" or gaining access to the population or system of interest. Although the researcher can establish a level of acceptance through professional identity and explanation of purpose, an indication of management approval can make the difference between acceptance and exclusion. Introductions from an on-site contact, identification badges, and letters of recommendation can help allay participant's concerns. As site selection for the study proceeded, planning for availability of on-site contacts to facilitate access to the site continued in parallel.

The POET on-site contact(s) identified key informants for formal tape-recorded oral history interviews because they had special knowledge of the implementation process.

The on-site contact also identified persons and groups involved in implementation as those with knowledge of how decisions were made.

The POET on-site contact suggested users and set up appointments for observation sessions. These users were selected as representative of the broad spectrum from least to most adept with the system. Observation sessions were also initiated ad hoc by the observer visiting a floor or clinic chosen at random. Participants were asked to identify potential participants that would meet needs of the research. These needs included observing or interviewing minimal users and superusers, proponents, opponents and skeptics.

Focus groups were also employed as a data-gathering method. These groups were usually identified and invited by the POET on-site contact.

Observation strategies and procedures

Background information was reviewed well before the site visit took place. Scientific publications from the institution regarding their electronic records, Davies' award presentations, vendor supplied publications, institutional websites, etc. were reviewed to gain an early insight into the site.

A system demonstration was arranged for our research group personnel early in each site visit to provide familiarity with the system. The on-site contact scheduled a 1-2 hour demonstration by someone involved in training with deep understanding of the system. The familiarity gained through this session allowed observers to focus on participant use of the systems.

Oral histories with key personnel were approximately one hour in length. These interviews presented the opportunity to elicit the institution's history with electronic

systems as well as descriptions of the process of implementation itself. The tapes were then transcribed by professional oral-history transcriptionists.

Participant observations were performed by the multidisciplinary POET research group, including the author. Individual observation sessions would last from approximately 10 minutes to several hours depending on the researcher's sense of saturation. Saturation will be discussed further in a section "Data Saturation" later in this chapter. Fieldnotes were recorded in spiral notebooks or on clipboards. Fieldnotes were transcribed by the researchers themselves as soon as possible after the session to preserve memories of the events.

On occasion during participant observation sessions there was an opportunity for an informal interview with a participant. Informal interviews were either handwritten or taped after informed consent was obtained. The tapes or fieldnotes of these interviews were transcribed by the researchers themselves.

Focus groups were held to take advantage of open-ended questioning and the group process in which participants provide information and often ask insightful questions of the group based on their experience in the institution. These focus groups were audio taped after informed consent was obtained from each participant. These tapes were also transcribed by professional transcriptionists.

Human Subjects / Informed Consent

This study was approved by the Oregon Health & Science University's Institutional Review Board and the corresponding board of each of the visited institutions prior to data collection. Informed consent forms approved by those boards were used during the

consent process with study participants in all settings. No protected health information (PHI) was collected or used in this study.

Strategies for Trustworthiness

Trustworthiness is related to the quantitative criterion of "rigor" and is equivalent to the soundness of the research. [46] The goal is to demonstrate that the study was performed in a way that the results reflect the participants and settings.

Reflexivity

Reflexivity is the self-conscious assessment and statement of one's own values, history, and agenda in order to examine personal biases and allow others to evaluate the findings. The author is an internist with 25 years of practice experience in hospitals and clinics and has used an electronic medical record in outpatient practice for the past ten years. The author's personal perspective as a treating physician will be reflected in the results. The researcher must try to be aware of preconceptions and reflect on the findings aware of the role of perspective on emerging understandings throughout the research process. It is important for the researcher to report on these interests and perspectives to allow the reader to fully understand the findings.

Triangulation

Triangulation is a term borrowed from surveying in which measurements from reference locations are used to determine the location of a third point. Triangulation was introduced to the social sciences in the 1950's to characterize the use of multiple methods to measure a single construct and has come to include multiple data sources, observers, or theories. Triangulation is divided into four types. [47] Efforts to meet the four types are as outlined below. The "confirmatory" function of triangulation is reassuring, but

triangulation is also capable of exposing dissonant positions, positions at odds with the developing research. These dissonances mark important territory for further investigation.

•***Data triangulation;*** in which various data sources are used. Documentation, such as scientific publications and published descriptions of the systems, as well as Davies' Award papers were available and studied for four of the institutions prior to the site visit. Data were collected at eight hospital sites and four clinic sites in various areas of the country with different practice and governance models as well as "home-grown" or vendor origin. It must be mentioned, however, that all sites would be considered "successful" at the time studied although several had gone through a periods of relative "failure" before succeeding.

•***Investigator triangulation;*** in which data from various (multiple perspective) observers are used. Since the POET's inception in 1998 the POET data set has been acquired by a multispecialty multiple-perspective research team including librarians, informaticians, pharmacists, nurses, statisticians, students and senior researchers. In addition the Menucha conferences have assembled international CPOE experts to discuss CPOE.

•***Theory triangulation;*** in which data is analyzed based on various perspectives, hypotheses, or theories. For this study multiple theories were considered throughout the analysis eventuating in selection of Schramm's models (Osgood-Schramm) of channels and shared-field of experience, and Daft's model of channel-richness.

•***Methods triangulation;*** in which various methods for data collection are applied. Included in the full data set were formal oral histories, informal interviews, focus groups, and participant and non-participant interviews. Two types of document analysis were used. First, in preparation for the site visit, the institution's "paper trail" was carefully

evaluated, that is, what has been written about the site, implementation, and participants? Second, during and after the visit, "artifacts" such as flow sheets, med lists, rounding forms, and etc. were used to interpret and understand the observations.

Member Checking

Member checking is the process in which data, themes, interpretations, and conclusions are tested with members of stakeholding groups. Member checking with participants was not done routinely in this sub-study of the POET work. In another form of member checking, after the analysis was complete, two POET researchers steeped in the data but not participants in the communication study evaluated the results of the re-examination to provide validation for the observations.

Data Saturation

At some point in data collection it becomes clear that enough data has been acquired at that site, with that participant and that further observations there will not yield much new data. At that point the researcher notes that the volume of fieldnotes is diminishing and there are few new observations being made. For example, in the case of observing clinicians with patients in the outpatient setting, saturation was felt to be achieved in the course of three to four patient-clinician encounters. For the case of an inpatient unit or ward, saturation was achieved within 3-4 days of observation.

Audit Trail

The audit trail is the archiving and documentation of the data, methods, and findings of the study. It consists of field notes and write ups (de-identified as necessary), analysis documents, process notes, and reflexive notes (i.e. personal notes about expectations, biases, etc.). The author became a member of the POET group and gained access to the

accumulated data in late 2001. In late 2003 the audit trail for the communication study was begun.

Data Analysis

This section will describe the process followed by the author in analysis of the data with respect to communication issues. This process was kept separate from that of the POET.

Grounded Theory Methods

Grounded theory (GT) methods form the basis for analysis. GT gets its name because themes are derived directly from, or are "grounded in" the data. GT is a qualitative research methodology initially developed for analysis of social phenomena that has steadily expanded its range since introduction in the 1960's and 1970's. Data are systematically obtained through interviews and observations.

The ***methods*** of grounded theory were used to uncover themes in the data although the full ***"Grounded Theory,"*** process, per se, was not. The attributes of grounded theory methods recommending them for use in the present study are found in descriptions of the GT: 1) Grounded theory "is an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data"[48] 2) "A major premise of grounded theory is that to produce accurate and useful results, the complexities of the organizational context have to be incorporated into an understanding of the phenomenon, rather than be simplified or ignored" [49] 3) Grounded theory facilitates "the generation of theories of process, sequence, and change pertaining to organizations, positions, and social interaction" [50]

The three important features of grounded theory are that it is; 1) an inductive process that, 2) considers complexity and context to produce theories of, 3) process and interaction.

Coding

In GT, analysis begins shortly after the first data is acquired and the process continues through the life of the study. The initial task is to identify major themes in the data and, secondarily, relations in the data. Open coding is the grounded theory term for the process of identifying and naming persistent patterns and underlying themes in the data. Each sentence, and sometimes phrase, is individually examined for themes, i.e. the processes, situations, actions, etc, that describe overall features of the phenomenon under study.

As higher level themes develop, sub-themes describing more-detailed features or properties of the parent theme will often develop as well. As the process of coding continues the codes become an explanatory framework for the data. Data collection, analysis, and theme formulation occur iteratively and recursively as new data are acquired. These iterations, continually comparing emerging themes to new data and developing the themes is referred to as the "constant comparison" method of GT.

Qualitative research software (QSR-N6 software (available from QSR International, www.qsrinternational.com) was used for database organization and cataloging themes.

The POET began open coding looking for themes related to success factors for CPOE starting after the first site visit. These early thematic ideas then informed the data collection process, guiding further site selection, specific areas to be visited and questions to be asked.

I joined the POET during its fourth year at a time when the group was refining the success factors themes. After familiarization with the POET themes I reviewed the data from the first site visits up to that time. During this review, which included coding to the existing themes, the theme of how CPOE influences communication and vice versa emerged. Communication effects were closely related to the success factors but were not a success factor itself. My independent study of the interaction of CPOE and communication began at that point.

Phase 1 data were used to develop themes relating CPOE to communication effects in the inpatient arena. This first analysis was presented at the AMIA fall symposium and subsequently published. [22]

Outpatient data from the Phase 2 KPNW were "folded into" the data set again using the constant comparison method. Addition of these new data led to a reformulation of the communication issues. These themes were presented at the 2004 International Conference on Information Technology in Health Care. [44]

Phase 3 data from four additional sites in Indianapolis, IN and Boston, MA were added in the fall of 2004. Reexamining codings for coherence and appropriateness to the new data resulted in a refinement and extension of the results as presented in this thesis.

Results

Background

The iterative grounded-theory approach described above lead to the identification of five high-level themes with sub-themes that describe the interaction of CPOE and communication processes in medical settings. These themes will be developed in this section and will be illustrated as much as possible with representative quotes from informants. The results are organized as follows;

- CPOE Changes Communication Channels
- CPOE Allows Communication Anytime, Anywhere: Ubiquitous Communication
- CPOE Affects User Awareness
- The Computer Changes the Patient-Clinician Conversation
- Paper is Changing Role from Records to Communication

1) CPOE Changes Communication Channels

The reduction in bandwidth discussed in the introduction was perceived as a reduction in the quality of communication and contact, *"You lose a lot in the computer. There is nothing like talking directly to the doctor."* Loss of "give and take" did not go unnoticed, *"When they used to be on the floor writing their orders, we could talk back and forth."*

1.a) Physical Separation Causes Problems with Team, Presence, and Interaction

CPOE allows clinicians to perform their work from distant locations causing physical separation when they do. Teams are built through cooperation, teamwork, and familiarity. Replacement of physical "presence" on the floor or ward can erode the sense of team.

"And you move that away from the ward into a room. And now you eliminate the sense of team, and the kind of human communication that really was essential to taking good care of patients." "Physical presence" extends to simply recognizing individuals as members of the floor team and seeing them during contacts is important. Even intermittent face-to-face contact can be important. *"The residents come by with their teams, the 'Doc and docklings,' and we're able to talk to them once in a while..."* From the field notes, *"She told me that she had just started a program of rounding with physicians; I interpreted this to mean that she saw the need for relationship building..."* Although the flexibility of being able to enter orders anywhere is very convenient it can lead to isolation, *"I mean we're walled up in those little rooms. I mean that's where you have to do all your work so I think it's a huge, when I did inpatient here, it was a big issue I think. You're just not at where the patients are and the nurses are all the time."*

Disconnected from the locus of activity, doctors have less of an idea of the actual processes involved. The process from physician ordering through delivery to patient became more of a "black box" as described in an interview, *"Doctors writing orders on a computer don't understand how this affects nurses. They don't actually know how or in what format the nurse ultimately sees the order. With paper orders the nurse was involved earlier in the order writing process, but now, many steps occur before the nurse sees the order."*

Separation impairs care planning; this from the field notes, "*This has had a big impact on floors. I heard more than once today that although nurses should round with the doctors, it can be very impractical."* Another nurse reported, "*The nurses don't round with the ward team. Dr-nurse communication has been scant for years but it has fallen*

off in the last few years since staff has been cut due to cost savings. We're not on rounds; we don't even know when patients are to be discharged."

Close contact among the members of a patient care team is important for other reasons; one of the more significant is that of teaching or informing the staff. This teaching goes from physician to nurse as well as nurse to physician. *"[She] noted that with online order entry the nursing staff loses a lot of the face-to-face interaction with the clinicians that used to occur. She noted that in the past this was a time at which the nurses could "educate" the less experienced clinicians regarding proper ordering procedures on their unit.*

When completion of clinical notes is delayed for whatever reason, such as transcription, physical separation compounds the problem. In this case, documentation is absent and the document's author is not available for questions either. An inpatient nurse stated, *"[The] problem with incomplete notes is bad. Have a new admit, very sick but the admit note isn't complete. It may be mostly done but it can't be viewed, I can't tell what's wrong with the patient."*

1.b) The Level of Interaction Changes

Working at a distance causes a reduction in perceived interaction and esprit de corps. A common perception heard across the study sites as stated by a participant, *"With the computer we talk to patients and colleagues less,"* without necessarily putting a value judgment on whether this trend is good or bad. Some clearly found the reduction in face-to-face contact disturbing, or at least, unsatisfying. For example, *"I think people now they substitute interaction with the computer for communication with individuals [...] the sort of end result is - oh put it in the computer, rather than tell me about it."* Both ends of

electronically mediated communication felt the disconnect, this from a physician, *"So, I think it's worse, only in the sense that we're stuck at the computer all day long - at least sometimes it seems that way - entering words, communicating through the computer [...] the personal communication is worse."*

Physical proximity was particularly valued, *"So one of the complaints we've heard is that there's not that physical presence. That people aren't around as much to ask questions."* And this observation from another site, *"Well, I know that the nurses have complained, and still complain, that now that the physicians don't have to come to the ward to enter their orders and write notes, they don't see them there."*

A few expressed an increased sense of contact and communication; some stated that their contact with patients was improved. From field notes, *"These clinicians remarked that they felt they were able to spend more time with patients at* [Hospital 1] *than they were at* [Hospital 2] *due to the use of the computer system."* For RN – MD communication the ability for both sides of the contact to share information, for both sides to be, literally, "on the same page" was felt to improve communication. (See "Same-Page Communication below.)

1.c) Redundant Channels, When Both Verbal & Text Channels are Preserved with CPOE

One approach to reducing the impact of narrow communication bandwidth inherent in current electronic systems is to maintain verbal channels similar to those predating the electronic systems as a redundancy or check on success of a message. As one nurse concisely phrased the problem, *"POE does not replace communication."* Another observation from the field notes, *"There is somewhat less interpersonal contact here yet*

they are careful to back up electronic communication with personal notification." CPOE is only one of several redundant paths, *"There's a lot of interaction that goes on. It's not as simple as the physician writing the order."* Participants recognized the necessity of redundant paths, at least until the time when electronic systems may provide them, *"So the nurses are aware of needs of patients and will step in or page them and ask why. Other than that, at this point I don't see a better or another solution other than the face-to-face communication.*

Urgency and importance can drive verbal ordering in parallel with CPOE; *"You know, sometimes that's okay, because the urgency sometimes of what you want done, it makes it necessary for you to actually have to talk to someone. And probably better that way, to make you communicate..."* Another physician remarked, *"If it's a really important order, you know, I'll find them. I'll occasionally call, but I'll find them if it's an important order."* The nurse needs to be alerted that an important order exists, *"...when orders are stat the computer prints them out like any other order so the docs need to let the nurses know they are important by calling them or telling [them].*

In some institutions, verbal channels are truly parallel to and separate from electronic channels, especially in locations where the CPOE is "the" ordering processes. From the field notes, *"In the hallway he is 'curb sided' [regarding a med] and the patient's request for a flex sig [...] The R.Ph. will send him the note so he can act."* In this particular institution it is difficult to order virtually anything outside of CPOE.

Maintenance of verbal channels will persist as long as health care providers see a need and make verbal communication a personal priority. From the field notes, a nurse stated, *"My goal is to be with the rounding team every day."* She feels she is successful in this

endeavor the majority of the time and adds, *"If I'm not there, they come to me."* A nurse at another institution noted, *"She also adds "Docs are only here for a short time, like three minutes. We [nurses] have to communicate with them while there here or else they are not going to see everything. I try to catch up with them when I see them."* A physician summed up her antidote to limited communication, *"So I think a little bit extra effort on the part of [physician] and a little extra effort on the part of the nurse to make sure that we're touching base at least once a day as part of routine rather than just hoping to collide in the hallway through random chance."*

The "persistence of paper" will be discussed in more depth in a subsequent section but an example of the venerable use of paper in maintaining parallel communication is appropriate here. *"I notice that on one of the charts sitting out on the counter by the computer terminal is a 3x5 note taped to the front cover "Pt would like an order for throat lozenges – Thanks."*

1.d) Technologic Solutions Provide Redundant Channels

CPOE, itself a technologic solution to order entry error, may in turn cause problems. CPOE and EMR cause physical separation and promote use of narrow built-in communication channels. These channels, however, if integrated into the electronic work environment, can provide shortcuts to completing tasks. As a simple example, writing a message about a patient might automatically open patient's record.

Some pre-digital communication devices, such as the "greaseboard" or "whiteboard," which commonly display patient name, problems, etc and are used to organize work on the floor or in the ER, will no longer be acceptable since HIPAA now forbids public display of patient names. The EMR can produce an "electronic whiteboard" that serves

the dual roles of unit census coordination and notification of new orders for the staff. From the field notes, *"A new order is written and the nurse gets alerted on the computer. Her list of patients is seen and the ones with new orders are marked or highlighted."*

Other technologies are increasingly employed to compensate for the reduction in face-to-face contact. Cell phones, text paging and other wireless devices are filling the need. From the field notes, *"All the docs and nurses carry cell phones."* Often the cell phones are related to the clinician's role, *"Cell phones related to task are common, i.e. the ER [coordinator], ER docs [for example].* At some institutions, electronic scrolling message boards notify staff of important changes in patient condition. Identification is by room number rather than by patient name.

Among wireless technologies, text messaging stood out at some institutions as being particularly effective when supported by an adequate infrastructure. From field notes, *"Text messaging substitutes for much interpersonal communication, yet it is, in a way, more personal [Used throughout the hospital, docs in clinic text message consultants, etc.]"* A nurse stated that she loved it because, *"It's hospital wide, I can call and get an order from anywhere. Text messaging on pager, that's really powerful. You're here and they already know the problem. It's easy then for them to just call back with the answer."* The system described above consists of a computerized phone book, message-entry application which quickly finds the appropriate recipient and forwards the message.

2) CPOE Allows Communication Anytime, Anywhere: Ubiquitous Communication

Communication can be "ubiquitous" or *"...seeming to be everywhere at the same time."* [51] Ubiquity manifests in several properties to be illustrated in this section. Also,

communication can be characterized as synchronous (simultaneous), asynchronous, or perhaps something in between.

2.a) Synchronous vs. Asynchronous Communication

The clinician workday is frequently interrupted. A physician trying to get through his workday as observed in the field notes, *"Back to the office, he types about 3 words in the note when he gets a phone call from a call center [about another patient]. He closes [the current patient] and goes to "patient calls" [section of EMR] to get the appropriate telephone message to discuss with the caller. It's about meds."* Clinicians reported needing uninterrupted time to work through and formulate difficult patient problems, *"I like to step out of the office to think. I like to go someplace where I don't get interrupted, [...] The more complicated the patient is the more I need to step out."* Also, interruption can lead to error, *"I was ordering Cortisporin, and Cortisporin solution and suspension comes up. The patient was talking to me; I accidentally put down solution."* Another clinician stated, *"I'll have to ask... 'please don't interrupt, or just let me just order all this, because I get distracted and I could easily make a mistake with order entry.'"*

Synchronous communication is often needed when tasks have to be done simultaneously. Clinicians often have several "threads" in process at any one time, each awaiting an event to trigger an action such as availability of a lab result. An excellent example comes from the field notes, "*A first year resident is sitting at the terminal. He is on the phone, looking at the message on a text pager. He has 2 charts open in his lap, and he is using the mouse to locate something on the computer screen. There are 5 people surrounding him asking questions. I wish I had a camera. This is some fine real time processing and context switching."* The obvious efficiency gains are those of

avoiding interruption of the consulted provider and minimizing the time investment of the consulting provider. As advice nurse observed, *"He doesn't have me waiting outside the door when his mind is already full of what the patient's just told him of what he's gonna chart to try and change all of that thought process now to another patient with what I'm saying."*

2.b) Same-Page Communication

The electronic record's ubiquity allows for the chart to be "present" in different forms in many places simultaneously, unlike the paper chart. *"A typical scenario is this; I get a call from an advice nurse regarding a patient who has contacted her. She'll state, 'I got this call from a 72 year old woman... Do you want her health record number?' I do and now we are on the same page of her medical record... The result is a rapid assessment and treatment with a deep basis in facts."* A primary care physician stated, *"When I call consultants the first thing they want to hear after the thumbnail is the health record number. We are then on the same page looking at the same data."*

This ability to be "on the same page" can improve relationships, from an interview, *"I think the information systems actually promote collaboration between the doctor and the nurse, believe it or not... having all the information right in front of her... it promotes the communication."*

2.c) The EMR/CPOE Systems Allow Clinicians to Participate in Care Decisions from Locations Distant from the Site of Care

In the past it was common for clinicians to work effectively in only one clinical location at a time, the one in which they were physically present. With EMR/CPOE clinicians can be virtually present in several locations simultaneously. *"So we call Dr.*

Jones and say - you know, we have to read all of the lab orders to him. Well, if he has[CPOE] in his office...he can review those labs, and then he may put an order in based on that from his office."

Clinicians may opt to do some of their "office work" from home. A common sentiment was that going home to spend time with the family was important, and "office work" would be done after the children were in bed. Those without home access stated they did not want hospital or medical work intruding on their home lives.

CPOE seems particularly liberating for pharmacists who are now able to do tasks on the ward that used to be limited to the main pharmacy. *"In the old system I couldn't approve meds and be on the floor. I'd either be in the pharmacy or a clinical pharmacist on the floor. Now, almost all of our pharmacists are 'clinical pharmacists' on the floor working with the teams."* This from the field notes, *"I'm covering two floors, 14th and 9th, approximately 140 patients." He is now on rounds with the 9MICU team and will later go to the floor teams he is covering. He checks the computer often to see about meds he has to approve."*

At some locations the pharmacist has a laptop with wireless access to allow order entry while on rounds as well as accessing internet resources to advise the team while they are still together as a group. This example illustrates that ubiquitous communication can also bring information to the bedside. *"You can be standing right beside the patient in the room and look up orders there. All sorts of information is available to you, like dose range, right there, on the computer."*

2.d) CPOE Can Cause an Illusion of Communication

An illusion of communication, that a message is received and acted on, occurs when clinicians do not understand the electronic message process or the receiver's method of processing a message. To them messages go into a black box with no assurance that the message will be received or that anything will happen on the other end because of it.

CPOE seems less tangible than handwritten orders: *"I think, every time I put an order in the computer, and I still have the uncertainty, well I put it in, but is somebody gonna see it?"* Another stated it more colorfully, *"...docs picture it going into a black box, that it's a magic process, it's an illusion of communication, but at the other end there's not any kind of prompt [to alert the intended recipient.]"* A provider at another institution stated, *"It's not clear what the brand new orders, not acted on, are. I don't know what's been acted on-- how does nurse know?"*

Misunderstanding the process of communication can lead to false assumptions, *"[Doctors ordering,] expecting the nurse, when they put it in, even if they put it in stat, for her to know it almost immediately, and this doesn't happen."* Misunderstanding can lead to frankly dangerous assumptions; *"Otherwise, I'll just assume that it's being done and hasn't been a problem."*

Electronic systems come up short when compared to the familiar paper, "*The computer 'gives a false sense that communication is happening.' You enter it and think it went to the right place. With handwriting, you know it hasn't gone anywhere, so you pick up the phone."* Delivery confirmation can be crucial, as noted by a participant, *"The* [EMR] *has an internal mail system.[...] There is no return receipt function. They do not use this for patient care messages."*

2.e) CPOE Increases Speed of Access to Information: Processes Move Faster

CPOE and the EMR speed information transfer in the order-entry process; *"[The] advantage of it and the reason we wanted to have it was it increases the speed of access to information."* Rapid, more efficient communication is enabled by the availability of information everywhere. *"The idea was to be able to do things quickly and more efficiently, which it does."* Rapid, more efficient communication speeds the ordering process. *"[I have] ten years of the guy sitting on the screen... So it makes the whole process more efficient.* In the outpatient arena, responding to phone requests is accelerated. *"It's just everything is in real time. I mean the response time to a phone call used to be a couple days. Now it's an hour."*

Access to specialist recommendations is hastened, *"You know some consultant sees my patient and word about the guy's on the screen here ten minutes later you can do something about that. Everything is sort of pitched forward."*

Reduction in the time from medication order to administration can yield an unexpected consequence. From a pharmacist, *"Turnaround time is remarkably better now than the three hour turnaround without the system." "From doctor entry through approval process to the [medication management system] takes awhile but less than 1 hour."* He then described how this could cause problems, *"Even an hour is too long now. In few cases are meds that stat. The RN sees the order, it's on the agenda and they do it NOW."*

2.f) Hectic Environments Test CPOE's Efficiency

The Intensive Care (ICU), Emergency Care Unit (ECU), and "code" situations are "hectic" in that orders come rapidly, interventions are time-critical, and there is pressure

to stabilize and transfer the patient as soon as possible. CPOE alone may not be fast enough; CPOE needs verbal supplementation, *"...in a critical care unit, the physician, if they're entering new orders, they need to verbally communicate that, because ... a new order could go in, and then I may not get to giving that stat dose of Lasix for two more hours because I won't know it's in there."*

Perception of Emergency Care CPOE ranged from unimaginable to essential. From field notes, *"He cannot conceive how one could do CPOE (completely computerized) in the ED."* At another institution the feeling was expressed that the ECU setting itself limited CPOE, *"So the software itself is not conducive to an ER setting, and that probably doesn't help. There's no, like, way that a physician writes the orders in the computer and the nurse is immediately alerted to - that there's no orders, as opposed to a piece of paper they can write on and hand to the nurse."* On the other hand, in a different institution an ECU doctor was asked about using CPOE in the "hectic" ECU environment, she replied, *"Too hectic in the ER? We've found just the opposite. The ER is to hectic NOT to use it. We would never be able to organize our work."* This informant continued, *"The medical care in the ER is so time-sensitive it reemphasizes communication, the importance of communication." "I can't imagine working without it now."*

"Code" situations, i.e. the emergency response to a patient's sudden collapse, present a still more extreme test of CPOE. "*Physicians are giving orders very rapidly, and so that orders didn't [get transmitted], because the one thing you always get is, you know, the blood's downstairs and they're saying, 'We don't have an order.' Well, no, you don't. Everybody's in the room treating the emergency."* The response in many studied

institutions was to revert to paper processes with subsequent documentation; *"...especially in high intense situations, code situations... you're giving all this medication, and eventually that all does need to get documented."*

2.g) Care Transitions Test CPOE's Flexibility

Patient movement from one level of care to another can cause problems if communication is poor; *"An example here is a lack of communication between emergency department and the floor in the hospital there often questions arise on whose responsibility is to in transfer the patient in the computer system. Sometimes the emergency department transfers the patient, discharging them from their unit while at other times the floor "arrives the patient" when they get there. If this not done properly the new orders often show up in the wrong location in hospital."*

The discharge transition is also a problem. *"The discharge medication orders are often based upon the 'med list,' which is comprised of only those things ordered in the hospital. The receiving out-patient physician sees the new list and may assume that the lack of a previous med was intended and will erroneously stop it."* Recognizing the seriousness of this problem JCAHO now requires a process called "medication reconciliation" to be done at every transition of care. [52]

3) CPOE can Enhance User Awareness

Health care workers need to be constantly aware of situations impacting patient care. CPOE provides this awareness at several levels through embedded communication.

3.a) Patient Level: Flagging New Orders in the Electronic Age

Several methods of informing those delivering patient care, (nurses, dieticians, therapists, etc.) in a reliable and timely fashion have been used over the years. Direct

verbal notification has served for decades and will likely persist into the electronic age. *"If it's a major issue that requires the nurse's attention it needs to be [verbally] communicated."* This persistence is illustrated by another statement, *"I think for most of that stuff you usually grab a nurse and say, hey I put a new order in for this...we use to usually do that anyway - even when we wrote orders in the old days."* Since then electronic media have become more available, perhaps more efficient and usable than their predecessors; as a participant stated, *"...each new order that comes in, the nurse receives that in her - each nurse has a little mailbox, and she retrieves her orders every fifteen minutes. She looks in her mailbox throughout her shift and sees the orders that have been entered on her patients."*

Various physical or mechanical devices or "flags" were used in the pre-electronic era as noted by a nurse, *"So there does have to be a system in place to know that - you know, the old school was you put an order on the chart and you flag the chart. There was some sort of tag or something you did to a chart to know that a doctor had written a new order in there. Now, that isn't a fail-safe system because sometimes they forget to flag them, and an order would sit there for a long time."* "Flag" refers to the physical devices used to alert specific individuals or groups to the presence of an order and/or the urgency of an order. This nurse went on to explain the implications, *"But on the computer side, they can put the orders in from anywhere in the hospital on any patient that's theirs. And some of them have the capability of doing that from an office setting. So each floor has had to develop a system..."*

In many institutions orders are printed in the patient care area. In those locations, both inpatient and outpatient, hearing the printer startup may be the only system notification of

new orders. In some other institutions, informational screensavers as part of the EMR/CPOE was observed filling this role,. *"Orders placed will appear on the workstation on the appropriate ward as a screen saver, alerting the nurse that they need to be taken off."* From another institution, *"A new order is written and the nurse gets alerted on the computer. Her list of patients is seen and the ones with new orders are marked or highlighted.* Participants continue to use direct, verbal channels when there is a press for action, *"She said that stat orders done from remote sites need to be communicated to the nursing staff."*

3.b) Floor Level: Who are the Patients, Where are They, and Who is Taking Care of Them?

Until recently, the "Grease Board" or "White Board" on which patient information was listed was in public view to give a broad overview of unit function. The broad overview of unit function necessary for efficient care-delivery on a floor or unit but is, unfortunately, no longer acceptable from the regulatory perspective. Electronic systems can fill this role in a HIPAA compliant way. This excerpt from the field notes describes a system in an ER, *"On this display, patients can be moved from one area to another by drag and drop, much like the [computer] Solitaire game. All of the information displayed in colors of frame, background and font would be a worthwhile study. Each color and combination has meaning and can be seen from yards away."* Similar systems were observed that can display inpatient patient lists by unit, clinician and nurse. Outpatient systems as well were seen to display the clinician's office schedule as well as where each patient was in the clinic's process, i.e. checked in, in exam room, etc.

Triaging available resources to meet the needs of the patients is another essential function. *"The [electronic] greaseboard allows the clinician to select the most appropriate patient to see when the doc is free. It is also capable of alerting the doc to research study enrollment opportunities."* In another institution, the electronic "grease board" program actively triages; *"Its function is to keep track of the patients in the various sections of the ED. The data from the Address Confirmation Form, based on a rules based program, generates an acuity score (1-5), which relates to how quickly the patient is seen."*

3.c) Institution Level Awareness

Rapid notification of hospital staff to situations affecting the hospital's ability to meet care needs has been difficult in the past. Electronic systems are emerging to fulfill the need to alert hospital staff to situations that limit care delivery. This from the field notes informing of a critical lack of beds, *"Each time she logs on there is a pink screen, '*[The Hospital] *is on total divert.'"* During the study period there was a national shortage of influenza vaccine. Logon notices to staff displayed the current status of the shortage and guidelines for rational use of the available supply.

3.d) Patient's Individual Health Situation

Electronic systems can speed the dissemination of information to decision makers. These observations from the outpatient arena, *"One of the hopes of [health system] administration is that through use of the electronic medical record system providers throughout the care delivery system will "know" the patient better."* This from the field notes, *"A phone call direct from a patient on inside line, "I know you, I'll bring you up." He types patient name into [the EMR] and starts a phone encounter. ... He goes over*

patient's needs and reviews her med history on the "Patient Medical History" page and finds some solutions."

4) The Computer Changes the Patient-Clinician Conversation

Using a computer with CPOE/EMR during a patient encounter invokes changes in the conversation between patient and clinician. The presence of CPOE and an interactive record in the room can enhance information transfer and make CPOE a collaborative effort between patient and clinician.

4.a) Use Varies by Clinician and Experience

Physician reaction to exam-room computers varied from totally ignoring the computer to using it extensively. From a clinician nonuser, *"It's too distracting to me to break the eye contact to enter on the computer. I've tried it. I don't take notes in the room..."* On the other hand, these field note observations of heavy users tell a different story, *"MD is in the room for almost the entirety of the time allotted for the encounter."* A clinician observed at another institution, *"He is a touch typist, typing as he talks keeping eye contact with the patient."* Another clinician stated, *"There is no question that the EMR makes me more efficient and faster."*

Reasons for and against CPOE in the exam room varied. Some clinicians worried that patients will view them as inept if they are not in command of the electronic milieu; *"I'm a very bad typist. I took band in high school instead of typing. It's the biggest mistake I ever made; that I didn't learn how to type properly."* Another clinician reported, *"I like to go someplace ... where I can look up something without looking stupid."* For others it was a continuation of their pre-CPOE/EMR practice, *"It's like in the old days, some will chart [in the room] and, when they walk out... they're done. I never did that."*

Some clinicians expressed strong, even emotional, feelings about the reasons they do or do not use the EMR/CPOE with the patient present. Nonusers frequently cited a negative impact on communication or the doctor-patient relationship. From the field notes, *"Some clinicians are able to talk and type at the same time but he feels that is not a human interaction."* Another physician stated, *"I think it is hopelessly rude. I just, I can't, people say that their patients don't mind and I can't, to me it's such a huge part of the doctor visit is like the making of eye contact."* Yet another physician stated, *"I've tried it...I need to talk and joke with my patients. I need to have some fun...so that I can enjoy coming to work...It degrades my experience in the visit.*

4.b) CPOE can Enhance Communication

Heavy users of the EMR cited improvements in communication and the doctor-patient relationship, from a clinician, *"I'd actually go one step further and say it increases patient satisfaction ...these little monitors pull out so you can actually pull it right next to the patient. They can read their own reports and offers them reassurance that we're not hiding something from them. They see the plots of the graph that we plot for their labs. They can see all this information right in front of them.*

In situations where CPOE integrated well, clinicians were seen to include patients in charting and ordering activities. *"I try to build the after-visit summary while I'm with the patient. They can participate in it and ask questions."* A parallel statement, *"I do orders in the room because it only makes sense to do it with the patient present."* Patients were sometimes observed to correct clinicians; *"Patient, 'You were going to change my [medication].' Physician, 'Oh yes, that's right. It's nice to have you here to help me.'"*

4.c) Room Arrangement Can Be Critical

Room geometry was seen to affect use of computers; *"He orders silently with his back to the patient. (That's the way the room is arranged.) After a minute he says, 'Sorry, I'm just entering into the computer.' 'OK.' He has to turn around to ask 'How do you pay for your medicines.' He is a fast touch typist ... It matters little since the patient is behind him anyway."* Elsewhere, more favorable room arrangements allowed a three way interaction of patient, clinician and computer; from field notes, *"He has the screen turned roughly 45 deg to the patient, approximately bisecting the angle between himself and the patient. He looks at the screen a lot but will turn to pt and make eye contact at least between each sentence and often in the middle of the sentence."* At another institution; *"... the patient, physician and screen form a triangle with the screen more facing the physician. The screen is always visible to the patient. He is also facile with using the screen to illustrate his points, much as we might have used paper forms or reports in the past."*

5) Paper is Changing Its Role from Records to Communication

"Going paperless" is a highly visible and frequently stated objective of implementing CPOE. In reality, however, none of the sites visited were "paper-free."

5.a) Paper Processes Continue for Several Reasons, Regulatory as well as Cultural / Historical

At one institution, according to a physician informatician, *"the official medical record is half computerized, half paper."* This is at least in part due to state regulations.

Paper-based processes seem essential even in institutions leading the way in CPOE. From the field notes, *"Orders are now written through the CPOE system. In the ER,*

however, they are printed and executed from the printed pages." From the fieldnotes, *"At the time of [shift change], they use the '14 bed sheet' basically a long sheet of paper divided into 14 'beds,' seven per row."* The form used was computer-generated and hand annotated, included patient history, orders, and treatment plans.

The paper-record persists in both the computer and human metaphors, demonstrated by electronic "charts" with computer entry "pages," and heard in the language clinicians use to describe medical recording tasks. From the field notes, *"He tells me you must complete the data entry – 'you have to finish the note' - before you can see the next patient. He tends to call the whole interaction with the computer as 'writing the note.'"*

5.b) Compatibility of Computer Processes and People

Users stated how they found the established paper processes comfortable and the replacement electronic processes upsetting. *"...the big change was not transcribing. I feel at ease if I write [orders] down, I feel like I really know them. In EMAR you just click on them, it was weird."* A care coordinator stated, *"A lot of this is available on line and on the internet but I like to have a handle on it. I like to have the information on paper where I can hold on to it," as he clutches his sheaf of papers to his chest.*

Clinicians often adapted CPOE/EMR printouts into daily workflow. They wrote clarifying and planning notes on these pages, which became hybrid information tools with widespread use. From field notes, *"Each of the participants has a bundle of paper. Most have the Long rounds, Dr-Pt list and chart notes."* Participants expressed confidence in these paper reports and used them in novel, labor saving ways; one of the residents stated, *"We use these reports to write progress notes on. The synopses are*

really accurate... it keeps you from having to rewrite all of the labs and patient summary by hand each time you need to chart."

Some computer documents are multi-use hybrids by design. *"They have a form called "sign-out" with multiple uses. If the patient is in for less than a week, it will autopopulate a discharge summary... It's also updated by the intern daily so it can be printed out to fulfill its name of "sign-out" when one intern leaves her patients in the care of a covering physician. 'It can be a blessing or a curse, if not updated it looks like the admit note and is of little use, but if it is kept up to date it's great!'"*

Discussion

Distinctions among the parts of electronic health care systems are blurring. Separating and examining the components CPOE, EMR, and CDS individually are increasingly difficult and artificial since each component blends into the other. CDS is on the interface between the EMR and CPOE using information from the EMR as well as other data bases to inform the decisions of CPOE. Although each component has intrinsic value, it is only in their combination that they achieve maximum usefulness. This bundling of functions has been referred to as a "technology cluster." "A *technology cluster* consists of one or more distinguishable element(s) of technology that are perceived as being interrelated."[53] For these reasons, although this thesis will focus on CPOE it will also range into related areas such as EMR, CPOE, and communication devices when the relationships are close.

The following chapter is divided into three sections. The first section, "Communication Models" reports on the "implications for theory" aspects of this study. As analysis of the data unfolded, there was an increasing realization that communication theories could enhance understanding of the phenomena which is reported in this section. The second section deals with the communication themes developed from the data. This is the "human impact" side of the study discussing the changes in communication and effects on people. The final section deals with study limitations.

Communication Models

As presented in the introduction, the Schramm models [33] and the Daft analysis of channel richness [35] can be useful in understanding some aspects of the processes of

communication. Themes developed in this study are used to detail and extend the Schramm models and the Daft model to new situations.

The first Schramm model concerns the structure and function of communication channels. The current work extends this model to include redundant communication channels and multipath communications.

The second Schramm model describes the importance of "shared field of experience" between communicants to understanding messages. Data are presented illustrating how situations and circumstances in the studied institutions affect this "shared field."

A discussion of Daft's channel-bandwidth model describing how characteristics of communication channels relative to the intended message influence channel selection will conclude this section. Channel selection was also found to depend on a previously unmentioned variable, the "importance of the message," which will be developed in this section.

Schramm's First Model of Communication: Channels and Noises

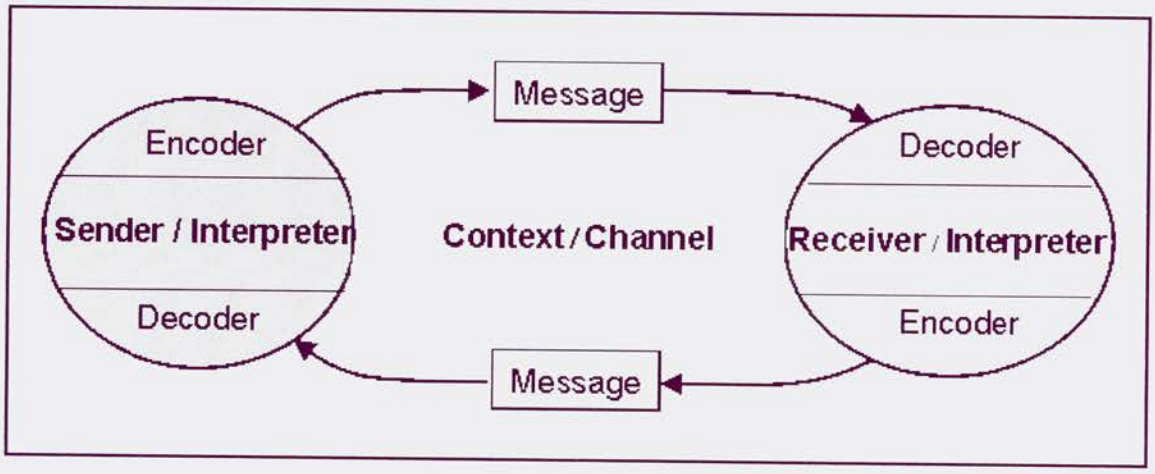

Figure 6. Schramm "Circular" Communication Model

To review, in Schramm's first communication model messages are encoded by a sender then sent through a communication context/channel to be received and decoded by

the receiver. The message is subject to noise or "interference" of several varieties during each step of the process including the encoding and decoding steps. "Noise" includes anything that impedes a message from getting through and includes physical noise and semantic noise. These will be discussed in the following sections.

As illustrated in Figure 6, there may be a return message, involving the same steps of encoding, transmission and decoding, by which the receiver of the first message can notify the sender of "message received" or to post a reply to the message. In either case, the action will "close the loop" of communication. Participants voiced uneasiness using channels with no feedback terming them "black hole" or "black box."

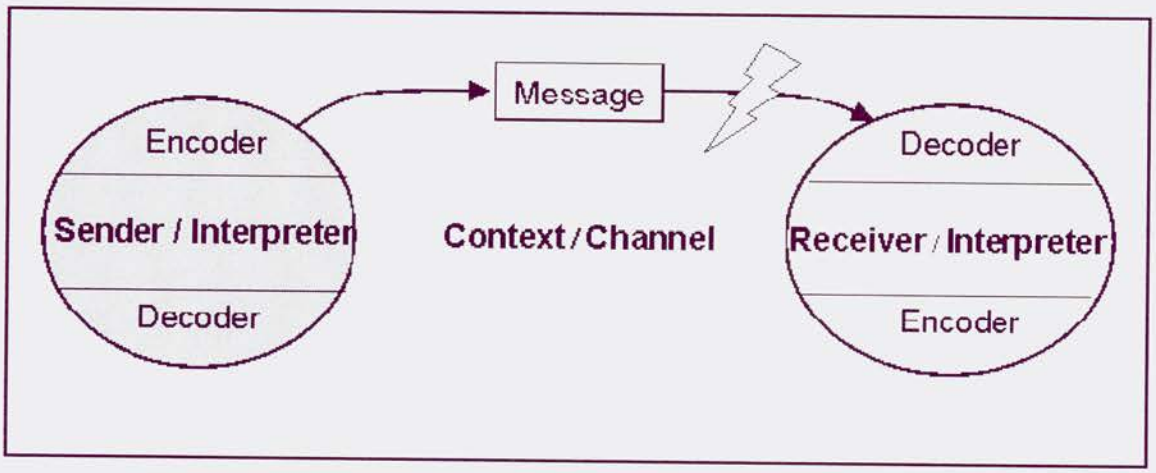

Figure 7. Physical Noise in Model

Physical noise was rather uncommon in the data but was occasionally present. (see Figure 7.) Cell phone transmission occasionally would "break up" to the extent that the messages were difficult to understand. In this case, the noise problem was often identified easily. In some cases it led to the use of a different communication channel, often the "land-line" phone. Cell phones were noted to be "out of range" when turned off or if in an area in which there was no service.

Pagers, either numeric or text, sometimes displayed an incomplete message or an inaccurate message, for example only 4 digits in a 5 digit system. In the case of the text page, which is less "information dense" the context is often adequate to reconstruct the message. Unfortunately, the meaning of numeric messages often hangs on the accurate receipt of each digit in order.

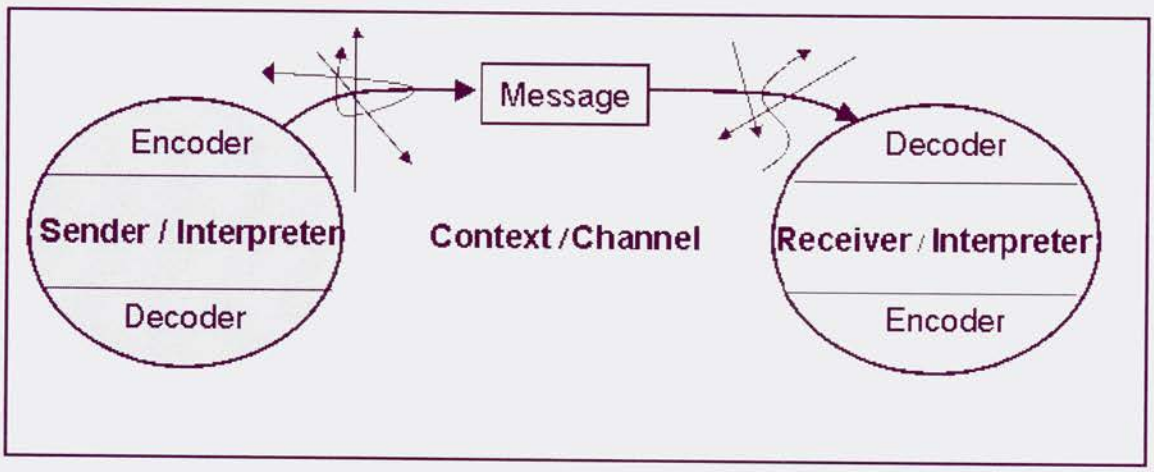

Figure 8. Semantic Noise in Model

Semantic noise affects both the sender and the receiver resulting in impaired communication of information. See characterization in Figure 8. Semantic noise affecting the sender during the encoding process leads to malformed messages. On the other end of the communication semantic noise may cause the receiver to miss parts of the message. Unlike the case of physical noise, semantic noise may often create information transfer errors that go undetected.

Examples of semantic noise are readily observed although the actual resultant misunderstandings are difficult to detect in an observational studies. Semantic noise takes the form of distractions from the process of communication by directing consciousness away from the message. Distractions such as alarms for IVs, monitors for blood pressure, heart rate, etc are common in medical venues. Beepers often distract more than just the

intended recipient since beepers often sound alike. A frequent sight was to see an entire ward team simultaneously check their beepers when one of them sounded. Extraneous messages such as overhead pages or simultaneous but unrelated side conversations may divert attention from the process.

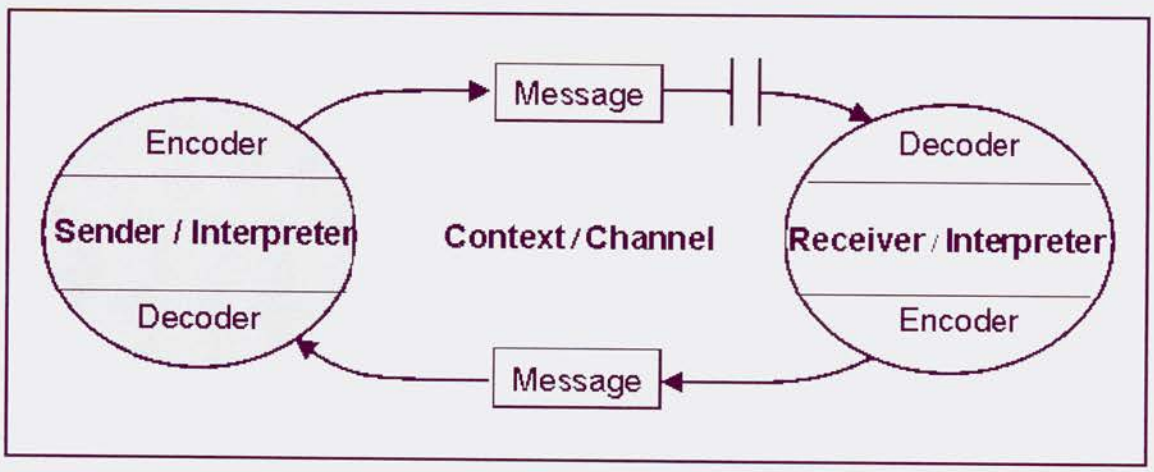

Figure 9. Blocked Communication

Communication can be reduced, delayed, or even blocked in CPOE. (See fig 9.) Some situations are a direct result of CPOE and others only indirectly through systems closely associated with CPOE. Delays in transcription or posting of orders or notes result in a situation in which a message exists but cannot be transmitted. In some systems orders and notes will not be available to anyone but the author until it has been signed and released.

With CPOE and the EMR many clinicians expressed a perceived reduction in the amount of communication they had with colleagues and patients. This occurs in several areas and is due to several problems. In the inpatient arena it appears to be due to the ability to work remotely, separating participants. A common observation, stated in many ways, was that health care workers, pharmacists, nurses, doctors, etc. now spend much time "staring into computers" instead of interacting with others.

In the outpatient arena both the private-office and exam-room computers are blamed for reduced communication. In the case of the private-office computer, it is sometimes because the clinician spends time reviewing medical information before seeing the patient, and after seeing the patient, the clinician goes back to the office to enter orders. All of this takes place away from the patient. Exam-room computers are blamed for commandeering the attention of the patient and clinician and reducing the amount of communication between them. By diverting eye contact of the physician and patient the computer is felt to reduce the personal quality of communication. Clinicians frequently remarked that eye contact was necessary to establish a therapeutic relationship, especially when difficult or personal problems were being evaluated.

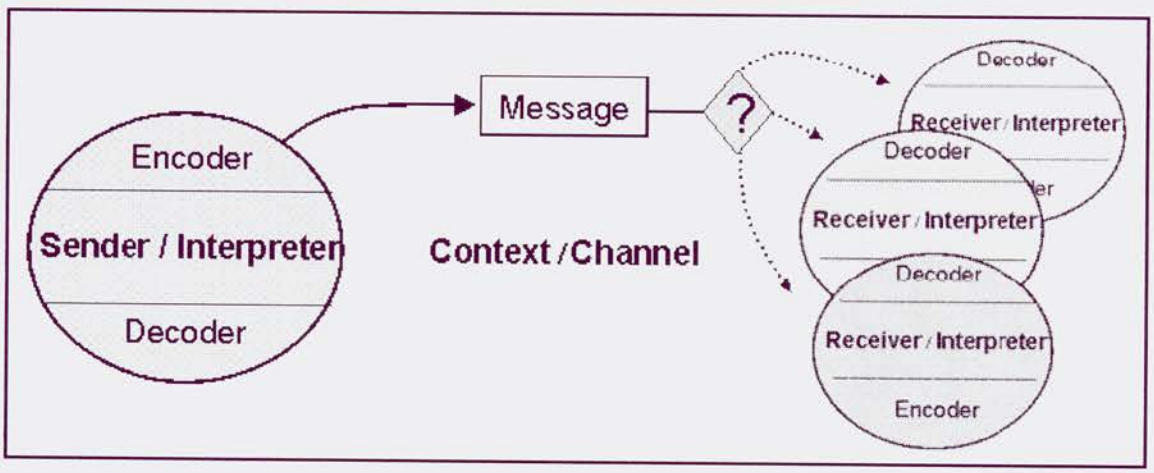

Figure 10. Ambiguous Receiver

Situations arose in the course of patient care in which the intended receiver of the message or the routing to the proper recipient was not clear. (See fig. 10) In the case of orders this was seen especially in the setting of care transitions, when a patient moved from one unit to another. Problems may arise when the CPOE system is rigid in its application of the scope of orders, for example. Orders are location-specific as required by the JACHO; the orders written for location A will not apply in location B. "Holding

orders" written by an ER physician may not be acceptable outside the ER if that physician does not have the proper privileges. There may be subtle differences in order effect if the floor physician "receives" the patient vs. the ER "transferring" the patient.

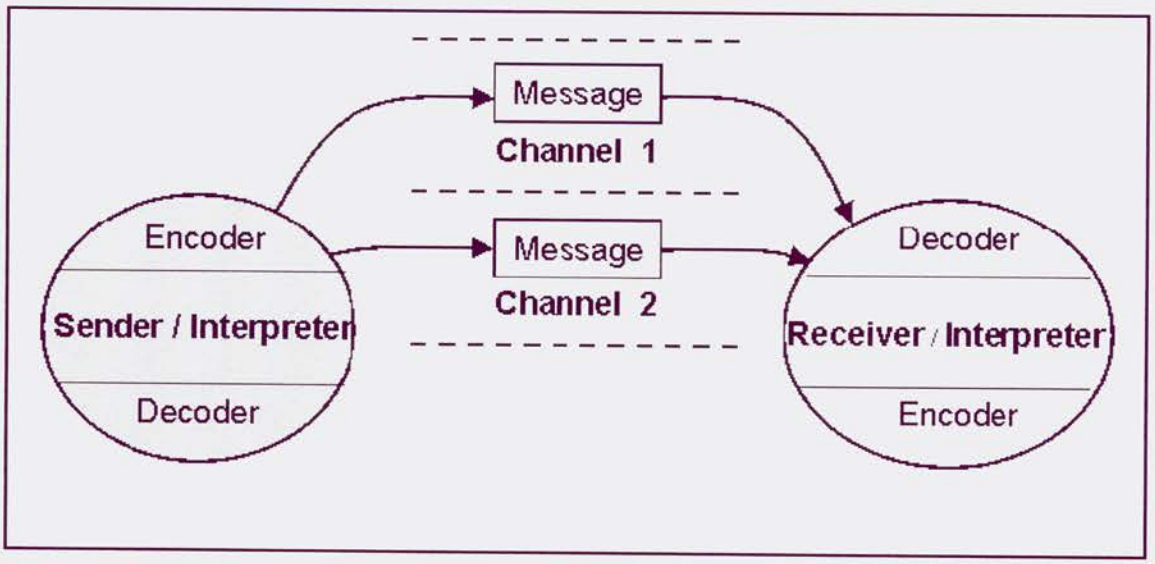

Figure 11. Redundant Channels

Another strategy to address the fallibility of communication channels is to employ redundancy, using more than one channel when sending a message. This was observed when orders were placed through CPOE as well as telephoning the order to the nurse. While not closing the loop of communication directly, it increases the probability that a message will get through. The receiving nurse can, at least, recognize that the promised order has not been received. The more complete model is illustrated in Figure 11.

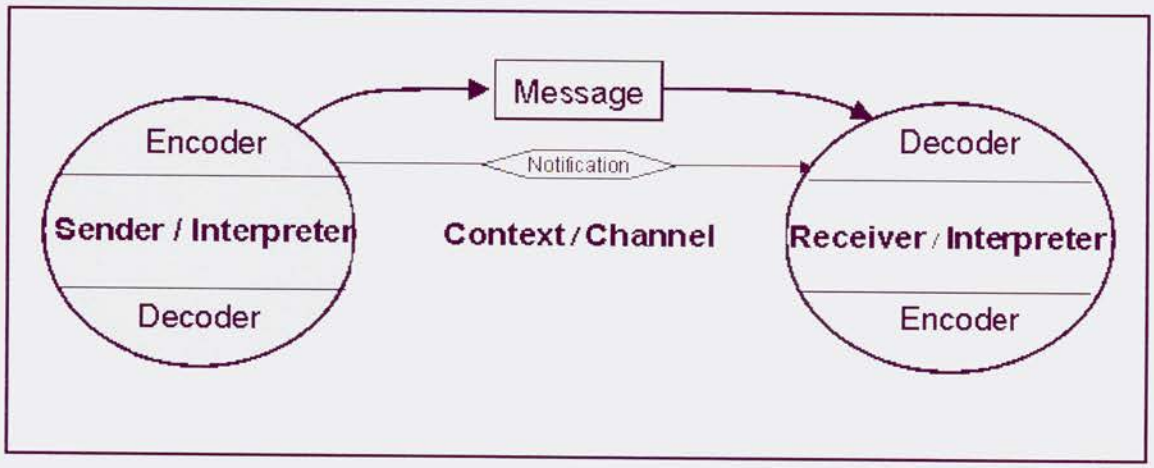

Figure 12. Notification Channel

A special case of redundant channels is the use of a second channel to post notification to the receiver as shown in figure 12. As an example, the use of email to notify nurses of new orders was observed at one institution and phone or pager use is widespread. A notification function may be a part of the communication itself such as systems that turn on flashing lights or flash monitor screens to call attention to the presence of a new message or order.

Schramm's Second Model of Communication: Shared Field of Experience

Schramm's Second Model develops the concept of "shared field of experience" in which shared history and experiences, similar training, common language and terminology define a "space" in which messages can be encoded and decoded.

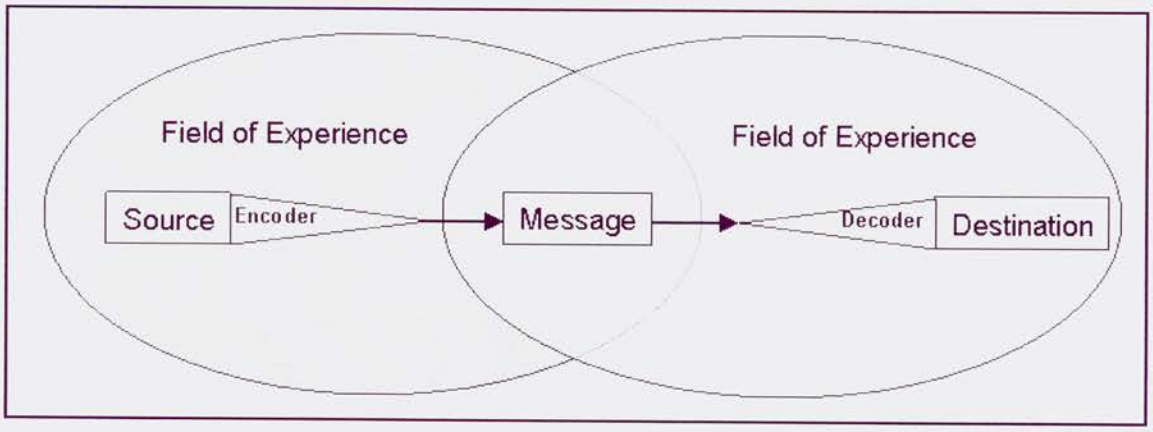

Figure 13. Normal Shared Field of Experience

Each of the communicators creates and interprets messages within their personal fields of experience. The more these personal fields of experience overlap the better the communicants will understand each other.

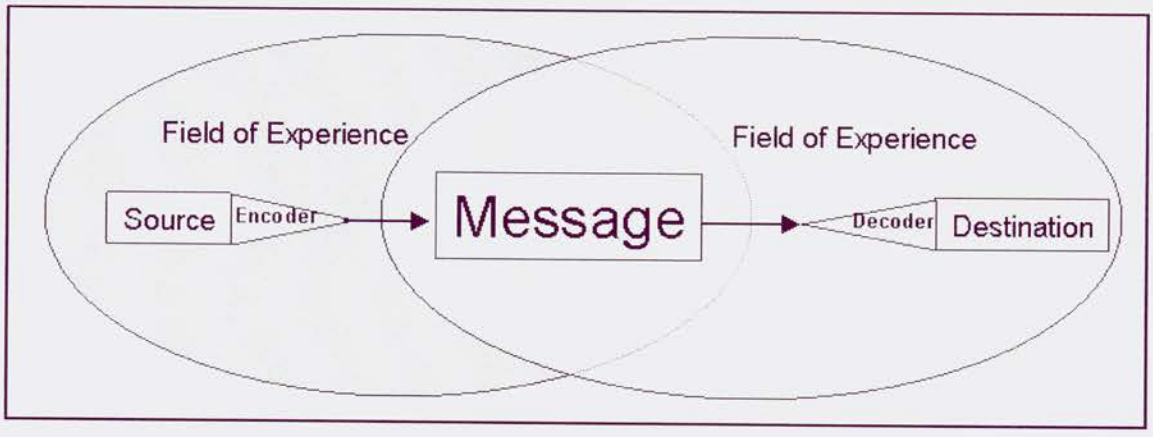

Figure 14. Expanded Shared Field of Experience

The larger the shared space, the more complex and information dense the message can be. Common training, meeting frequently, shared vocabulary, and duration of acquaintance or collaboration can all contribute to a large shared field and support complex, information dense messages.

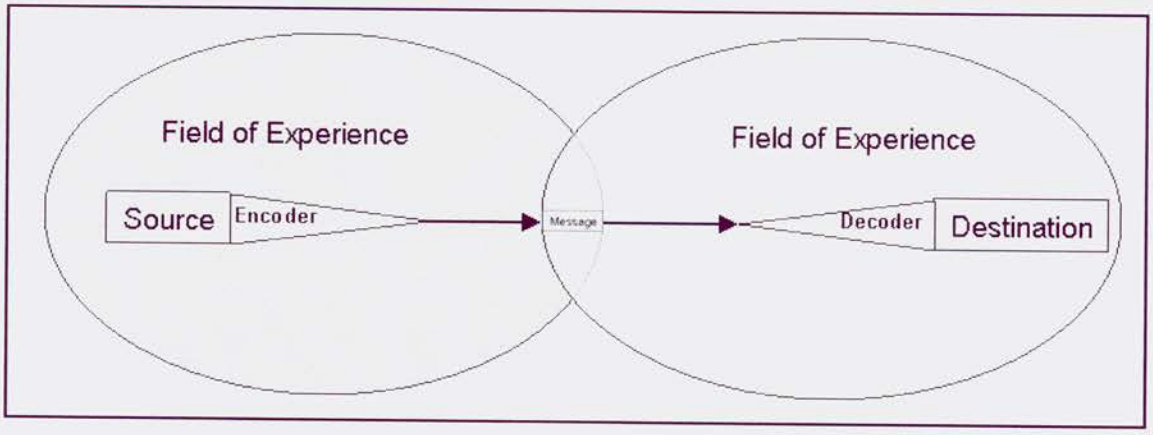

Figure 15. Contracted Shared Field of Experience

On the other hand communicants with little in common will have more trouble communicating. Scant shared language and jargon, different processes for handling situations, differing opinions and more can lead to a tiny shared space that may or may not be adequate for communication.

Daft's Model of Channel Richness: Channel Chosen Appropriate to Message Content

In Daft's formulation, the richness of a communication medium is related to the medium's capacity for immediate feedback, the number of cues and nonverbal channels utilized, personalization, and language variety. [35] When available, i.e. in a rich communication medium, these attributes allow communicants, receivers and transmitters, to check that they have correctly interpreted the message often through the use of nonverbal channels.

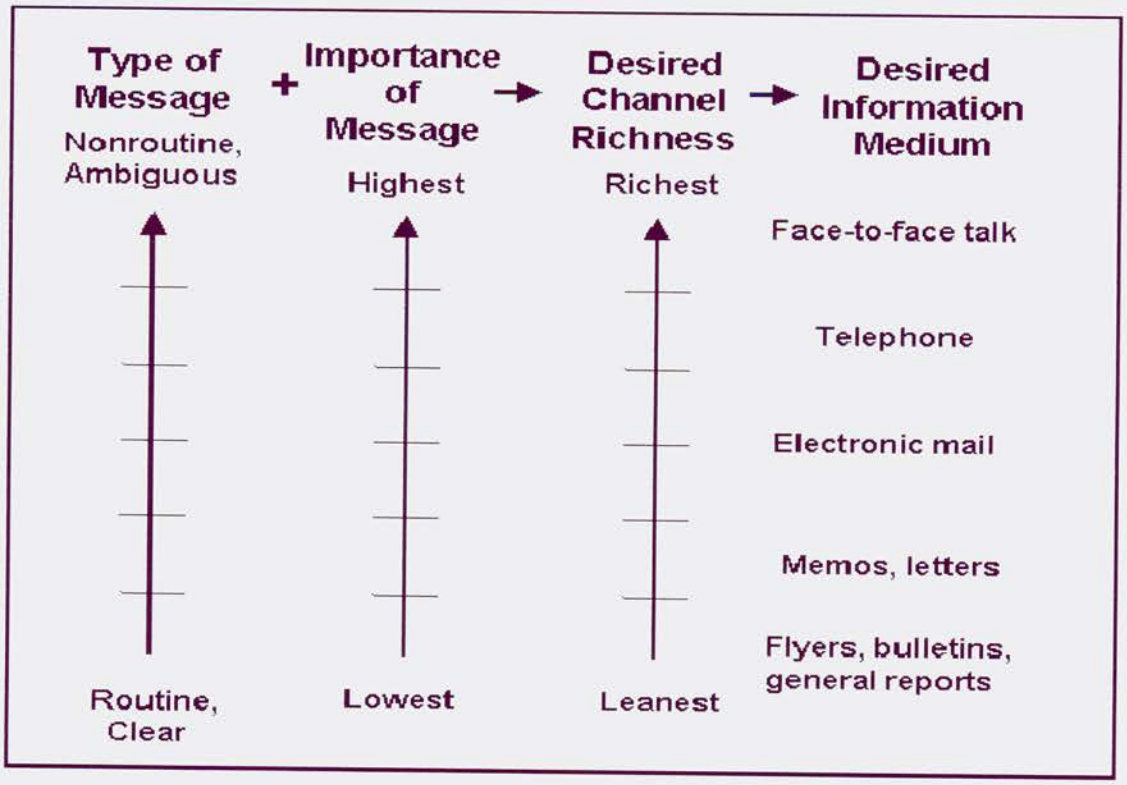

Figure 14. Selection of Appropriate Channel is Affected by the Importance of the Message

In this study we found that participant's base criteria for choice of communication channel also included an "importance of message" dimension. Participants reported uneasiness in committing important messages with high potential "cost of failure" or "high stakes" to less rich or less secure communication channels. In some cases this extended to utilizing a redundant channel with higher richness, often including feedback/loop closure, like the telephone.

Communication Themes

The grounded theory methods approach to the early data uncovered an overarching theme of communication as both a mediator of change in CPOE/EMR implementation as well as a process profoundly changed by CPOE/EMR implementation. After separating the current work on the interaction of CPOE with communication from the ongoing work

of the POET on Success Factors for CPOE and Unintended Consequences of CPOE, analysis proceeded independently. The current work represents a fresh analysis of the entire data set with respect to communication themes using the recursive constant comparison method of grounded theory.

CPOE Changes Communication Channels

Introduction of electronic systems over the years has changed the relative use of various modes of communication. Electronic communication media such as telephone and pager were introduced in the distant past and have been assimilated into the culture and workflow and are now part of the "background." As they developed, however, they came to replace a portion of then existing face-to-face communications. Now, newer electronic data and communication systems, CPOE and the EMR, make it feasible to do a broad range of tasks from a remote location. Previously, remotely available information was often limited to what could be read over the telephone. Currently available CPOE/EMR systems offer a full suite of up-to-date laboratory, imaging, nursing, and clinician information remotely in real-time as well as the ability to act directly through the system, rather than by telephone. In other words, clinicians are now able to conduct "business as usual" from remote locations without personal contact. The ramifications of these developments continue to be discovered.

Physical Separation Causes Problems with Team, Presence, and Interaction

Depending on the participant however, verbal, face-to-face communication may be perceived as having suffered, been maintained, or even increased. There was no recognizable pattern to these perceptions across staff categories by job classification (including clinician), years on the job, hospital unit, or institution. There was however, a

qualitative association between the perceived effectiveness of alternative communication media and the perception of communication quality. (See section on "Technologic Solutions" below.)

Teams need to interact to increase trust and openness. [54] Through interaction teams develop "common ground," a shared "field of experience," or a "common frame of reference." [55] Participants in the health care field share a great deal of "generic medical experience" through their training histories, yet even more commonality can be produced through face-to-face meeting. Medical care teams have some features of both "traditional," i.e. some face-to-face time and of "virtual care teams," since much work is done remotely. "Traditional teams have generally been found to outperform their virtual counterparts with respect to the ability to orderly and efficiently exchange information and engage in effective planning." [56] This difference can be mitigated by shared norms, team building, and a clear team structure, i.e. a "common frame of reference." Patterson et al. recently described how the loss of coordination among clinicians as time was taken up by their interacting with technology rather than communicating with each other could lead to new ADEs. [57]

Not surprisingly, there is a sense of separation and isolation due to remote order entry and functioning "without...interaction with others." Isolation is seen in other industries as well and has been poignantly termed "electronic solitude," a structural loneliness that is forced upon a person in the electronic workplace. [58]

Redundant Channels: When Verbal and Text Channels are Preserved

"Loosely-coupled" is an engineering concept relating time, redundancy of completion paths, and system capability for error recovery. Tightly coupled systems, the faster,

simpler systems that seem so attractive, are time-critical because there is little time between steps in the process. These systems are faster but leave less time for decisions, and simpler allowing fewer checks on error propagation. In a tightly-coupled system, failure or error in any subsystem or process often causes a general failure or completed error. In a loosely-coupled system, other subsystems or processes can recognize the problem and react to recover from the problem before error occurs. From To Err is Human, "Large systems that are tightly coupled have more time-dependent processes and sequences that are more fixed...There is often only one way to reach a goal. Compared to tightly coupled systems, loosely coupled systems can tolerate processing delays, can reorder the sequence of production, and can employ alternative methods or resources." [5]

The traditional ordering process fits the model of a loosely coupled system because many individuals are involved in processing an order and can potentially correct an error. Compare this to a tightly-coupled CPOE system in which an order is handled completely electronically; from physician entry to the eMAR; to the med-dispensing system on the floor; to the nurse administration of the med to the patient. This entire process could potentially proceed with no human accuracy checks between the order and the patient. Face to face communication serves to sustain the error-correcting nature of the loosely-coupled system.

All of the institutions studied were successful in their CPOE implementations in that CPOE was in place and being used, yet in some CPOE was qualitatively more integrated into workflow. The smooth function of CPOE in these institutions appears to be accomplished, at least in part, through the preservation of redundant communication channels. In these institutions reports of the illusion of communication were rarely heard.

Rather, the participants reported good communications and preservation of pre-CPOE verbal communications. CPOE replaced the paper ordering process and became an additional channel of communication. Physicians and nurses spoke of being sure to make "a little extra effort" to meet informally each day. Reserving time for doctor-nurse synchronous communication has been proposed. [59] A caveat to interactions outside electronic record is that, although they may improve efficiency and speed results, they are not part of the official ordering process nor are they part of the record. This presents a potential documentation or medico-legal problem. On the other hand, "curbside consulting" has been part of standard practice for a long time and appears not to have generated major difficulties.

Technologic Solutions: Provide Redundant Channels

Communication aids can be effective in supporting knowledge-based activities, such as CPOE, and examples include text paging, electronic staff messaging and alerting in CPOE, mobile alerts of key information, and of general medical information. These may be available through fixed workstations or may be wireless through handheld or personal devices. [60] [61] [62] "Awareness displays" to reduce interruptions can be devised to indicate how busy the interruptee is to the interrupter. [63]

Frequent pages and the interruptions they cause, are an important cause of active errors. [64] As Coiera put it, "...providing appropriately designed asynchronous messaging facilities such as voice and email should decrease the reliance on synchronous channels, increase the use of asynchronous channels and, as a consequence, decrease the number of inappropriate interruptions." [30] Just as electronic channels, both old and new, may be disruptive, electronic systems may serve to improve communication

efficiency simply by fostering asynchronous communications through providing new channels. "One of the simplest interventions is to improve organizational infrastructure by introducing new channels for staff. For example, the introduction of pagers, mobile phones, or e-mail offers new options for interaction among staff who might otherwise have difficulty contacting each other." [21]

Of the many recent innovations available including several communication-over-wireless-network technologies and text messaging, text messaging will be used as an illustration. Some locations have used text messaging to great effect while others have not. In this study, apparently most successful site has a web-based phone book combined with the messaging function. From the keyboard a user can select the recipient, compose and send the message using one application. The web phonebook enables easy lookup of the recipient and the keyboard allows for easy entry of the message and transmission to the receiver's pager. This is an example of a technology cluster and, is itself, a component of the larger CPOE/EMR cluster. Typical usage finds the clinician asked the patient-care question over text-messaging, which the clinician often answered electronically through CPOE. While this hypothetical transaction occurred without face-to-face contact, some find it more personal due to promptness.

Another feature of text messaging is allowing the receiver to prioritize the response. By giving the receiver the crux of the question initially, the receiver can determine the time-frame of response instead of forcing an immediate "pager" response. "Residents must always respond immediately when they are paged, because the urgency of the information is unknown." [65] McFarlane's study of interrupted activity shows that interruptions prioritized in this way lead to the best overall performance but subjects may

not handle interruptions in a timely way. [38] A significant problem associated with implementation of this, or any specific system in the private practice situation is that clinicians carry a wide range of communication devices, not all of which are amenable to text messaging. Standardizing communication around specific devices and protocols could bring order to the situation but is difficult. One approach is to convince all providers in the area to accept one standard device / protocol, which could happen. On the system side, institutions could supply or subsidize communication devices to the area's clinicians but that is illegal under current US law, the Stark legislation. Proposed exceptions would allow health care systems, such as hospitals, to provide hardware and software to participate in area-wide CPOE / EMR systems. It is not clear if those exceptions will apply to communication media.

CPOE Allows Communication Anytime, Anywhere: Ubiquitous Communication

Electronic systems bring an element of ubiquity to communication by making what were previously localized activities more generally available across locations. Again the development of "common ground" among the participants is key; participants who felt communications were good also seemed to know more about their correspondents' habits and routines.

Convergence of information and communication technologies (collectively termed "ICT" in Europe) is seen in the participants' use of these new devices. Many clinician-participants spoke glowingly of their mobile devices for medical information and were more than happy to demonstrate them. These developments and the promise of still more devices indicates that the current mobile information and CPOE device situation will

continue to change rapidly. Technology is steadily advancing toward systems that are available to users anywhere they may be with wireless remote access allowing an impressive combination of connectivity and mobility.

Synchronous vs. Asynchronous Communication

Asynchronous communications do not provide the speed and efficiency that is achieved in the rapid back-and-forth exchange of ideas seen in synchronous communications, but may achieve other efficiencies by limiting interruptions and reducing multi-tasking. The text-paging technology cluster discussed above is an example. In groups with highly mobile participants, asynchrony allows team members to work efficiently despite not knowing their co-workers' locations, availabilities, and schedules. [66] Messages sent through asynchronous channels will await reception until the desired team member accesses them.

There is, however, the demonstrated preference for synchronous contact, at least by the initiators, the interrupters. There are advantages for the initiator of synchronous communication that are not shared by the interruptee. The interrupter typically gains more from an interruption and incurs less cost than the receiver. [67] Synchronous contact also gives the initiator of the contact specific feedback that her duty in the task is complete. Sometimes referred to as the "check box" analogy it is exemplified by the current widespread practice for clinicians to carry handwritten paper lists with penciled "check boxes" on them. These boxes are then "checked" on task completion, providing a positive record.

Physical Noise, Semantic Noise

As discussed in the introduction, communication "noise" includes both "physical noise" and "semantic noise." One form of semantic noise, illegible handwriting is reduced by design of the system, an intended outcome. On the other hand, synchronous communication can introduce semantic noise through interruption and task-switching. Interruptions were commonplace in this study's observations and were qualitatively consistent with the broad range of published estimates of 3.5 to 15 interruptions per hour. [40-68-69] In addition to distractions, practitioners in this study were frequently observed to carry on more than one communication task simultaneously, consistent with Coiera's findings, [40] and also in agreement with Spencer, et.al., "On average, the subjects spent 10% of communication time carrying out 2 or more overlapping conversations (communication multitasking), with one of the registrars involved in communication multitasking events for 17% of the observed time." [69]

"Interruption of people is problematic because people have cognitive limitations that restrict their ability to work during interruptions." [38] Even in aviation with its admirable safety record, context switching has lead to the loss of commercial aircraft. In an example, pilots preparing to take off were distracted from their pre-flight checklist and never returned to finish it omitting critical settings, resulting in an accident. [39] Participants reported making errors due to interruptions and distractions including entering orders on the wrong patient or selecting the wrong medication from a checklist.

Same-Page Communication

Same-page communication was felt to be particularly powerful by primary-care clinicians and valued by referral specialists as well. In the paper era, the consultant would

usually have only the information relayed to him by the primary-care clinician. The result was a slow process of the consultant iteratively requesting pieces of information, the primary-care clinician finding and relaying the information back to the consultant before treatment decisions could be made. Now, with consultant and primary-care clinician both looking at the same record they often are, literally, reading the same electronic page simultaneously, collaboration on patient care is promoted.

The "check-box" denoting completion of a communication task is analogous to the feedback in "closed-loop communication." This feedback provides positive verification that the message has been received; there is "acknowledgement" of the message. "Acknowledgment was possible with synchronous channels but not with the available asynchronous channels." [30] Participants in the current study felt uneasy with open-loop communications referring to them as *"the illusion of communication."*

On the other hand, participants as interruptees are not happy with interruption. Although not asked for a reaction to a page, participants in the current study frequently expressed frustration nonverbally with a scowl. In a study by McKnight, et. al., focus groups of nurses and physicians highlighted "frustration with the interruptive nature of their work environment that is inevitable in clinical medicine." [70] Yet, potential interruptive media increase, for example, lab result paging is available in some locations. [71]

Studying communication loads in emergency departments, Coiera et al [68] found that nearly a third of communication was interrupted, with an interruption rate of 11 times an hour. In addition, practitioners are frequently carrying on more than one communication task simultaneously. [40] *Such disruptions can cause an individual to forget to carry out*

an intended act, even when only 10 seconds separate the intention from the interruption. [41]

The EMR/CPOE Systems Allow Clinicians to Participate in Care Decisions from Locations Distant from the Site of Care

CPOE and the EMR form a web of information services that allow clinicians to perform information tasks from "anywhere." Clinicians have a "virtual presence" that contributes to the quality of care and the security and confidence of care providers and patients. The ability to work from anywhere is producing new models of care. For example, the "virtual intensive care unit" allows physicians to care for patients in several intensive care units from a remote site using links to physiologic and chart data and order to the unit electronically.

Ubiquitous communication is both a boon and a problem for pharmacy, freeing pharmacists from the main pharmacy but requiring more time. At some study sites; CPOE seemed to "liberate" the pharmacist for more consultative tasks. In these institutions the pharmacist often rounded with the doctors and was available on the floor at other times. In other study sites, the pharmacist stayed in the floor satellite pharmacy as described by Shane who described how CPOE "...created a form of paralysis in which the pharmacists stayed in front of the computer screen..." [72]

There is concern that electronic order entry medication systems, (such as Pyxis), eMARs, and BCMA, could remove the pharmacist from the medication order entry "loop" and cause problems. "Interfacing CPOE with decentralized automated cabinets raises the question of whether the pharmacist will need to verify orders before the nurse accesses the medications. This may not be an "all-or-none" issue, since certain conditions

or therapies may warrant nurse access to drugs before pharmacist review. Organizations will need to determine what process best balances safety with timeliness of drug administration." [73] Excluding pharmacists from the process was not observed, indeed, all health-care systems visited mandated pharmacist verification before medications were released.

CPOE Can Cause an Illusion of Communication

Participants reported their uncertainty in communication frequently throughout the study beginning with the very first site visit. The "illusion of communication" was often described and refers to the sender not knowing if the message was received, was understood, or had any effect. This insecurity is widely present as illustrated by its being a major finding in the HIMSS 2005 nurse survey. [74] The problem occurs when there being no feedback on the outcome of a message in some communication channels so the sender doesn't know the message's fate. Since senders often bear a responsibility that the recipient carries out some action, i.e. sees the patient, does the test, gives the medication, etc., the ambiguity may not be acceptable.

For routine or unimportant messages, the sender may be satisfied with this uncertainty, but if the message is important enough she may turn to alternate methods of confirmation such as a phone call or a personal visit, checking off, i.e. "checking the box." Some institutions have a hierarchy of communication channels varying along axes of reliability, speed, and feedback. Examples among electronic channels are using email when there is no hurry or the outcome is not important to using a synchronous medium such as a cell phone for important or time dependent communication. Participants demonstrated that some channels may be ignored such as an email system that is not trusted.

This raises the point that each channel is only so good as the discipline and behavior of the persons using it. Electronic systems and tools can do a lot but much depends on individual reliability and responsibility and on understandings of the "shared field of experience." (Schramm Shared-Field Model, Figure 3) Physicians are trained that, as the leader of the medical team, they are ultimately responsible for a patient's care. Physicians tend to rely on their own interviewing and decision-making skills and often do not trust the word of others. There is a culture of independently corroborating most findings, especially very important findings, those with a high cost of failure, in line with the discussion regarding desired channel richness vs. the importance of the message. (Figure 6.)

CPOE Increases Speed of Access to Information: Processes Move Faster

"The words 'slowly' and 'fast' have quite new meanings. The same can be said for 'close' and 'far away.'" [58] Electronic systems are intentionally introduced with the expectation that they will decrease the time needed for many tasks. How that manifests in medical reality can be a surprise to users. Clinicians may be used to events happening on a cycle that is hours to days for each step, waiting for the paper chart. Introduction of CPOE/EMR can reduce these turnaround times from days to, literally, milliseconds. The effect on an individual task is that each step that used to take hours can now be done in minutes. The overall work for the clinician has not changed: it is just that it is done more quickly and there is less pending at any one time. Reducing the number of pending tasks can reduce cognitive load on the clinician.

When health-care workers' expectations catch up to performance, new problems arise. When the time from medication order to delivery of that medication to the floor *can* be

measured in minutes, the expectation becomes that it *will* be delivered in minutes, leading to frustration at many levels as was reported by participants. Beyond frustration, in some locations this has lead to the submission of repeat/redundant orders if the orderer believes the initial order has been lost.

Hectic Environments Test CPOE's Efficiency

The author's previous work [22-44] indicated that in the sites studied for them, "hectic environments" such as the intensive care unit or emergency room were difficult sites for implementation because of the pace of medical care. The literature has also documented problems with hectic environments. A 1998 Dutch study evaluating five Patient Data Management Systems (PDMS) found that none of them met Dutch specifications, several of which, relating to speed of use could be problematic in the ICU. The authors conclude, "The PDMS might become a valuable tool in improving the quality of ICU practice, but full implementation of these systems according to the specifications still has a long way to go." [75]

More recently increased mortality was reported among children admitted to a pediatric ICU after introduction of CPOE. In that case, the introduction of CPOE was not the only change but was accompanied by multiple changes to the care team's workflow, many of which would be expected themselves to cause problems with time-sensitive medical care. Thus, it may not be the CPOE system implemented that causes but the way in which it is implemented. [76]

Significantly, new data from sites visited later in this study disconfirmed the theme of "hectic environments" in which locations such as intensive care units, emergency rooms, and urgent care clinics were too pressed for time to implement CPOE. These findings

also substantiated mechanisms in the recent literature for successful CPOE implementation. The number of articles documenting success in emergency rooms and intensive care units began appearing in numbers by 2003. [77] [78-79] Success may depend on detailed workflow analysis with revision of care processes, [80] "workarounds" in some locations, [81] [82] or maintenance of redundant verbal channels. [83] In this study, the success of CPOE in a hectic environment was due to two factors; some sites employed both. Workarounds, including reversion to paper and surrogate entry by a clerk or nurse with later countersignature served the hectic environment in some locations. Maintenance of verbal channels parallel to CPOE served the hectic environment very well. The combination of the verbal order initiating the medication administration process quickly with immediate CPOE entry by the clinician appeared to work very smoothly.

Care Transitions Test CPOE's Flexibility

Care transitions, sometimes called "interfaces of care" are a general problem not limited to CPOE. CPOE often adds another dimension of difficulty, however, by rigorously enforcing JACHO requirements for rewriting orders when a patient's location or level of care changes. In this respect the flexibility of paper was an absolute boon allowing interim execution of orders that could be, strictly speaking, invalid. Ambiguity in exactly where care is being transferred (Figure 5) can make orders effectively disappear if the patient actually transfers to a different location than planned. This phenomenon was observed in several locations as well as being described by the participants as a significant cause of confusion, extra work, and potentially, error. From

the literature it is seen that specific transfer procedures are sometimes used to address the problems associated with interfaces of care. [84]

CPOE Affects User Awareness

The signals that inform healthcare workers, the pagers, overhead pages, mechanical chart "flags," the "new-orders" rack, etc. are in some cases improved with the implementation of CPOE. Some of these changes are because of newer, better electronic replacements. In other cases, the old system still works fine but is no longer acceptable for other reasons, such as regulations. CPOE systems can disseminate timely information to support situation awareness at multiple levels. This user-awareness or situation awareness function applies to multiple ranges from the local, individual level to that of the institution, and to the region or even nation.

At the individual level, we observed processes and technologies to alert individuals to new orders, vital sign changes, etc. Some processes were crude but effective, such as the whirr from an office or floor printer alerting staff to new orders. More sophisticated solutions included inboxes for patient, nurse, and clinician to receive new orders. Another approach was a screensaver for floor computers that displayed patients with new orders or important findings, such as lab or imaging. Color coding of the entries was used in some institutions to communicate importance or urgency of care. Alerting attending clinicians to immediate or important patient needs was met through the traditional beeper / phone call from support, laboratory, imaging, or other staff. Systems are available that automatically page clinicians with critical results. [85-86]

At the wider perspective of clinic, floor, or unit, we observed more changes, again some due to CPOE and some due to changes in regulations. The traditional

"whiteboards" centrally posted on one wall of a unit publicly displaying patient names and medical problems are no longer acceptable under HIPAA. Tracking and coordinating care, the function of the whiteboard, is essential to unit function and, despite their unacceptability under HIPAA, were still observed in several institutions. Some institutions had developed "electronic whiteboards" with selective viewing that protect patient confidentiality and might indeed meet HIPAA regulations. There are now companies specializing in software and hardware to provide situation awareness tools.

At the institutional level, there may be problems with shortages of individual medications or availability of care, such as a full ICU, that can be addressed through CPOE. The total number of beds in an ICU or emergency room is finite; when they are filled no more patients can be accepted. Often called a "divert" situation, ambulances are directed to other hospitals. If staff is aware, priority may be placed on activities that will help resolve the bottleneck. We observed screensavers that alerted clinicians to the hospital divert status. Medication supply may be limited such as methylprednisolone was during a shortage in 2001. [87] Such shortages have been increasing in frequency and traditional methods of responding have seemed inadequate. [88] During our observations there was a national shortage of flu vaccine, not just at the host institution. Each time a clinician entered the CPOE system, it would alert her to the flu vaccine situation and the current recommendations for use of the limited supplies.

The Computer Changes the Patient – Clinician Conversation

Building on the work of others, Scott presented the "Doctor-Patient-Computer" relationship as a triad or triangle. (See Figure 15.) [29]

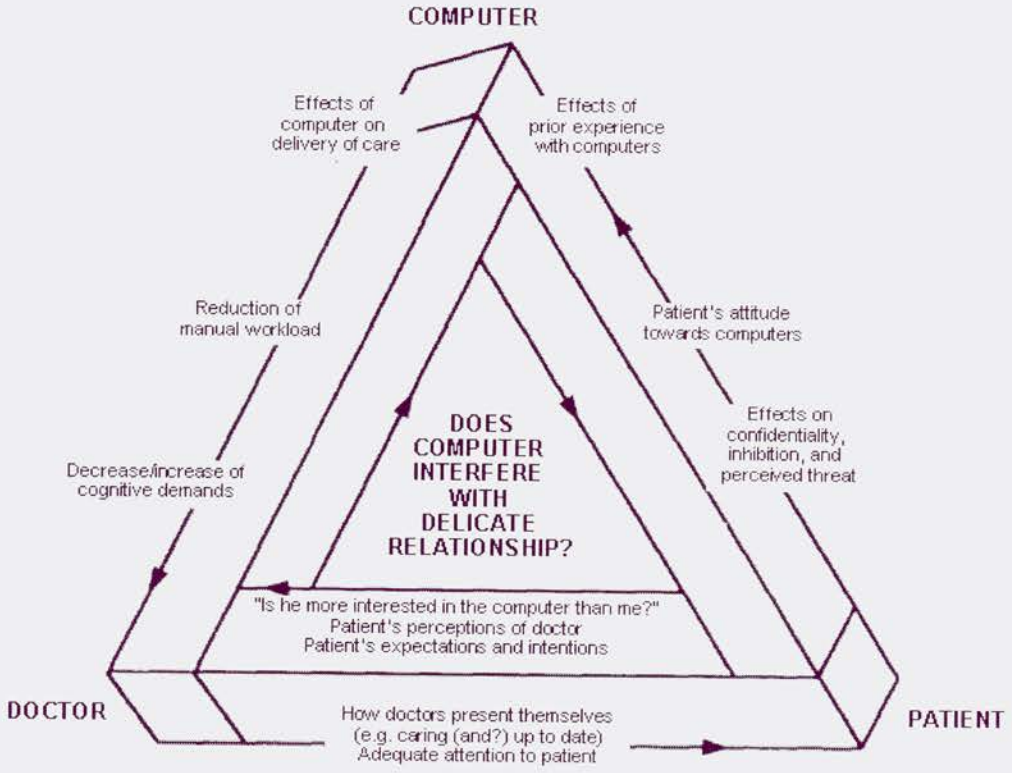

Figure 15. Scott "Triadic Relationship"

Some clinicians were seen to use this triadic relationship in their patient encounters, turning or bringing the computer screen to a position where both patient and clinician could see it. Others however, were seen to turn between the computer and the patient with the clinician maintaining two separate relationships, one with the patient and one with the computer with little or no interaction of patient and computer. Certainly further work will be necessary to see if this relationship leads to improved clinician and patient satisfaction as well as improved outcomes. Decades ago it was expected to enhance the patient-clinician relationship, ""mechanization frees the physician and nurse to provide the very empathy and warmth in doses far exceeding those previously possible." [89]

The concept of "conversational" use of computers has been introduced [29] but not yet clearly defined. This may be an excellent term for clinicians who involve the patient in a three-way conversation by sharing the screen with the patient and allowing the patient to observe all that is entered. Some of the participants referred to a similar construction, "collaborative charting," in which the patient participates by editing and suggesting changes to the note, even pointing out and correcting errors the physician has made.

The "geometry" of the encounter, that is, the physical relationship of clinician, patient and computer, screen and keyboard is also important. Exam rooms were visited in which the placement of chairs, desk and computer screen prevented the patient from viewing the screen, or in other cases, forced the clinician to work with her back to the patient. The exam-room's physical layout may interfere with the ideal. "...it was clear that EMR physicians in this study could not physically orient themselves toward their patients as easily as did physicians who worked with paper records." [24] Other authors have also noted the importance of the orientation of computer hardware in the examination room." [90] One clinician in this study stated that moving to a new suite of exam rooms with an unfavorable arrangement had reduced his exam-room use by 50% or more.

Paper is Changing Role from Records to Communication

We observed no examples of systems that have actually achieved the goal of the paper-free office. The reasons why a "paper-free" office or hospital would be desirable are not clearly defined in the literature. Since electronic-based and paper-based systems are neither in competition nor mutually-exclusive it may be that some combination of the two could be optimal. This study demonstrated persistence of paper use into the CPOE/EMR age and, at some institutions, paper use may paradoxically increase.

"Conceptualizing information technologies in workpractices as reading and writing artifacts allows one to blur the boundaries between computer-based and paper-based technologies." [91] Reading and writing artifacts do fill particular roles but the role of paper is changing in institutions employing CPOE/EMR. Lab order slips and paper medication order sheets are certainly gone in fully electronic CPOE installations but interim reports have emerged. Before the introduction of CPOE and EMR, paper was the archival medium for information. In the new paradigm, paper is used to transmit current information. It is a transient role and, rather than being archived at the end of the session, it is shredded. These forms of "persistent paper" are not necessarily bad; they may actually represent what could be termed "better paper."

Electronic records have a potential flexibility that would allow it to be re-organized almost instantly in a number of configurations, historical, episode of care, organ system, etc. Multiple user interfaces to support each configuration would need to be written first, of course, and this flexibility of the electronic record is little-used to date. If it were, computer applications might replace paper in some niches.

Paper, too, has a number of attributes peculiar to it that are not easily reproduced in electronic forms. Luff, et.al., described paper's "ecological flexibility," and "tailorablity" as being important to its use over that of screen-based systems. Ecological flexibility was his term applied to paper's being small enough to be held in the hand and its ready mobility compared to screen-based electronic systems. Electronic devices now partially fulfill Luff's criteria for "ecological flexibility." Paper has properties that will assure at least a near-term persistence. Most hand-held devices have problems with available "real-estate". That is, the screen is often too small to display a useful amount of information.

Paper also has the capability to be folded to reduce size and unfolded to enlarge the information area. This is partially addressed through the use of scrolling, but does not allow the "full page" to be viewed simultaneously. Making fonts and illustrations small enough so the whole page fits the screen leads to pages too small to read.

Luff, et.al., also discuss the "tailorability" of paper, that is, the ability to change colors and highlight easily, support freehand drawings, and access other information such as handwriting to identify an author. As computer fans will note, all of these are possible at present, at least in principle. That an appropriately functional electronic analog is not yet available suggests that paper will see continued use in hospitals and clinics, for some time to come.

A computer-paper hybrid communication medium possessing useful features was observed in use in some locations. These institutions had EMR functions to generate succinct thumbnail descriptions of a patient's medical conditions, lab, imaging, etc. Where these reports existed, they seemed to be in the pockets of nearly all physician and nursing staff. McDonald et.al. described the Regenstrief/Wishard version, called "pocket rounds." [92] Outpatient clinicians sometimes used computer-generated synopses of patient status as patient-teaching devices, sending the synopsis home with the patient.

At another institution a computer-paper hybrid communication called "sign-out" was in use. Sign-out is a particular function of their EMR that includes up-to-date allergy, medication, lab test, code status, and an ongoing narrative medical history. It was initially conceived as a document for housestaff to "sign-out" to the covering house officer. Over the course of time this has become an ongoing hospital summary. Currently this note can

be used as the discharge note for some patients. The document itself is edited and updated not simply recopied to keep it up-to-date. [65]

Study Limitations

There are several limitations to this study that warrant consideration. Data for this study were collected by a changing group of investigators involved in ethnographic observations at multiple sites over the course of five years. During that time the research questions evolved, building on findings. During the first study, the focus was on the "success factors for implementing CPOE." In the second study the focus moved to finding "the unintended consequences of CPOE." Only one of the investigators, the author, collected data with specific interest directed toward communication and its relation to CPOE, while the remainder of the team performed broad-based ethnographic observation. In this situation there is a potential for bias in that communication was not the center of interest of all researchers. In practice this meant that many of the fieldnotes were not as "rich" in communication references as others. Conversely, observations concerning communication in these fieldnotes are from the perspective of someone investigating CPOE in general, potentially neutralizing bias.

This study is also limited by the institutions studied, in that the majority of studied institutions were academic, although many had private practice components. Although every site and implementation was unique, yet there were also similarities. The studied institutions have all included large physician groups. The large HMO practice, from which much of the outpatient data comes, has been working for years to obtain a "small-clinic feel" by providing consistent small teams of clinicians and staff and local control. In the academic institutions both resident clinics and private-attending clinics were

observed. It is also unclear if our observations can be extended to small, one- or two-clinician practices.

Another limitation is that institutions studied were all "successful" implementations in that a significant proportion of orders were entered by the physicians into the system. As such, the conclusions from this thesis may not apply to institutions that have failed in this respect. On the other hand two institutions had significant failures in their pasts and information on those episodes was sought specifically. Also, information from pilots in the other institutions was sought, particularly "lessons learned" from those pilots. Adaptations observed in this study could be important to eventual success but this hypothesis cannot be evaluated with the data at hand.

Conclusions and Future Research

Conclusions

What we see now is a snapshot of sociotechnical systems in evolution.

Communication and CPOE systems will continue to change and adapt to new technology; communication channels, expectations, and norms will evolve. CPOE systems have not yet been in a stable or steady-state condition but rather have been changing constantly since first introduction. The pace of change, however, has been increasing steadily to the present due to regulatory pressure, system improvements, and addressing concerns of potential users. With the promise of technologies to come, the pace will likely increase still more. CPOE and related systems are emerging technologies with some way to go to maturity. As examples, CDS still needs to be effectively and acceptably integrated, interoperability is still lacking, and human-computer interfaces need work. During these times of change, problems will inevitably occur.

CPOE is a transformational innovation that is often implemented without regard to the communication channels it will transform. Both human and technological segments of the system changed mutually to establish new and reliable communications. New understandings, workflows, and hardware/software changes may eventually produce more robust communication channels than those replaced, but these new channels require "empowerment" of individual and clinical teams to accomplish the changes. Implementers need to take forewarning of these potential problems to provide time and advisory support to sites, teams, and individuals to overcome detrimental unintended communication changes brought about by CPOE.

Technology itself is no more "to blame" for the problems and changes that are occurring anymore than it should "get credit" for improvements. "Thus, the key theoretical issue is not the relationship between particular features and particular outcomes. Rather, it is the degree to which the outcomes, whether positive or negative, are the inevitable results of technological characteristics, or, on the other hand, might be subject to other influences, such as people's deliberate choices about how to use the new electronic media." [93] We found support for the "rational-actor" perspective which "holds that impacts result, not from the technology itself, but from the choices individuals make about when and how to use it." [93]

The reasons of clinicians and staff use or do not use in-room computing stem from values that are, in general valid and should be accepted. For many clinicians these values run deep and include what it means to be a physician and the sanctity of the "doctor-patient" relationship. It is arguable that these values will need to change if medicine is to move forward from its current "cottage industry" status.

The consequences of CPOE/EMR are not nearly all bad. The introduction of electronic systems may enhance communications by several mechanisms. The most obvious seen in the data is the speed at which messages can be addressed. Clinicians overall remarked about how quickly messages came forward, were evaluated in light of accessible and rather complete information, and were answered. By shifting some interruptive synchronous communications to asynchronous forms, time may be saved on both ends of the contacts. In addition, most of these now asynchronous contacts are documented by the system as they are completed. Having available documentation of these conversations contributes to the completeness and integrity of the medical record. The move to

asynchronous communication improves time efficiency and reduces the interruptedness of workflow simultaneously.

Although elimination of paper has been seen as a goal of CPOE implementation, it has not occurred at the institutions we studied. Paper is in use in all locations; however, its role has been changing dramatically from the historic archival role exemplified by the paper chart to an evanescent communication medium communication. Temporary paper checklists are widespread, invaluable to clinicians, and missed when they are unavailable. In the outpatient arena the printed page is used to pass information among clinic staff and also to pass information from clinician to patient. Printed summary pages are given to patients to add to their personal record and available for reference to at any time. Some of this function will likely be replaced by personal health records, of course.

Implementers should make a special point of recognizing and maintaining humanity in the computerized office, or regaining it if it has been lost. As has been done in some of the institutions studied, regular staff meetings by team, clinic, and department were resumed to rekindle teamwork. These also allowed a resocialization of the individuals, teams, and clinics that had become increasingly isolated and estranged.

Those within implementing organizations should plan to be surprised; be prepared to alter course; and be sensitive to the changes occurring in your organization. There is, indeed, a "deep intertwinement between technological and human elements" [1] of the networks that will be transformed by the implementation of EMR/CPOE systems. One network or system does not change without reciprocal changes in the others; so be aware of the unintended consequences of communication changes during and after implementation.

Future Research

My thesis opened up several interesting areas of research I would like to pursue. The most significant of these are offering solutions to improve exam-room computer use, legitimizing paper's use in areas where it is useful, and supporting provider's situation awareness in hospital and clinic settings.

Exam-room computing

To improve patient care significantly, technologies as CPOE, electronic medical records, and clinical decision support will need to offer solutions at the point of care. In addition to error reduction, in-room computing can be a powerful communication medium between patients and clinicians as well. However, clinician and staff use of exam-room computing varies greatly. We observed that physician values about care and CPOE differ and affect use, as do exam-room layout and encounter workflow similar to the findings of Ventres. [94] More studies are needed in this area to supply system designers and implementers with needed information to overcome the physical and psychological barriers to use of exam-room computing. Future development work should center on characterizing the factors affecting exam-room computing and identifying processes that improve communication between patient and physician.

Persistent paper

This thesis uncovers several reasons for institutions **not** to put undue effort into eliminating paper. There are good reasons to keep paper around. For example, hybrid computer-paper treatment plans and paper "pocket-notes" for clinicians and backup for downtime are quite useful. If institutions used these and other paper instruments to address problems in CPOE and communication they could improve their odds of success.

The focus of future work would be to describe these implements and how they may be used to augment the EMR and CPOE.

Situation Awareness

CPOE changes communication channels in ways that may reduce health-care workers' awareness of the needs of patients, leading to delays or omissions in care. This thesis categorizes the types of awareness needed, and the level of the organization in which they occur. Several institutions had devised solutions to these problems -- but others had not. Further investigation should focus on how socio-technical systems maintain awareness of important information, and how that information can be made available to the human elements of the systems.

Direction

This thesis helps establish the role of qualitative research in depicting processes such as communication and their contributions to the function of socio-technical systems. These techniques can also be applied to help remedy problems in those systems, such as suggesting mechanisms for preserving situation awareness or overcoming barriers to the use of exam-room computing. CPOE and EMR systems are now in just the early phases of development, a time when carefully applied research can make significant contributions.

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