A Task Analysis of ICU Attending Physicians During Rounds: Utilizing Clinical Informatics

Saif Khairat, Catherine K. Craven, Yang Gong

Abstract— **Clinical communication failures are considered the leading cause of medical errors[1]. The complexity of the clinical culture and the significant variance in training and education levels form a challenge to enhancing communication within the clinical team. In order to improve communication, a comprehensive understanding of the overall communication process in health care is required. In an attempt to further understand clinical communication, we conducted a thorough methodology literature review to identify strengths and limitations of previous approaches. Our research proposes a new data collection method to study the clinical communication activities among Intensive Care Unit (ICU) clinical teams with a primary focus on the Attending physician. In this paper, we present the first ICU communication instrument, we introduce the use of database management system to aid in discovering patterns and associations within our ICU communications data repository, and we present our Human-Computer Interaction observational study results looking into the impact of clinical team size, day of the week, and Attending physician's behaviors. We have identified and analyzed key Human-Interaction behaviors and tools in the ICU In addition to refining the clinical communication model we previously proposed [2], our goal is to build an exhaustive knowledge representation of the clinical communication process through utilizing an ontological approach.**

Index Terms— **ICU, Communication, Education, Database Management Systems.**

I. Introduction

ICU Attending physicians are the nucleus of most communication events. They delegate tasks, examine and diagnose patients, request lab orders, teach students and residents, and communicate with the clinical team. In order to improve clinical conversation, which we define as the verbal interaction between the clinical team, a thorough communication task analysis for Attending physicians is necessary. The significance of analyzing communication instances rises from reports such as the Institute of Medicine (IOM) [3], the Harvard Medical Practice Study [4], the Quality in Australian Health Care Study [5], which state that inefficient communication is a significant factor in the occurrence of medical errors. Other reports exclusively state that Clinical miscommunication, the failure or incompleteness of message exchange, is the lead cause behind 75% of medical errors and 82% of sentinel events [3, 6]. Thus, there is a need to further understand and analyze clinical communication in order to improve clinical outcomes and to provide higher patient safety levels.

The choice of conducting this study in the ICU comes from its multidisciplinary and complex nature of care required in the ICU makes it a setting ripe for the frequent occurrence of medical errors. The overwhelming environment, overloaded clinicians, and critically ill patients provide a major challenge for effective communication to take place. Moreover, bed rounds sessions are communication intense and multidirectional conversations can take places in one communication instance, which adds more complexity to the exchange of information. Among the benefits of better communication is the reduction of patient harm, shorter length of stay, higher caregiver satisfaction, and reduced cost [7-11]

Communication task analysis is the characterization of communication instances into finer defined categories. This characterization and comparison enables comprehensive understanding of the purpose of bed rounds conversations between the Attending physician and their team. To the best of our knowledge, this phenomenon has not been widely investigated especially in ICUs. A research study conducted a task analysis on the physician's associate focusing on percent of task performed, task decreases, level of independence [12]. Recent studies with different focus analyzed task analysis in Emergency Care (ER) [13], and cognitive psychology focus in critical care [14]. The literature has few attempts to analyze communication behaviors for Attending physicians through task analysis approaches. To the best of our knowledge, no work has studied ICU task analysis with a communication focus.

This study aims at analyzing the purpose behind communication between the Attending physician and their team members during bed rounds. This research investigates if there are significant associations between the type and intensity of communication; and day of the week, size of the clinical team, and among the Attending physicians. Further understanding of ICU physician's communicating patterns will

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serve as a continuum to our clinical communication foundational work which aims at developing a comprehensive communication framework that captures and conceptualizes all aspect of human-human and human-computer interactions.

II. METHODS

In order to design a methodology that captures real-time clinical communication instances during ICU bed rounds, a clear understanding of the logistics of rounds and the setting of the ICU rooms is required. For that reason, the clinical team conducted a pilot study for three days exploring and observing the ICU setting, the nature of the patient rounds, and communication among the clinical team. The design and development of our observational checklist instrument was built to fit the ICU environment by following the same chronological order of activities.

The location and specialty chosen for this study were selected based on certain criteria. Communication practices are various, and a location that can capture most communication practices would be most preferable. The University of Missouri Hospital offers primary, secondary, and tertiary health care services, and it provides formal academic teaching and constructive research services concurrently. Considered as a national leader in health care quality improvement and quality patient care, the level of adherence to national health care standards and regulations are guaranteed and thus, the quality of trained staff and resources provided a fair environment that may be extrapolated to other large health care institutes. Moving on to our specialty choice, we chose to observe at the ICU, specifically Pulmonary, Cardiac, Neonatal, and Burn ICUs for its critical patients' condition, and its quick and rapid scenarios.

Each ICU Attending physician is assigned a two-week rotation in which they conduct morning meetings, bed round sessions, and hand offs sessions. During their 2-week rotation, each Attending physician was shadowed on the first day of the rotation, twice during the week, twice during the weekend, and on the last day of the rotation period, adding up to 6 days. This distribution was suggested by biostatistician and ICU domain experts. From a clinical stand point, the first and last day of the 2-week rotations would capture the communication patterns during a chaotic first day and then, the more organized communication found at the end of the rotation period. Also, weekends provide a different pace and intensity than week days, which might show new patterns.

Two clinical informatics researchers simultaneously shadowed the clinical team during bed round sessions. The decision has been made to utilize observers with no medical, especially ICU, background; the reasoning behind this is to ensure that the observational process is free of any bias and the observers have no clinical experience or knowledge that might distort or affect their judgments. Both observers used the same observational checklist we built to record what they observed, communication between the observers was restricted during the observation to limit any biases.

During bed rounds sessions, the aim was to capture the purpose of each communication instance made by the Attending physician. Four purposes were identified to capture all instances made, shown in table I. First, the Attending provides patient information to the clinical team; this information can be medical updates that some team members were unaware off. Second, the Attending asks for patient information from their team members, usually it is the fellow, residents, or registered nurses. Third, after the Attending listens to a debriefing about the patient's status, the Attending requests new actions to be done such as labs for the patient, or to add or discontinue certain medications. Finally, the Attending provides an educational component during the round to their team and especially medical students, mostly this occur in the form of questions and answers.

A. Data Representation

55-hours were spent observing the ICU clinical team, patient visits were made over the course of six weeks. During data collection period, data captured was transformed from the paper-based instrument into electronic format through the utilization of a database system. The database schema shown in figure 1, consisting of nine tables, is designed to capture all the data from the ICU study into one repository that will facilitate further analysis. The attending physicians' information is stored in a separate table. Each day at the ICU is treated as a unique data entry point, since we examine communication per day; each study has two tables associated with it, one for the data collected during observation and another table for that day's survey results. Table Survey is designed to store the role of the participant, the date, and the responses for the four Likert questions. Answers on the Likert scale will be converted into a scale from 1 to 5, 1 being "disagree" and 5 being "agree."

The complexity of data captured during observation generated four weak entities associated to the observation table, shown in dashed border lines. A weak entity is a table that cannot exist if the main table, i.e. observation, does not exist. Table Observation stores the quantitative variables whose values are based on frequency. Table Roles is used to identify which observer recorded the corresponding observations. The other tables store qualitative information about human and technology interruptions, and computer interactions. The variables stored in the weak entities include more than frequencies; we want to know the response of the attending physician to interruptions and the types of computer interactions. During the occurrence of either a human or technology interruption we capture the response of the attending physician to the interruption by recording an "A" for accept or an "R" for reject." Table ComputerInteractions records the types of interaction an attending physician has with the computer station available in the room. These interactions are can be either reading information on the screen or physically interacting with the computer.

B. DBMS integration

We created a local environment that comprises MySQL 5.0,

Apache web server 2.2, and PHP 5.2. This powerful combination of instruments facilitates the automation of over 500 data collection sheets of data into a well-structured database of nine tables. Hypertext Preprocessor (PHP) is a general-purpose scripting language that is suited for web development and is known for its powerful interactivity with DBMS. Apache is web server software known for implementing complied modules to support common languages such as PHP and Python. Apache serves as a mediator between PHP and MySQL by interpreting commands from PHP and then sending and retrieving information to and from each component. PHP scripts were written to organize the data into a format readable by the database and insert the data into the correct tables.

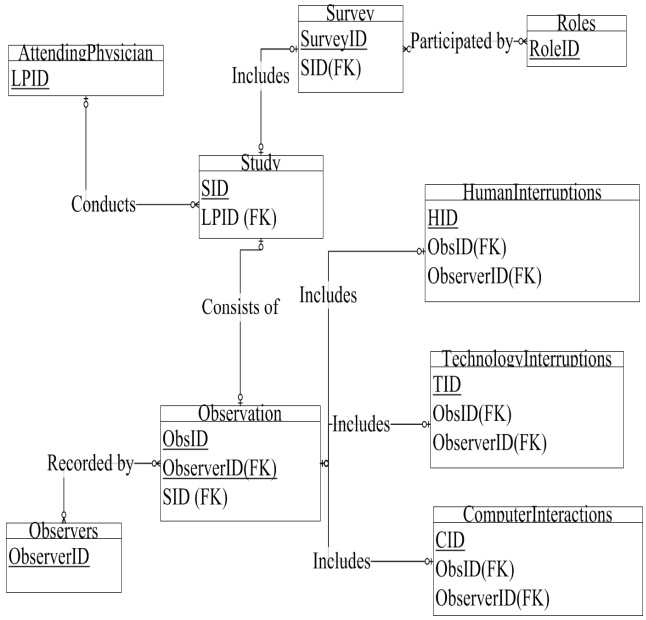

Fig I. Entity-Relationship Diagram of Communication Database

Post observation, data was collected from both researchers; the data was automated and stored in the first database in the system named "raw data". Data captured was slightly different among both researchers, for that reason, a second database was created to store the average of the results from each researcher, the decision of computing the average was made because the mean of their numbers has higher integrity than taking the floor or ceiling of both numbers. In order to further facilitate statistical analysis, two new databases were created; one database sums and organizes the data by each day (n=18), and the other database organizes the data by patient (n=279). The four databases are hosted on the same server and each database has its unique storage and retrieval, and organization programming code, which enables each database to serve as an independent data repository.

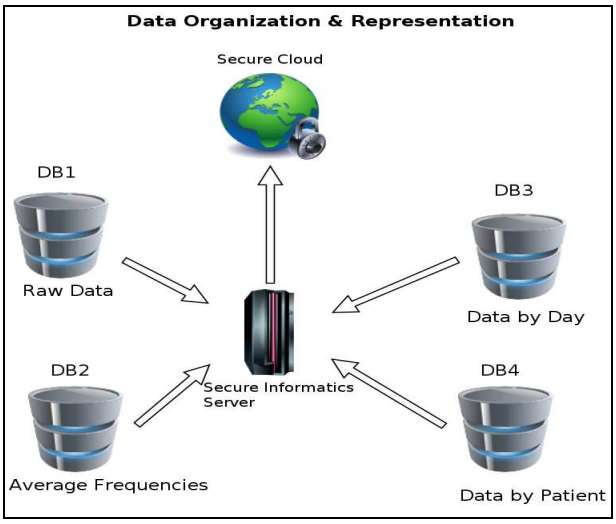

Fig II. A schematic of the distribution of the four databases

III. Results

The research team shadowed the ICU team through 279 patient visits. The data collection instrument is a product of literature findings, domain expert experiences, and findings from preliminary data collection trials [15-17]. Data collected was automated and imported into a MySQL database in order to prepare for further statistical analysis.

Communication instances from the Attending physician had the highest rate of frequency with 13 instances per patient visits. These types of communication from the Attending physician included teaching statements, requesting new tasks, inquiring about patient status, and providing information that new team members were not aware of. The second most frequent activity during rounds was feedback provided from the Attending physician while conversations with other team members.

TABLE I
CATEGORIES OF COMMUNICATION TASKS DONE BY THE ATTENDING PHYSICIAN DURING BED ROUNDS

Categories	Description	Measurement type
Give Information	Provide patient or diagnosis information	Frequency tallies
Request patient information	Ask for specific patient data or imaging	Frequency tallies
Request new task	Requests that specific actions, labs, or medication be done or administered	Frequency tallies
Teaching	Provide educational information or asks educational questions	Frequency tallies

Table II shows that most of the Attending physician's communications were directed towards requesting patient information with an average of 5.72 instances during a single patient visit, and 43.6% (n=3658) of total communications. The least type of communication was the Attendings giving information to the clinical team with a mean of 1.25, and 9.5% (n=3658) of total communications. Requesting a new task to be done and teaching came in the second and third place simultaneously. They averaged 3.57 and 2.57 during each patient visits respectively.

TABLE II
DESCRIPTIVE STATISTICS FOR THE FOUR COMMUNICATION CATEGORIES

Categories	Min.	Max.	Mean	Std. Deviation
Give Information	0	8	1.25	1.321
Request patient information	0	23	5.72	3.804
Request new task	0	20	3.57	2.426
Teaching	0	16	2.57	2.754

When investigating the difference in communication patterns among the three Attending physicians, it was evident that there were differences between the mean ranks for the three Attending physicians in requesting patient information, requesting new task, and teaching, shown in Table III. While there were similar mean ranks for giving information. Running Kruskal-Wallis test verified the previous observations. There were significant differences in all communication categories (alpha < 0.05) except for giving information, which had an alpha > 0.05.

Table IV shows the results for testing the hypothesis that there is a relationship between communication intensity and the size of the clinical team; small size teams are include 10 clinicians or less, while large teams include more than 10 clinicians.

TABLE III
MEAN RANKS, CHI-SQUARE, AND KRUSKAL-WALLIS TEST STATISTIC FOR THE FOUR COMMUNICATION VARIABLES AMONG PHYSICIANS 1, 2, AND 3

	Mean Ranks			Std. Dev.	Asym. Sig.
	P1	P2	P3		
Give Info.	144.9	133.4	142.4	1.157	0.561
Request patient info.	129.6	114.5	177.5	31.5	0.000
Request new task	171.3	90.7	163.2	58.95	0.000
Teaching	0	16	2.57	2.754	0.000

Column 'Mean Ranks' displays the average rank for communication categories for small and large teams. Results show that variables 'Request Information', 'Request New Task', and 'Teaching' are close in frequency among small and large teams, this shows that there isn't much difference in those categories. Variable 'Give Information' showed the largest difference in mean ranks between both teams. After running 2 t-sample tests, namely Kruskal-Wallis, only variable 'Give Information' had an alpha < 0.05, which means there is significant difference in frequency among small and large size teams. As for the rest of the variables, alpha > 0.05, which shows insignificant difference between both teams.

TABLE IV
MEAN RANKS, CHI-SQUARE, AND KRUSKAL-WALLIS TEST STATISTIC FOR THE FOUR COMMUNICATION VARIABLES AMONG SMALL AND LARGE SIZE TEAMS

	Mean Ranks		Chi-Square	Asymp. Sig.
	Small	Large		
Give Info	134.2	152.5	3.38	0.03
Request patient info	138.1	143.9	0.31	0.57
Request new task	135.2	150.1	2.09	0.14
Teaching	134.8	151.1	2.55	0.11

Moreover, the analysis tested if there are any associations between the occurrence of the four communication categories and the type of day, such as week days and weekends, shown in Table V. Unlike previous statistical tests, the mean rank of all communication variables show significant differences between week days and weekends, with more intense communication tasks done on week days rather than weekends.

TABLE V
MEAN, CHI-SQUARE, AND KRUSKAL-WALLIS TEST STATISTIC FOR THE FOUR COMMUNICATION VARIABLES AMONG WEEK DAYS AND WEEKENDS

	Mean Ranks		Chi-Square	Asymp. Sig.
	weekday	weekend		
Give Info	148.0	126.9	4.89	0.027
Request patient info	146.3	129.7	2.81	0.093
Request new task	147.0	128.6	3.5	0.061
Teaching	150.7	122.6	8.24	0.004

In order to identify if these difference are statistically significant, Kruskal-Wallis test was conducted. All alpha values can be considered statistically significant, however, since we use 95% confidence interval, only variable 'Give Information' and 'Teaching' are considered statistically significant with alpha <0.05. As for variables 'Request Information' and 'Request New Task' have an alpha > 0.05,

and therefore, the difference between week days and weekends are not statistically significant.

IV. Discussion

This paper aims at understanding what Attending physicians mostly communicate about during bed rounds, and to explore relationships between communication intensity and team size and day type. Also, we investigated if physicians are similar in communication behaviors by comparing the frequency of each communication variable across all three physicians.

Overall, most communication instances aimed at requesting patient information from the accompanying team members. We observed that the Attending would ask for specific details such as lab results or latest X-Ray. In some cases, the Attending would log on to the Computer-On-Wheels (COW) and lookup information through the Electronic Medical Record (EMR) or the PACS imaging system. The Attending physician did not provide patient information, mainly because there are team members who are assigned to monitor patients throughout their shift. So, it is logical that 'Give Information' came last in the list of most communicated tasks.

When investigating differences between the three Attending physicians, we could see there are significant difference in requesting patient information, requesting a new task, and teaching. The researchers shadowed three physicians from different ethnic backgrounds, and hence, there is a possibility that culture plays a role in communication. This is an area of utmost interest to the authors, and it should be explored in future studies.

It was logical that only 'Giving information' showed significant difference between small and large sizes, because large teams has more team members and more questions and requests and therefore, the Attending has to provide information in response. Table IV shows that more information was provided from the Attending during larger team sizes. As for the rest of the variables, there is no relationship between requesting new information or tasks, or teaching, and the size of the team.

Significant differences were shown among the communication variables when comparing weekdays versus weekends. The researchers noted that during weekdays there were more patient admitted and so, more patient visits, the team was significantly larger therefore, there was less time to communicate. On weekends, the Attending physicians did less of giving information and teaching because there were fewer team members on rounds and less patient visits. Also, on weekdays there are more newly admitted patients hence, there are new cases that the Attending can discuss and educate the team about.

Lessons learned from this study include that communication complexity levels increase drastically on weekdays with a team size greater than 10. Also, we have observed that communication is more intense on the first day of the two week rotation compared to the last day of the rotation, the reason for that is on the first day team members have significantly more details to convey to the Attending. Also, the first day is more chaotic and team members familiarize themselves with fellow members. Table VI shows this observation from a statistical point. The Attending gave, on average, more information on the last day of the rotation compared to the first day; however, the difference was not statistically different. On the other hand, the Attending requested patient information, requested new tasks, and taught significantly more on the first day compared to the last day. The results of a Mann-Whitney test showed that the previous three variables show statistical significance between both days.

This research will continue to understand communication among the clinical team by exploring the same variables with respect to other roles and environments. We plan to shadow additional clinical teams; by studying more teams in other clinical settings such as Emergency Rooms (ER) and Operating Rooms (OR), we will increase the potential for identifying more team communication patterns. We will also conduct more observational studies that will be focused primarily from the point of view and on processes of clinical team members other than the Attending physician, such as respiratory therapists, nurses, etc. This will help refine current results and might uncover additional factors. In these next steps, we will digitize our data collection instrument so that it can be used on iPads to facilitate data acquisition.

TABLE VI
Mean ranks, Mann-Whitney test statistic for the four communication variables among the first and last days of two week rotation

	Mean Ranks		Std. Dev.	Asym. Sig.
	First	Last		
Give Info.	16.2	21.7	120	0.126
Request patient info.	24.9	13.4	64	0.001
Request new task	25.5	12.8	53.5	0.000
Teaching	28.0	10.5	9	0.000

One strength of this study is that the ICU clinical team conducted bed rounds in multiple ICUs such as, Burn ICU, Cardiac ICU, Surgical ICU, and Pulmonary ICU. Capturing communication instances from different ICU settings provides this research with more validated data across specialties. One of the limitations of this study is the limited number of Attendings at the ICU. Even though this research is conducted at a 300-bed hospital and 68 ICU beds, there is a challenge to find more Attendings to shadow during ICU bed rounds. Besides the limited number of Attendings, in order to further expand this research, more human power is needed to conduct such a large scale study.

V. Conclusion

Clinical communication is reported to be the leading cause of medical errors and sentinel events, and studying this phenomenon is crucial for improved care outcomes and services. Literature discusses the importance of better clinical communication, and fragmented efforts have been made to study the communication behaviors and patterns among the clinical team [16-18]. Nevertheless, there is still need for improvements. We have analyzed ICU Attending physician's communication during bed rounds. We identified four main exclusive communication categories that any communication by the Attending would fall under one of them. Our research roadmap highlights the two core steps to link between the current state and the targeted state, namely, data analysis and building a knowledge base through statistical analysis. Finally, the ultimate goal of this research is to develop clinical communication framework that serves as foundational science for future research in this field.

One of the challenges to this research is the scarcity of data. The absence of a mandatory reporting system has resulted in many medical errors not being reported. With the exception of Veterans Health Administration and the Department of Defense, there are no nationwide reporting systems that mandate error reporting. We believe that with more data, this research can provide new information for clinicians to improve communication within a single team. Through knowledge representation, we aim at developing a framework of the communication process and hence, increase clinician's awareness of solutions and risks during interactions. Along with increasing communication awareness, these steps will enhance clinical communication, minimize medical errors, and reduce costs which will increase patient safety as well as overall population health status.

Research strongly suggests that in order to reach higher patient safety measures, there needs to be a significant improvement in clinical communication. This paper has focused understanding Attending physician's clinical communication and its relation with clinical tasks. The methods section was divided into two main parts, the first being the representation of data collected and the second is how multiple database management systems were built and integrated. Through building a comprehensive knowledge base, inclusive communication ontologies can be integrated into Error-reporting system to concisely identify communication faults.

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