Falling through the Cracks: Information Breakdowns in Critical Care Handoff Communication

Joanna Abraham, PhD[1], Vickie Nguyen, MA[1], Khalid F. Almoosa, MD[1,2], Bela Patel, MD[1,2], Vimla L. Patel, PhD, DSc[1]
[1]Center for Cognitive Informatics and Decision Making, School of Biomedical Informatics, [2]Division of Critical Care Medicine, UTHealth, Houston, TX

Abstract

Handoffs have been recognized as a major healthcare challenge primarily due to the breakdowns in communication that occur during transitions in care. Consequently, they are characterized as being "remarkably haphazard". To investigate the information breakdowns in group handoff communication, we conducted a study at a large academic hospital in Texas. We used multifaceted qualitative methods such as observations, shadowing of care providers and their work activities, audio-recording of handoffs, and care provider interviews to examine the handoff communication workflow, with particular emphasis on investigating the sources of information breakdowns. Using a mixed inductive-deductive analysis approach, we identified two critical sources for information breakdowns - lack of standardization in handoff communication events and unsuccessful completion of pre-turnover coordination activities. We propose strategic solutions that can effectively help mitigate the handoff communication breakdowns.

Introduction

A patient handoff refers to the transfer of care from one care provider to the next[1] and involves three aspects: a transfer of information, responsibility and authority[2, 3]. Handoff therefore is a critical clinical and organizational process that occurs at all levels of the hospital; starting from an individual level (e.g. between nurses during shift reports[4]) to an organizational level (e.g. between hospitals during patient transfers[5]). Despite its important role in ensuring the continuity of patient care activities[3, 6], it remains a huge threat to patient safety[7]. Communication failures have been cited as the leading cause for a range of medical errors and adverse events (nearly 70%) in healthcare[8]. Almost half of these communication errors occurred during handoffs between care providers[9]. Consequently, handoffs have been characterized as being "remarkably haphazard"[10] and "biformulaic, partial and cryptic"[11]. Several healthcare researchers and practitioners have highlighted that poor "handoffs often end in patient harm."[12]

We exemplify the challenge of faulty handoffs using an illustration from an incident reported by Mike Chassin, a board-certified internist to HealthLeaders Media: "*An elderly woman was admitted to the hospital with an order for 300 mg of dilantin three times a day. The resident got the information from an electronic source, and didn't recognize there might be a problem. The hospital's pharmacist, however, reviewed the order and saw the error. He filled only the first dose and told the evening nurse: "make sure the next shift knows about this." But that communication never happened, either on the physician's side or the nurse's side. The problem was not discovered until the patient had a toxic reaction; she spent three to four days in a severely toxic state*."[13]

Some of the other reported consequences related to ineffective handoff incidents included delays in treatment and ordering of tests[14], incongruence in patient data[15] and increased patient length of stay[16]. To investigate the contributors to handoff communication errors, we conducted a qualitative study on group handoffs in a critical care setting at a large academic hospital in Texas. We conducted observations of care providers and their work activities, semi-structured interviews and also audio-recorded handoffs between care providers to gain an understanding of the handoff communication behavior in critical care. With this understanding, we were able to (a) identify information breakdowns during handoff communication and (b) examine two critical sources of information breakdowns. Using insights gained from this study, we provide suggestions for the development of potential intervention strategies that can improve handoff communication effectiveness and efficiency.

Background

The issue of handoffs has been receiving increased attention from researchers, thereby illustrating the ubiquity and relevance of the problems associated with transitions in care. Some researchers have highlighted the barriers to effective handoffs[1], while others have studied the consequences of poor handoffs[14].

The three main handoff barriers highlighted in prior research were related to communication challenges[17, 18], lack of a standard handoff system[19, 20] and lack of handoff training for healthcare providers[21]. For example, Arora et al.[22] highlighted that handoff communication was mostly influenced by content omissions either related to medications, treatments, tests, consults or active medical problems and failure-prone communication processes due to the lack of face-to-face communication, double sign-outs (night floats), and illegible/unclear notes.

To overcome these handoff barriers, some key strategies have been proposed such as (a) the incorporation of standardization methods[23] for instance, with the use of templates, heuristics[24] and communication mnemonics (e.gs. including SBAR (Situation, Background, Assessment and Recommendation)[25], (b) the incorporation of education sessions to better train care providers perform effective handoffs[21, 2], for instance, with the use of simulated clinical exercises (e.g.,[17]), and finally (c) the incorporation of tools such as online forms[26], checklists[27] and other computerized technologies[23] that can provide a structure to guide healthcare providers to share relevant and critical information.

Nevertheless, although prior research provides a strong foundation to understanding the problems associated with the handoff communication activity, there is still very limited knowledge on the nature of these handoff barriers[28]. In other words, it is still unclear what causes these information breakdowns that lead to transition errors. As a result of which, the solutions proposed in research have been highly elusive and "conceptually limiting"[28]; on one hand, they are very structured and exhaustive (for e.g.,[29]), while on the other hand, they are ambiguous and open-ended in nature (for e.g.,[11]). Besides, conclusive links between the various handoff solutions and reduction in medical errors have not been fully established[30]. As a result, hospitals are still very apprehensive about adopting these solutions.

Consequently, the issue of handoff continues to remain a threat to safety and quality of care. To address this, we first need to identify where the problems occur and why the solutions cannot be standardized within and across hospitals. This calls for a deeper examination and analysis of the current handoff workflow in hospitals. To understand the sources of the information breakdowns that affect handoff process, we conducted a study in a large hospital.

Method

The study was conducted at an academic hospital in Texas consisting of approximately 55,000 emergency department visits per year. We chose the medical intensive care unit (MICU) for two related reasons – first, handoffs are very common in critical care, resulting from (a) the increased length of patient stay which exceeds a care-provider's shift time[31], and (b) restricted resident work hour limit/week[32] and second, handoff errors contribute to almost 10% of adverse events in critical care[33]. The MICU is a "closed" ICU with 16 patient beds and approximately sees 120 patients/month. When patients are admitted, the MICU team becomes the primary care team responsible for the care of the patient. The study was approved by the institutional review board (IRB).

Group Handoffs in MICU

We studied the resident handoff activity in the MICU which is an example of group handoffs.

Role	Responsibilities
Attending	Intensivist supervisor over all MICU team patient care decisions.
Fellow	Intensivist in training, second in command supervising over all MICU team patient care decisions, care, and procedures in the attending's absence. The fellow also keeps the attending informed of daily MICU activities.
Resident	A physician in their second or third year of internal medicine residency training in charge of daily patient care activities working under the direction and supervision of the attending and fellow.
Intern	A physician in their first year of internal medicine residency training tasked with implementing daily patient care activities under the direction and supervision of the attending, fellow, and other residents.
Pharmacist	Pharmacist that monitors drug therapy, reviews the medication regimen and provides other medication recommendations

Table 1. Medical Intensive Care Unit (MICU) Team Roles and Responsibilities

Since there is no resident sign-out (i.e. formal handoff) of patient care information, the outgoing resident's presentation during morning rounds is the primary handoff activity in this setting. They occur between the outgoing resident (i.e. sender) and oncoming team (i.e. receiver) which is comprised of an attending physician (i.e. attending), clinical fellow, resident, intern and pharmacist (a description of roles and responsibilities is provided in Table 1). An outgoing resident presents the patient case to the oncoming team during daily rounds. Typically, each day during rounds 16 patients' case information is handed over to the oncoming team. The attending physician, being the MICU head, manages the rounds and is “active” in the communication activity while the other oncoming team members are “passive” in the communication activity and get involved in the discussion as needed.

Data Collection

We adopted a *shift-centered* data collection approach, where we followed a care provider (i.e. outgoing resident) during their shift. By closely shadowing the outgoing resident, we obtained rich temporal and continuous data on the care provider’s activities during the overall handoff process, which is divided into three phases – pre-turnover, handoff and post-turnover phases. The *pre-turnover phase* is comprised of coordination activities (such as patient examination, updating and reviewing patient record), the *handoff phase* is comprised of communication events (such as patient problems, assessment and plan) and the *post-turnover phase* is comprised of patient-care delivery activities (such as performing an artery line) [34]. Furthermore, we were able to isolate information breakdowns in handoff phase and identify how they related to or manifested in the other two phases.

Ethnographic data collection methods such as observations, shadowing and interviews were employed. *Observations* of general MICU work practices were conducted to understand the overall MICU workflow and the patient care teams and their responsibilities. We closely *shadowed* care providers during their entire shift to gather detailed data on their care workflow. Formal and informal *interviews* with MICU attending physicians, fellows, nurses and residents were carried out. The interview questions were mainly focused on (1) handoff strategies and mechanisms used, (2) handoff content and structure, (3) handoff obstacles, and (4) recommendations for process improvement. The interviews each lasted between 20 to 40 minutes. In addition to these, *audio-recordings* of handoff communication were also conducted to trace information flow during handoffs. We also identified and collected a progress note that was used to structure their handoff communication activity. The progress note was comprised of patient-case information detailed in a SOAP (Subjective, Objective, Assessment and Plan) format. The data collection methods are detailed below in Table 2.

Method	**No. of Participants**	**Participant Types**	**Data Collection Time (in hours)**
Observation	Varied	Healthcare-providers including: Attendings, Fellows, Residents, Nurse Manager, Nurses, Pharmacists, Nutritionists, Consults	30
Shadowing	30-40	MICU team (Attending, Fellow, Residents, Interns) during group handoffs	75
Audio-Recording	80 Handoffs (5 rounds with 16 patient cases each)	Attendings, Fellows, Residents, Interns, Medical Students	15
Interviews	7	Attendings, Fellows, Residents, Nurses	3

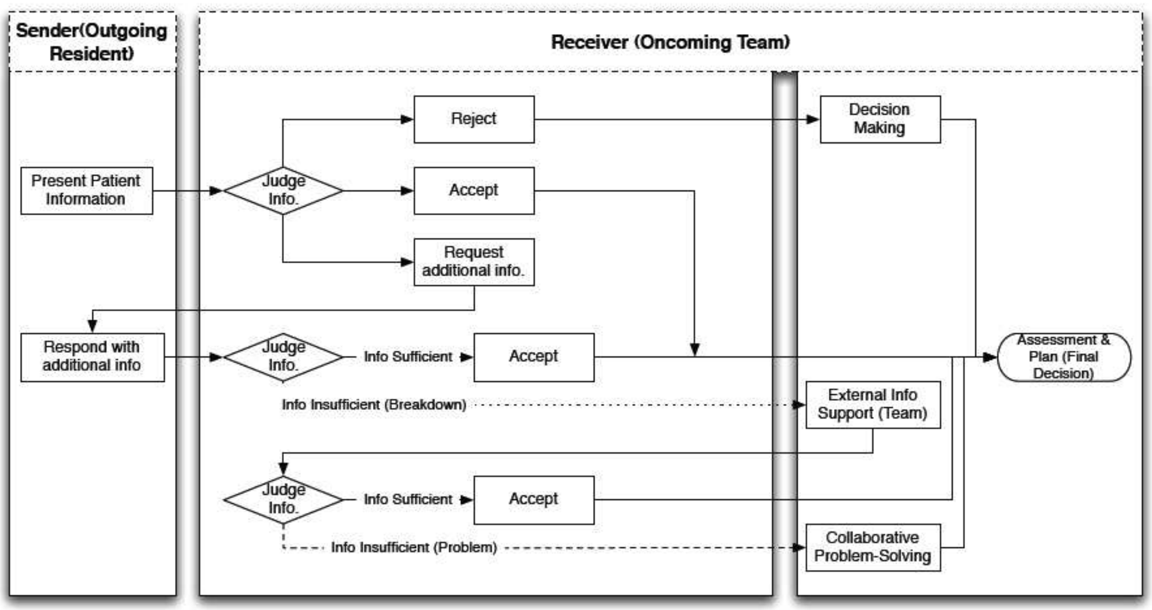
Table 2. Details of Data Collection in the MICU

Using these multiple methods, we were able to describe how the handoff process is integrated with the MICU workflow and characterize the nature and types of information breakdowns in handoff communication and locate their sources.

Data Analysis

The analysis was performed in two stages and involved a mixed *inductive-deductive* approach. *Stage 1* of data analysis was based on an inductive method of analysis using grounded theory approach[35], while *stage 2* of data analysis was based on structured coding template (i.e., handoff communication model) developed from stage 1.

Stage 1 of data analysis was focused on examining the observation, shadowing and interview data related to care provider activities using a grounded theory approach which has widely been used in the medical informatics domain[36]. The coding process comprised of the following three steps - (a) *open coding* where a line-by-line analysis on the observation and shadowing data was performed to derive open codes related to MICU workflow and handoff communication activity. Examples of some open codes include handoff goals, roles and responsibilities, handoff activities (information presentation by sender and feedback/judgment by receiver), decisions made during handoffs (assessment and plan), interdependencies between activities, roles of participants (sender, receiver), information resources and artifacts used (progress note, computer on wheels), communication challenges (information ambiguity, loss), strategies to overcome the challenges (information support from team). (b) *axial coding* was performed by re-organizing the open codes that were generated in the earlier step to identify repeated patterns of events and relationships between them to develop core categories relevant to handoff process. Examples of axial codes included three handoff phases including pre-turnover, handoff and post-turnover phases and their related activities such as coordination activities (one that helps manage interdependencies between individual tasks), communication events (passing of a message through a channel for a particular purpose) and patient-care delivery activities respectively, the team communication protocol, rules of interaction, decision choices (accept, reject and request information), the information breakdowns during patient communication events and also the decision making and collaborative problem solving cycles. (c) *selective coding* where the coding was iteratively performed around the core categories to develop an emerging theme related to three phases in the handoff process. For instance, the activities in the three phases in the handoff process were clearly identified and distinguished and by mapping the various information paths and the central decision points that led to the final assessment and plan of care, we were able to generate a conceptual model that describes handoff communication activity in the MICU (Figure 1). This process was done until we reached thematic saturation where there were no more new codes that were generated.



LEGEND	Symbol					
	Meaning	Process Point	Decision Point	Information Breakdown	Information Problem	End Result ("Outcome")

Figure 1. Group Handoff Communication Model in MICU (Adapted from [34])

The model in Figure 1 represents the handoff communication activity that occurred between an outgoing resident ("sender") and oncoming MICU team ("receiver") comprised of the attending physician, fellow, resident, intern and pharmacist). The handoff was initiated with the outgoing resident presenting patient-case information (i.e., comprised of a total of 15 communication events for a single patient case, Table 5) that got judged by the attending (i.e. active team member).

The attending made one of three decision choices – reject, accept and request for more information. When a *reject* decision was made, a decision making cycle was initiated. Decision making cycle involved examining available options, establishing baseline criteria for making a decision, evaluating the available options and finally, selecting an appropriate plan of action. The output of this cycle was incorporated into the final assessment and plan decision.

When an *accept* decision was made, the information was incorporated into the final assessment and plan of care decision. When a *request for information* decision was made, the sender tried to respond with more information, which then got evaluated for its sufficiency by the attending receiver. When the additional information was sufficient, the information was accepted by the attending. When the information was insufficient, it resulted in an information breakdown (gap in information caused by sender) that necessitated the oncoming MICU team (i.e. passive team member) to provide the additional information. If the information provided by the team was sufficient, it got accepted. Alternatively, if it was insufficient, it resulted in an information problem (gap in information caused by team), which then initiated a collaborative problem solving cycle which consisted of seeking information from sources and making sense of the information collectively and finally, applying the understanding to solve the problem at hand. The output of this cycle was incorporated into the final assessment and plan decision. This model was repeated for the fifteen communication events for each patient handoff

Stage 2 of data analysis was performed on the audio-recorded communication data using the handoff communication model (from Stage 1) as our analytical framework. We analyzed the communication events (15 in total) between outgoing and oncoming for each patient case which involved the evaluation of information presentation by the outgoing resident and the repeat-back comments and questions posed by the oncoming team in order to assess the presence and absence of an information breakdown (i.e. explicit gap in information). Once an information breakdown in a communication event was identified in handoff communication, we examined their sources by analyzing the workflow breakdowns during that particular shift (from our observation and shadowing notes). We repeated this analysis for all patient handoff communication data.

Results

We highlight two critical sources of information breakdowns that led to handoff communication failures - the lack of standardized format of presentation in handoff phase and unsuccessful completion of coordination activities in pre-turnover phase.

Standardization of Handoff Presentation

The first influential factor that affected handoff communication was the standardized format for information presentation by outgoing residents to the oncoming team. Although a standardized progress note provided a basic structure to information handoffs, based on our evaluation, we found that several outgoing residents did not consistently follow such a uniform format in their presentation. Table 3 shows illustrative examples on how the standardization format of four handoffs (out of 80 total handoffs) is related to frequency of information breakdowns.

Pt. No.	Followed Standardized Format – Y/N?	Frequency of Information Breakdowns
1	N	2
2	Y	0
3	Y	3
4	Y	2

Table 3. Influence of Standardization on Handoff Communication in MICU

The data (Table 3) suggests that there could be a potential association between standardization of handoff communication and information breakdowns. For instance, for pt no. 1, a standardized handoff format was not followed, which consequently resulted in two information breakdowns. Alternatively, we also found that following a standardized format did not always guarantee the absence of information breakdowns. For instance, although the outgoing residents followed a standardized format when presenting cases for pt nos. 2, 3, and 4, we identified the presence of information breakdowns for pt nos. 3 and 4 while information handoff for pt no. 2 did not comprise of any information breakdown. Hence, we analyzed that standardized format of handoff by itself, did not always contribute to handoff communication effectiveness and there was a wide variability in the use of the standardized form. This raised an important question as to what actually caused this inconsistency in the data which leads us to our next influential factor.

Completion of Pre-turnover Coordination Activities

The second influential factor that affected handoff communication was the completion of prior coordination activities in the pre-turnover phase. We identified five coordination activities that were performed - examining patient, gathering information, updating information, reviewing information and preparing progress notes[37].

We use a detailed example of pt no. 5 to illustrate how coordination activities in pre-turnover phase are related to information breakdowns in handoff phase. The *pre-turnover* phase comprised of coordination activities prior to handoff of pt no. 5. Table 4 below represents the status of coordination activities in the pre-turnover phase. In this table, CA2 and CA4 were missed coordination activities in the pre-turnover phase (represented by shaded rows).

Coordination Activity No.	Coordination Activity	Status of Coordination Activity – Performed/Not?
CA1	Examine Patient	Performed
CA2	Gather Information	Missed
CA3	Update Information	Performed
CA4	Review Information	Missed
CA5	Prepare Progress Notes	Performed

Table 4. Status of Coordination Activities in Pre-turnover Phase

The handoff phase comprised of communication events related to pt no. 5. The fifteen communication events were analyzed for its information breakdowns. Table 5 below represents the status of information breakdowns in handoff communication phase. In this table, CE2 and CE15 comprised of information breakdowns (represented by shaded rows). The information breakdown in CE2 was characterized as missing information on critical patient care events in the last 24 hours and the information breakdown in CE15 was characterized as inconsistent (or conflicting) information on assessment and plan of care with respect to the cardio-vascular system (CVS).

Communication Event No.	Details Provided in Each Communication Event	Information Breakdown – Y/N?
CE1	MICU Day #, Vent Day #, Problems, Lines, Drips, Nutrition, Prophylaxis	N
CE2	Events, ROS (Review of Systems)	Y
CE3	PE: Tm, BP, MAP, HR, RR, I/O	N
CE4	Vent: Rate, Vt, PEEP, FiO2, % Peak P, AutoPeep, ABG Gen: Intubated – Y/N	N
CE5	Psych: Sedated/Agitated/Calm	N
CE6	Neuro: Sedated/Confused/Alert-Awake-Oriented	N
CE7	HEENT: Pupils equally round and reactive to light – Y/N; GAG – Y/N, Secretion – Y/N	N
CE8	CV: Rhythm – Regular/Irregular, Rate – Normal/Tachycardic Murmurs – Y/N, Systolic, Diastolic, Location: Radiation	N
CE9	Lung: Clear to Auscultate Bilaterally – Y/N; Crackles – Y/N; Wheeze – Y/N, Labored – Y/N	N
CE10	Abd: Bowel Sound – Y/N; Soft/Hard; Distended – Y/N; Rash: Y/N; Tender – Y/N	N
CE11	Ext: Clubbing – Y/N; Cyanosis – Y/N, Edema – Y/N; Pulse – Y/N Integument: Rash – Y/N	N
CE12	GU: Foley – Y/N; Lesions – Y/N; Discharge – Y/N	N
CE13	Labs, Cultures	N
CE14	Chest X-ray, Other Imaging	N
CE15	Assessment and Plan (a) Neuro, (b) Endocrine, (c) Resp, (d) CVS, (e) GI, (f) Renal, (g) I.D., (h) Heme, (i) Other organs, (j) Prophylaxis	Y

Table 5. Status of Communication Events and Information Breakdowns in Handoff Phase

To examine the effect of pre-turnover phase on information breakdowns in the handoff phase, the coordination activities in the pre-turnover phase and communication events in the handoff phase were mapped. Figure 2 below depicts the mapping between the phases for pt no. 5 where CA1-CA5 are the coordination activities and CE1–CE15 are the communication events. The mapping in Figure 2 confirmed that information breakdowns in CE2 and CE15 in the handoff phase were caused by the missed coordination activities, CA2 and CA4 in the pre-turnover phase. This suggests that successful completion of coordination activities in pre-turnover phase may have an influence on handoff communication.

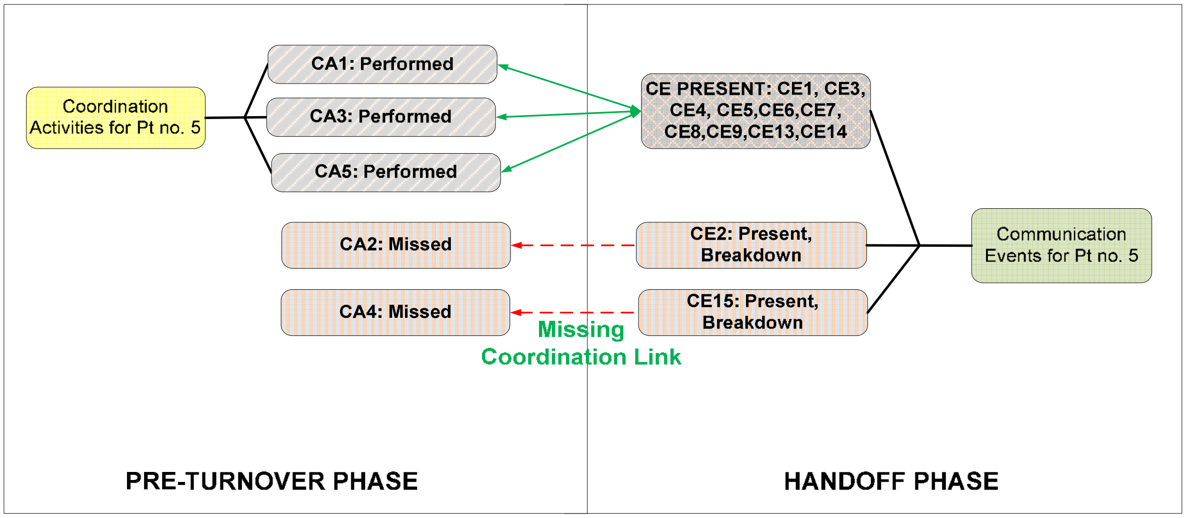


Figure 2. Influence of Pre-turnover Coordination Activities on Handoff Communication in MICU

To further validate this result, we revisited Table 3 (on influence of standardization on handoff communication) and analyzed the status of coordination activities in pre-turnover phase in conjunction with standardization format data.

Pt. No.	Followed Standardized Format – Y/N?	Frequency of Information Breakdowns	Coordination Activity Performed Status – Complete/Incomplete
1	N	2	Incomplete
2	Y	0	Complete
3	Y	3	Incomplete
4	Y	2	Incomplete

Table 6. Influence of Coordination Activities on Handoff Communication in MICU

For pt. no. 2, the standardization format was followed and the coordination activities were completed which resulted in zero information breakdowns (shown by lighter shaded row in Table 6). Alternatively, for pt. nos. 3 and 4, the standardization format was followed but the coordination activities were incomplete, which resulted in significant number of information breakdowns (depicted by darker shaded rows). Using the information on status of coordination activities, we were able to explain the inconsistency in the data. Therefore, based on the data in Table 6, we inferred that effective handoff communication depends on not only standardization of handoff format but also the successful completion of prior coordination activities in pre-turnover phase.

In this section, we identified two critical factors that led to information breakdowns: lack of standardized communication practices during the handoff phase and unsuccessful completion of coordination activities in pre-turnover phase. These factors are not mutually exclusive: in other words, the incorporating standardized protocols for handoff communication, by itself, may not resolve the information breakdowns if they were ignored or not optimally used. Instead, following such handoff protocols in conjunction with successful completion of pre-turnover coordination activities is often necessary to ensure continuity of patient care process.

Discussion

Studying handoff communication using a workflow perspective allowed a systematic temporal and sequential analysis of the features and constraints surrounding the context of the entire handoff process (pre-turnover, handoff and post-turnover phases)[28]. It also afforded deeper insights into the potential sources of information breakdowns and process bottlenecks. In this section, we discuss how the sources of handoff communication breakdowns suggest potential intervention strategies to improve information transfer between multiple shifts and multiple care providers. The two potential intervention strategies we identified include (a) standardization using a handoff tool based on body-system format and (b) collective information-push model for pre-turnover coordination.

Standardization using a handoff communication tool based on body-system format

Standardization of information content and form is important for effective communication during handoffs[7]. Nevertheless, there is an ongoing debate on the pros and cons of standardization of communication behavior. Some of the advantages of a structured format include allowing for clear, direct and concise information sharing. Such a pre-defined scripted communication template not only prompts care-providers to get relevant and pertinent information but also help establish common ground with other team members[38]. Standardization of handoff can potentially lead to desired patient and task outcomes, increased productivity and improved communication efficiency and effectiveness.

We argue that a handoff tool based on the body-system format can be an effective strategy to address issues with standardization of communication. A body-system format allows for the categorization of patient-care information by the different body systems including cardiovascular, neurologic and pulmonary. Such a structured communication tool can reduce some of the variability in content and form of current handoff process by incorporating a detailed and comprehensive record of the transition such as assessment, problems, medications, pending tasks, planned tasks and orders and short-term goals for a particular body system. Since the body system format represents the training provided to residents in medical school[39], a tool based on this format can provide a causal/effect account of patient-care events, which helps in developing a differential diagnosis for the patient. Such a format also allows for systematic and standardized representation of patient status and goals, thereby sharing both explicit and tacit knowledge[40]. Furthermore, the use of a body-system formatted handoff tool can potentially serve as a template for information seeking, documenting and organization activities in the pre-turnover phase that have an impact on the content of handoff. The process of detailing the patient-care information by body systems enables the outgoing resident to detect discrepancies, if any between patient-care events and interactions in the care trajectory. This apart, the recording of the information using this format helps to reveal the causal reasoning of care providers and rationale behind care provider orders/actions.

Collective information-push model

An information-push model emphasizes information to be sent to users without having them explicitly ask for the needed information. Examples of some communication technologies that adopt information-push model include newspapers, radio and television. In the pull model, the user has to know a priori exactly the appropriate location to find information. Alternatively, the push model relieves the user of additional effort and time in seeking information. However, it shifts the onus of the information-seeking task to the information providers, which consequently may increase the chances of receiving irrelevant information.

A collective information-push model to pre-turnover coordination can be an effective strategy to minimize information breakdowns caused by the individualized information-pull model. Currently in the pre-turnover phase, the outgoing resident is hard-pressed for time on one hand, to multitask and complete their coordination activities preceding handoff and on the other with the delivery of timely and appropriate patient care. The use of such a collective information-push model to coordination of activities in the pre-turnover phase can allow the outgoing resident to redirect his/her attention and other cognitive resources to reasoning the case[41]. The rapid use of patient-care related information depends on a comprehensive range of information-push tools that provide an ongoing source of highly filtered, relevant, accurate and valid information[42]. For instance, in the pre-turnover phase, the patient nurse and the respiratory therapist can provide relevant updated patient information such as current patient condition, status of test results and labs, pending orders, tasks in the order of priority, tasks awaiting physician decisions, family needs and other concerning issues etc. to the outgoing resident. The collective information-push model can thereby reduce duplication and redundancy of effort and time spent by outgoing residents in performing coordination activities. However, to incorporate information-push model into the handoff process, the model of the outgoing resident's information needs must be identified a-priori which can ensure relevant and accurate information is being pushed[41].

Results from this study can be *generalizable* to other care settings with two identifiable constraints although there are variations in handoffs across different care settings. First, the research was conducted at a single critical-care setting as a result of which there may be relevant issues that relate to this particular context, such as unit protocols and model of care. Second, the results were based on a particular type of inter-professional group handoff that may have had an influence on the handoff communication activity including its content. Nevertheless, the basic structure and model of handoff communication activity that was developed using a shift-centered data collection approach can be extended to examining the communication events and information breakdowns in different types of group handoffs irrespective of their composition. Furthermore, the detailed nature of the shift-centered data collection approach and the mixed inductive-deductive analysis supported a systematic investigation of the overall handoff workflow.

Conclusion

We illustrate that a sender and receiver handoff model with linear and unidirectional flow of information is inappropriate and inadequate to explain interactions in a collaborative environment such as a hospital. Our study results emphasize that the handoff communication activity is interactive and non-linear. Furthermore, a reduction in communication breakdowns requires a detailed examination of handoff problem using a handoff workflow perspective that takes into consideration the context of overall communication pattern rather than focusing on the content of the handoff communication and its barriers.

We have attempted to do this by highlighting two influential factors that contribute to information breakdowns including the lack of standardization in handoff communication phase and the ineffective coordination activities in pre-turnover phase. We suggest two key strategies that can potentially ensure effectiveness and efficiency of handoff communication - (a) standardization using a handoff communication tool based on body system format and (b) streamlining of pre-turnover activities using a collective information-push model. These intervention strategies have the potential to impact the overall MICU handoff process by (a) providing a structured and systematic approach to information transfer during handoff communication, (b) minimizing the information breakdowns (e.gs, information loss, ambiguity) in handoff communication and (c) ensuring the successful completion of coordination activities in the pre-turnover phase. Based on this understanding, we can design informatics tools that can better support the handoff workflow as described in the discussion section.

Acknowledgements

We thank all the participants in the study for their support. This research is supported in part by a training fellowship from the Keck Center AHRQ Training Program in Patient Safety and Quality of the Gulf Coast Consortia (AHRQ Grant No. 1 T32 HS017586-02) and from the James S McDonnell Foundation (Grant 220020152 to Vimla Patel).

References

1. Riesenberg LA, Leitzsch J, Massucci JL, Jaeger J, Rosenfeld JC, Patow C, et al. Residents' and Attending Physicians' Handoffs: A Systematic Review of the Literature. Academic Medicine. 2009;84(12):1775-87 10.097/ACM.0b013e3181bf51a6.
2. Arora V, Johnson J, Meltzer D, Humphrey H. A theoretical framework and competency-based approach to improving handoffs. Quality and Safety in Health Care. 2008;17:11 - 4.
3. Strople B, Ottani P. Can Technology Improve Intershift Report? What the Research Reveals. Journal of Professional Nursing. 2006 2006/6//;22(3):197-204.
4. Staggers N, Jennings BM. The Content and Context of Change of Shift Report on Medical and Surgical Units. Journal of Nursing Administration. 2009;39(9):393-8 10.1097/NNA.0b013e3181b3b63a.
5. Craig SS. Challenges in arranging inter-hospital transfers from a small regional hospital: an obvervational study. Emergency Medicine Australasia. 2005;17:124-31.
6. Gandhi TK. Fumbled Handoffs: One Dropped Ball after Another. Annals of Internal Medicine. 2005 March 1, 2005;142(5):352-8.
7. Horwitz LI, Meredith T, Schuur JD, Shah NR, Kulkarni RG, Jenq GY. Dropping the Baton: A Qualitative Analysis of Failures During the Transition From Emergency Department to Inpatient Care. Annals of Emergency Medicine. 2009;53(6):701-10.e4.
8. Sutcliffe K, Lewton E, Rosenthal M. Communication failures: An insidious contributor to medical mishaps. Academic Medicine. 2004;79(2/February):186 - 94.
9. National Patient Safety Goals, (2006).
10. Volpp KGM, Grande D. Residents' suggestions for reducing errors in teaching hospitals. N Engl J Med. 2003;348:851-5.
11. Payne B, Hardey H, Coleman P. Interactions between nurses during handovers in elderly care. Journal of Advanced Nursing. 2000;32:277-85.
12. Ruth. Resident Handoffs Often End in Patient Harm. Emergency Medicine News: . 2009;31(3):1, 6.
13. Chassin M. Joint Commission Touts Research on Reducing Handoff Failures. In: Clark C, editor.: HealthLeaders Media; 2010.
14. Streitenberger K, Breen-Reid K, Harris C. Handoffs in Care--Can We Make Them Safer? Pediatric Clinics of North America. 2006;53(6):1185-95.
15. Clarke SP, Aiken LH. Failure to rescue: Needless deaths are prime examples of the need for more nurses at the bedside. . American Journal of Nursing. 2003;103:42-7.

16. Lofgren RP, Gottlieb, D., Williams, R.A., Rich, E.C. Post-call transfer of resident responsibility: its effect on patient care. Journal of General Internal Medicine. 1990;5:501-5.
17. Berkenstadt H, Haviv Y, Tuval A, Shemesh Y, Megrill A, Perry A, et al. Improving Handoff Communications in Critical Care*. Chest. 2008 July 2008;134(1):158-62.
18. Arora VM, Johnson JK, Meltzer DO, Humphrey HJ. A theoretical framework and competency-based approach to improving handoffs. Quality and Safety in Health Care. 2008 February 2008;17(1):11-4.
19. Vidyarthi AR, Arora V, Schnipper JL, Wall SD, Wachter RM. Managing discontinuity in academic medical centers: Strategies for a safe and effective resident sign-out. Journal of Hospital Medicine. 2006;1(4):257-66.
20. Apker J, Mallak L, Gibson S. Communicating in the "gray zone": perceptions about emergency physician hospitalist handoffs and patient safety. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine. 2007;14(10):884-94.
21. Horwitz L, Moin T, Green M. Development and Implementation of an Oral Sign-out Skills Curriculum. Journal of General Internal Medicine. 2007;22(10):1470-4.
22. Arora J, J, Lovinger D, Humphrey HJ, Meltzer DO. Communication failures in patient sign-out and suggestions for improvement: a critical incident analysis. Quality and Safety in Health Care. 2005 14(6):401-7.
23. Van Eaton EG, Horvath, K.D., Lober, W.B., Pellegrini, C.A. Organizing the transfer of patient care information: The development of a computerized resident sign-out system. Surgery. 2004;136:5-13.
24. Patterson E, Roth E, Woods D, Chow R, Orlando Gomes J. Handoff strategies in settings with consequences for failure: lessons for health care operations. International Journal for Quality in Health Care. 2004;16:125 - 32.
25. Haig K, Sutton, S, Whittington, J. SBAR: A shared mental model for improving communication between clinicians. Jt Comm J Qual Patient Saf. 2006; 32:167-75.
26. Arora V, Johnson J. A model for building a standardized hand-off protocol. Jt Comm J Qual Patient Saf. 2006;32(11):646 - 55.
27. Stein DM, Vawdrey DK, Stetson PD, Bakken S, editors. An Analysis of Team Checklists in Physician Signout Notes. AMIA Annu Symp Proc 2010.
28. Lawrence R, Tomolo A, Garlisi A, Aron D. Conceptualizing handover strategies at change of shift in the emergency department: a grounded theory study. BMC Health Services Research. 2008;8(1):256.
29. Arora V, Johnson J. A Model for Building a Standardized Hand-off Protocol. Joint Commission Journal on Quality and Patient Safety. 2006;32:646-55.
30. Miller A, Scheinkestel C, Limpus A, Joseph M, Karnik A, Venkatesh B. Uni- and Interdisciplinary Effects on Round and Handover Content in Intensive Care Units. Human Factors: The Journal of the Human Factors and Ergonomics Society. 2009 June 1, 2009;51(3):339-53.
31. Nemeth C, Nunnally M, O'connor MF, Cook RI, editors. Creating Resilient IT: How the Sign-Out Sheet Shows Clinicians Make Healthcare Work. AMIA Annual Symposium Proceedings; 2006.
32. Accreditation Council for Graduate Medical Education A. Report of the Work Group on Resident Duty Hours and the Learning Environment2002.
33. Donchin Y, Gopher D, Olin M, Badihi Y, Biesky M, Sprung CL, et al. A look into the nature and causes of human errors in the intensive care unit. Quality and Safety in Health Care. 2003 April 2003;12(2):143-7.
34. Abraham J, Kannampallil T, Patel VL. Methodological Analysis of Handoff Communication in Critical Care Environment. Journal of Biomedical Informatics. Under Review.
35. Strauss A, Corbin J. Basics of Qualitative Research. Thousands Oaks, CA: Sage Publications; 1998.
36. Forsythe DE, Buchanan BG, Osheroff JA, Miller RA. Expanding the concept of medical information: An observational study of physicians' information needs. *Computers and Biomedical Research*. 1992;25(2):181-200.
37. Abraham J, Kannampallil T, Almoosa KF, Patel B, Patel VL. Analysis of Handoff Communication in Critical Care Environment. Special issue on Methods for the Analysis of Communication in the Journal of Human Factors. 2011 (Under Revision).
38. Clark H. Using Language. New York: Cambridge University Press; 1996.
39. Varon J, Acosta P, editors. Handbook of Critical and Intensive Care Medicine. Second ed2010.
40. Harvey CM, Schuster RJ, Durso FT, Matthews AL, Surabattula D. Human Factors of Transition of Care Carayon P, editor. Hillsdale, NJ: Lawrence Erlbaum Associates; 2007.
41. Cybenko G, Brewington B. The foundations of information push and pull. Cybenko G, O'Leary DP, J. R, editors. New York: Springer-Verlag; 1999.
42. Strayer SM, Shaughnessy AF, Yew KS, Stephens MB, Slawson DC. Updating clinical knowledge: an evaluation of current information alerting services. Int J Med Inform 2010;79(12):824-31.