



## Bridging gaps in handoffs: A *continuity of care* based approach

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### ABSTRACT

Handoff among healthcare providers has been recognized as a major source of medical errors. Most prior research has often focused on the communication aspects of handoff, with limited emphasis on the overall handoff process, especially from a clinician workflow perspective. Such a workflow perspective that is based on the *continuity of care* model provides a framework required to identify and support an interconnected trajectory of care events affecting handoff communication. To this end, we propose a new methodology, referred to as the *clinician-centered approach* that allows us to investigate and represent the entire clinician workflow prior to, during and, after handoff communication. This representation of clinician activities supports a comprehensive analysis of the interdependencies in the handoff process across the care continuum, as opposed to a single discrete, information sharing activity. The clinician-centered approach is supported by *multifaceted methods for data collection* such as observations, shadowing of clinicians, audio recording of handoff communication, semi-structured interviews and artifact identification and collection. The analysis followed a *two-stage mixed inductive–deductive method*. The iterative development of clinician-centered approach was realized using a multi-faceted study conducted in the Medical Intensive Care Unit (MICU) of an academic hospital. Using the clinician-centered approach, we (a) *identify* the nature, inherent characteristics and the interdependencies between three phases of the handoff process and (b) *develop* a descriptive framework of handoff communication in critical care that captures the non-linear, recursive and interactive nature of collaboration and decision-making. The results reported in this paper serve as a “proof of concept” of our approach, emphasizing the importance of capturing a coordinated and uninterrupted succession of clinician information management and transfer activities in relation to patient care events.

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### 1. Introduction

*Handoffs* in healthcare refer to the transfer of care from one clinician to the next and involve a transfer of information, responsibility and authority for patient care [11,46,56]. Handoffs are often considered error-prone [36], affecting the continuity, quality and timeliness of the patient care process [17,19,31,49]. To minimize handoff failures, the Joint Commission [57] has mandated all US hospitals to standardize information transfer practices by adopting safe and systematized communication protocols. While some hospitals have incorporated customized standards, mnemonics and tools for handoff communication [10,25,61], there are currently no universally adopted standards for handoff communication [46]. As a result, very seldom are they followed [26]. Limited adoption of such standardized practices for handoffs could be traced, partially, to a lack of proper understanding of the nature of handoffs, challenges faced during handoffs and its key contributors.

In prior work, researchers have often focused on understanding handoff as a discrete communication activity [12], independent of other surrounding activities in the clinical workflow. While handoff in itself is an isolated care-related activity, it must be considered within the overall context of the clinician workflow, both prior to, during and, after information transfer [53,54], in view to developing a detailed understanding of its challenges and related root causes. Such an understanding about the overall handoff process will help to better align our efforts towards the design of effective standardized tools and protocols that are integrated within the clinical, organizational and social fabric of the hospital environment.

Therefore, to gain deeper insights about the handoff process, we develop a methodological approach referred to as *clinician-centered approach*, predicated on understanding the handoff communication activity, within the global context of clinician workflow. The approach utilizes the “continuity of care” model not only to capture the nuances of handoff process and potential interdependencies within the process, but also to trace interdependent activities that mediate and affect the communicative exchanges between clinicians. The insights gained by using this approach can help us to (a) alleviate some of the handoff challenges that have been highlighted

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by researchers and hospital administrators and also, (b) develop standardized mechanisms for handoff communication activity through the design of information sharing tools that are theoretically and empirically grounded interventions.

The clinician-centered approach was developed based on a multi-faceted study on handoffs in the Medical Intensive Care Unit (MICU) of a large academic hospital. The methods and results presented illustrate the power of utilizing the clinician-centered approach and serve only as a “proof of concept” to emphasize the usefulness of our approach.

## 2. Background

Handoffs have been referred in the research literature using several terms such as handover [52], sign-out [13], transitions in care [44], bedside reporting [56] and transfer of accountability [5]. Despite these differences in terminology, the general consensus is that all these terms assume that handoffs involve “an explicit transfer of information between clinicians.” Alternatively, the differences in research (and methodological approaches) lie primarily in the *nature and type of handoffs* being studied (i.e., the level of analysis that is considered). For example, researchers have studied transitions between care-providers within a department [43], across departments [52], and also between healthcare organizations [18]. Irrespective of the levels of analyses, these studies have used similar data collection and analytical approaches for the investigation of handoff communication activity.

Across the research literature on handoffs that we reviewed, three prominent *data collection methods* were commonly used: clinician interviews, surveys, and observations of clinician handoffs. While each of these studies had specific foci in terms of illustrating the complexities of the various information transfer activities, they were constrained in terms of developing a holistic perspective on handoff processes due to their methodological choices.

Several studies used *interviews* as a primary source of handoff information (e.g., [7,38]). For example, Apker et al. [7] used interviews to examine handoff communication between Emergency Department (ED) and inpatient unit physicians. In a similar vein, Aroora et al. [9] utilized the critical interviewing technique to understand the mediating role of resident “sign-out” activity in the transfer of care for hospitalized patients. These studies, among other interview studies, have focused on obtaining a first-hand perspective on the communication and information sharing barriers during handoffs from key individuals who are involved in the handoff activity.

Detailed interviews with clinicians involved in handoffs were useful for developing an understanding of the handoff process, team members involved, technologies used, challenges faced, and potential consequences of handoff failures. The value and quality of such an understanding can possibly be improved with a larger sample of interview participants. Nevertheless, interviews are often retrospective recollections of events and are not effective in capturing the nuances of interactions and context, communication challenges, and generation and propagation of errors during handoffs. In other words, interviews, while valuable, have limitations for developing a holistic picture of the handoff process within the context of the entire clinical workflow.

In addition to interviews, some researchers have utilized *surveys* for collecting retrospective data on communication with significantly larger participant samples. For instance, Philibert [43] investigated the various aspects of resident handoffs that impacted information accuracy using a survey administered to 844 residents in various clinical services. The handoff survey used in this particular study (and others) was primarily focused on certain specific attributes of handoffs that were under investigation such as mechanism of handoff, handoff events, and handoff errors.

Surveys, in general, provide limited insights on the complex nature of handoff process and its interdependencies. This can be attributed to several factors: First, survey questions are often written in a standardized format enabling response from a large sample of participants, leading to the possibility of being only marginally appropriate for certain specific groups of respondents. Second, large sample size (usually in hundreds) is required to develop a significant understanding of the process. Third, and most importantly, survey questionnaires fail to capture the contextual elements of dynamic and clinical work.

Prior *observation* studies on handoffs were primarily focused on the investigation of the meaning and structure of communication content [37,40,42]. For example, Smith et al. [52] performed observations of the handoff communication activity to understand how anesthesiologists transferred information and responsibility to nurses in the recovery room. Although some of these observations provided some general insights on the important role of the clinical context in handoff communication, we are still unable to identify the inherent nature of the clinician activities (and characteristics) that may have an impact on the effectiveness of the information sharing activity.

Different analytical approaches and methods have been used to code and evaluate the communication data. Analysis of handoff communication data was mainly based on a range of qualitative methods such as the constant comparison method (e.g., [2,3,9]), content analysis (e.g., [20,37]), process tracing and discourse analysis [8]. For instance, using content analysis of a physician handoff tool (PHT) use, Flanagan et al. [20] found that over 90% of PHT forms contained patient identifiers, demographics, location, current medication list, short-term concerns, less than 50% contained race, allergies, code status, IV access, test results, long-term plan, psychosocial concerns and 70% consisted of assessment and plan.

Based on our review of the handoff literature, we identified that the research focus has been primarily on understanding the nature of “communication” behavior during handoffs [29,34,35]. Consequently, researchers have adopted a handoff-centered approach to study communication activity between clinicians. However, we would like to point out that most of these prior studies had specific research objectives (and questions) related to different aspects of the handoff communication activity as opposed to developing a complete understanding of the handoff process and its interdependencies. Nevertheless, as described earlier, most research methods used to examine handoff challenges have their own strengths and weaknesses. While these data collection and analytical methods are useful for understanding the types of breakdowns in communication *during* handoffs, they were in itself inadequate for evaluating the outcomes of handoff communication [47], which we believe, is often dependent on the clinicians’ activities that precede and follow the formal communication activity. Additionally, it also requires a methodological approach that is predicated on flexibly using multiple methods (e.g., observations, shadowing) to effectively capture the entire workflow around handoff-related activities. To address this issue, we propose and further develop a clinician-centered approach for investigating and evaluating handoffs.

### 2.1. Theoretical rationale

The *clinician-centered approach* is based on capturing the contextual factors that impact the *continuity of care* across multiple clinicians attending to a patient. Continuity of care supports a comprehensive and synchronized approach to patient care delivery and utilizes a “day in the life” approach [23]. Hence, it provides “a coordinated and uninterrupted succession of events consistent with the medical care needs of the patients” [51]. However, maintaining such continuity during a patient’s care delivery process is a major healthcare challenge.

To reduce fragmentation in care [1], hospitals have incorporated patient handoffs as avenues that facilitate the transfer of patient information (including responsibility and control) between clinicians. However, the effectiveness (i.e., quality) and efficiency (i.e., timeliness) of information flow between clinicians is dependent on the clinicians' activities and workflow. Therefore, we argue that by adopting a clinician-centered approach (grounded in the continuity of care model) where we shadow clinicians, we can develop a more accurate and nuanced representation of the overall handoff process with respect to a temporal sequence of the clinician's information management and transfer activities as they relate to patient care events. Capturing the nuances within such a model not only affords insights into the characteristics of a complex environment [28,40], but also provides increased clarity on the interdependencies between the various workflow components [32,41], the challenges that arise from these interdependencies and its impact on patient care [45,59]. Similar arguments were developed by Collins et al. [16], who described the importance of incorporating the handoff information elements into a continuity of care document (CCD).

The clinician-centered approach is based on the following key features: (a) it utilizes a multi-method approach with shadowing as the fundamental data collection method. The use of shadowing as a data collection method is a key aspect of the clinician-centered approach, as it provides a detailed trace of progression of events in a clinical workflow. The use of other methods (e.g., interviews or observations) is dependent on the particular context of study (e.g., primary care vs. critical care) and other environmental constraints, and (b) the specific methods (except shadowing) that can be used are interchangeable. For instance, interviews can be replaced with the verbal think-aloud method, if that can potentially provide better information regarding a specific aspect of the handoff process (e.g., reasoning behind how residents fill up the progress note prior to the rounds).

To summarize, our clinician-centered approach for studying handoffs provides several advantages: (a) identifying communication errors and related challenges during transitions of care between clinicians, (b) tracing the cause and progression of such transition errors, and (c) providing a systematic, temporal sequence of the features and constraints around the context of handoffs.

We believe that such an approach that utilizes the continuity of care model can potentially alleviate the current gaps in handoff research. Such a perspective helps us to: (a) evaluate handoffs within the broader context of clinician workflow, and (b) develop a comprehensive framework that describes handoff communication, and (c) identify the various points of communication breakdowns and also, trace the potential sources for these breakdowns.

### 3. Method

#### 3.1. Study site

The study was conducted in a 16-bed MICU of a teaching hospital in Texas with an average of 55,000 emergency department (ED) visits per year. The MICU in this hospital is a "closed" ICU, where the MICU team is primarily responsible for the care of patients admitted to the unit. Before the start of this study, the first author attended an MICU training session for new residents and interns rotating in the unit to learn more about roles and responsibilities of MICU team and to also familiarize with the unit's policies and protocols. Our research team also provided an overview to MICU staff about our prior research on patient safety, expertise in conducting fieldwork in hospital settings and efforts to ensure confidentiality of data. The institutional review board (IRB) approved the study.

#### 3.2. Participants

Participants included *patient-care teams* that were on-call (i.e., on service) and actively involved in continuity of care activities in the MICU.

These patient care teams comprised of an attending physician, a clinical fellow, residents, interns, a pharmacist, a respiratory therapist and nurses. The roles and responsibilities of each of the MICU team members are described in Table 1.

While the attending physician, fellow, pharmacist and nurses worked on 12-h shifts, the resident and intern worked 28-h shifts. During a 28-h shift, the resident with the support of an intern, was primarily responsible for care delivery activities of all the patients in the MICU. However, as patients often stay several days in the MICU, patient care responsibilities were transferred among residents across multiple shifts.

#### 3.3. MICU workflow terminology

*At the beginning of each shift*, the resident and intern who take charge of patient care activities are referred to as the "on-call resident" and "on-call intern". *During handoffs*, the on-call resident and intern are referred to as outgoing resident and outgoing intern while the oncoming resident and intern are referred to as the on-call resident and on-call intern for the new shift. Apart from the on-call resident and intern, the oncoming team is comprised of the attending, clinical fellow and the pharmacist. *After handoffs are completed*, the oncoming resident and oncoming intern takes charge of patient care activities in the MICU. In this paper, we report on our investigation of resident handoffs in the MICU. The MICU team workflow and terminology is illustrated in Fig. 1.

#### 3.4. Resident handoffs in MICU

Our study site did not have a formal resident "sign-out" or handoff between residents. Instead, the morning rounds in the MICU were used as a venue for resident handoffs. These rounds were an example of group handoffs that were attended by the entire MICU team. The MICU team during handoffs consisted of the *outgoing team* (resident and intern), and an *oncoming team* (attending physician, clinical fellow, resident, intern and pharmacist). During handoffs, the outgoing resident (or intern) presented patient status information and updates to the oncoming team (see Fig. 1). The attending physician managed the rounds and therefore was "active" in the handoff communication activity with the outgoing team, while the other oncoming team members were "passive" in their communication and was involved in the discussion only when there was a need for information clarification or teaching.

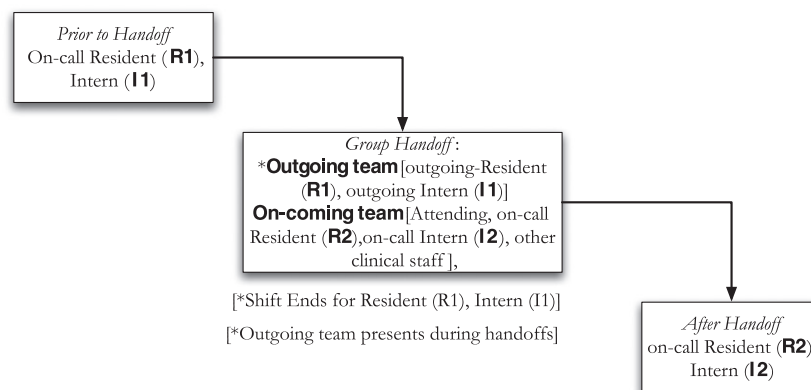
#### 3.5. Clinician-centered approach and its evolution

The clinician-centered approach to handoff analysis evolved over several iterations of data collection. We started our study with a *handoff-centered approach* and transitioned into a *patient-centered* and, finally, to a *clinician-centered* approach.

In the *handoff-centered approach*, data was collected only during handoffs (i.e., at shift changes). Several prior research studies have utilized this approach for data collection [29,43,52]. We observed and took meticulous notes on the interaction and verbal communication behavior during nine (9) morning rounds, each of which lasted between 3 and 4 h. During each round, upto 16 group handoffs occurred between the outgoing resident (and/or intern) and the oncoming MICU team. The first author observed a total of 144 handoffs [9 rounds × 16 patients per round] over a period of 2 months.

**Table 1**  
Medical Intensive Care Unit (MICU) team member roles and responsibilities.

MICU roles	Patient-care responsibilities
Attending physician	Intensivist head of the MICU team and is in charge of all patient-care decisions
Clinical fellow	Intensivist in training and makes major decisions in the absence of the attending, and keeps the attending informed of patients' status and also supervises all residents and students for daily duties, including patient care and procedures
Medical resident	Post-graduate physician in their second or third year internal medicine residency training and is in charge of patient-care activities in the MICU, and works under the direction and supervision of the attending physician
Medical intern	A physician in their first year of residency training and is in charge of care activities for patients in the MICU, and works under the direction and supervision of the attending physician and the resident
Pharmacist	Monitors drug therapy; reviews medication regimen and provides other medication recommendations
Respiratory therapist	Evaluates and performs therapeutic treatment and diagnostic procedures for patients with respiratory or other cardiopulmonary disorders



**Fig. 1.** MICU handoff workflow and terminology.

An example of patient data captured using this approach: “if we get the NGtube (Nasogastric intubation) back in, it will cause trauma, whatever issues she had and cause bleeding like last time. So she either has to take in PO or you have to give her ativan IV. You could rather do that. So she can't take librium.”

In this particular handoff case, when the outgoing resident provided patient management plan for inserting an NGtube, the oncoming attending cautions her about potential trauma and bleeding that will result from the proposed plan. Instead the attending suggested alternative plans such as PO or ativan IV.

While the handoff-centered approach provided rich data on the content and form of handoff communication, we were unable to characterize the context within which the information was described. In above-mentioned quote, although we captured detailed patient handoff data transferred between the outgoing and oncoming teams including patient demographics, overnight events, assessment and plan, we were unable to understand the reason for not administering librium to the patient and what types of patient issues that the attending was referring to. During handoffs, such reasoning efforts were rarely undertaken, leading to potential increased misunderstanding about a patient case and consequently, potential errors.

To better characterize and understand the nature and content of handoff communication within the larger context of patient care workflow, we adopted a *patient-centered approach*. In this approach, we focused on specific patients from the time they arrived in the MICU till they were discharged from the unit. We followed three (3) patients while using this approach. During these sessions we gathered data on the verbal information exchanges of care providers who came in contact with the specific patient (that occurred right outside the patient room). Two of the patients stayed in the unit for about 48 h while one patient stayed in the unit for 72 h.

The first author, with the help of a graduate student researcher, collected data on these patients when they were in the MICU. While the handoff communication between outgoing and oncoming teams for these particular patients was audio-recorded, the physician-patient, nurse-patient, and physician-physician interactions and information exchanges related to these patient cases were documented using field notes. Additionally, we also captured information on events in the patient-care trajectory [55] as they evolved over the course of the patient's stay in the MICU.

In spite of these data collection attempts, we were unable to track and follow multiple clinicians as they were attending to information regarding the selected patient elsewhere. For example, we were unable to record information on care activities for a specific patient performed simultaneously at different locations by the resident and the patient's assigned nurse. Furthermore, the success of this approach also depended on choosing the “right patient to observe” – some patients we followed were transferred out of the MICU in less than 2 days after they were admitted, while others were declared DNR/DNI (do not resuscitate and do not intubate) code status after a day or two. As such there was no way to ascertain the length of MICU stay or their acuity, at the time of patient admission into the MICU (i.e., at start of the patient-centered data collection). The uncertainty of the length of patient stay in the MICU resulted in significant challenges for using the patient-centered approach.

Finally, we utilized a *clinician-centered approach* to data collection. The clinician-centered approach was based on an underlying assumption that handoff-related events were not limited exclusively to the transfer of information between clinicians but depended on a temporal sequence of clinician activities both prior to, and, after the handoff. Such a trace of activities helped in developing a more accurate and nuanced representation of the overall



handoff process and its impact on the continuity of care activities. As previously explained (see Section 2.1), the clinician-centered approach was predicated on the well-acknowledged continuity of care model.

In the clinician-centered approach, we closely followed the *on-call resident during their entire shift*, i.e., from 8 am on first day to 12 pm on the following day (a total of 28 h at a time). During these shifts, we gathered data on both patient care and patient flow activities performed by the on-call resident. Patient care activities included performing procedures, evaluating patient status, coordinating patient care with consulting physicians, and communicating care decisions with patient families. Patient flow activities included getting patient report from a transferring service, coordinating with the attending physician about potential patient discharges, and preparatory activities for handoff of patient care information.

We provide examples from our data to illustrate the different types of data that were gathered using this approach (see Fig. 2). The example has three parts: the *first part* (refer to Fig. 2 under heading “preparatory activities of the resident prior to handoff”) describes the on-call resident’s activities prior to the handoff communication (i.e., morning rounds). For example, at 6:10 am, the on-call resident writes down the medication list and their values of patient in room 1 from the EMR on to her progress note. The *second part* of the example (“handoff communication sequence”) illustrates the actual handoff information exchanges between the outgoing resident and the oncoming MICU team. For instance, the outgoing resident presents the medication list with their values “*Medicines, she is on vancomycin.*” Finally, in the *last part* of the example (“resident activities following handoff”), the new oncoming team gets involved with the completion of pending tasks for the patients and newly assigned tasks. For instance, the on-call resident evaluates a new patient in room 5, writes DNR/DNI orders for an old patient in room 1, informs the attending that he has made necessary arrangements for an old patient in room 6 to get a protocath. These examples are highlighted in Fig. 2.

The example shows the level of granularity and detail that were captured about the entire clinician workflow activities with respect to handoffs including (a) preparatory activities for handoff such as patient-care workflow data, status of lab reports, and possible reasons for consult update delays, (b) handoff communication data such as problem list, MICU status, assessment and plan and, (c) clinician data on patient care delivery tasks and activities that were either pending or completed. Furthermore, the use of the clinician-centered approach helped in obtaining clinician data on a varied mix of patients (unlike the patient-centered approach which focused on specific patients) with different medical conditions and acuity ranging from simple to extremely complex.

To summarize, we identified that the various approaches (i.e., handoff-, patient- and clinician-centered) have different theoretical and methodological underpinnings: the handoff-centered approach is based on a discrete communication-event model, the patient-centered approach is based on a distributed patient-care model and the clinician-centered approach is based on a continuous care-delivery model. In order to capture the nuances and progression of handoffs, the clinician-centered approach is a better overall fit.

Next, we highlight the data collection and analysis methods that were undertaken using the clinician-centered data collection approach.

### 3.5.1. Data collection

We employed ethnographic data collection methods including general observations, clinician shadowing, semi-structured interviews, and artifact identification and collection [21]. Ethnographic methods allowed us to gain meaningful insights on the nuances and complexities of patient handoff practices in the MICU. Similar approaches have been utilized extensively in the biomedical informatics research [30,32,39–41].

**3.5.1.1. Observations.** We started our data collection with general observations of the clinician workflow to get a sense of the activities of the team members, and their roles. Once we obtained

#### Preparatory Activities of the Resident Prior to Handoff

(6:00 am) on-call resident is writing her progress notes at workstation outside room1. She starts browsing the EMR of patient in room 1- reads at the values, reviews information on lab report and Xray. (6:10 am) **Writes down the values from the EMR onto the progress note for room 1.**

(6:14 am) She then gets interrupted by patient alarms and walks into patient room 2[...]

#### Handoff Communication Sequence

*Outgoing resident:* So MICU day 5, vent day 5. Her problems are septic shock, left thigh abscess, respiratory failure, altered mental status, acute kidney injury on CVVHD, shock liver, DICU with coliothopy and enstemy. She has a right IJ which is 5 days old, a right femoral quinten which is 5 days old, a foley, a dopp off tube, no drip, she is on ozomyl.. at 60, she’s on prevacid and stds. **Medicines she is on vanc 1.25 gms, IV Q12 day 5, gent 70, IV Q day 5, merapinin 1gm IV Q 8 day 5, hydrocortizone 100 IV Q8, 100 pob IV, cena.. which actually I stopped yesterday, on latulose and (pause)**

*Oncoming attending:* that’s good idea.

#### Resident Activities Immediately Following Handoffs

Attending asks the on-call resident whether they sent urine for culture for room 5. [...] The on-call resident then writes orders for comfort measures for room 1. No intubation and no CPR. Then she talks to the attending and the nurse manager about room 1. The patient is a transfer. Medicine accepted the patient and transferred him to ER. They transferred him here late Monday morning. We got hold of the family only today. They told him that they were okay **about DNR/DNI (Do not Resuscitate/Do not Intubate). On-call resident informs the attending that he scheduled room 6 for a protocath.**

Fig. 2. Clinician-centered approach: examples from data (the examples are bolded in the text).

an overall understanding of the patient care activities and processes in the MICU that were related to handoffs, we incorporated clinician shadowing, audio recording of handoff communication during morning rounds, semi-structured interviews and artifact collection as additional sources of data.

**3.5.1.2. Clinician shadowing.** Shadowing techniques involve one or more researchers closely following a participant over a period of time. We closely shadowed the on-call residents, who were primarily responsible for carrying out the patient-care tasks and hence maintaining continuity of care in the MICU. Hence, shadowing was a fundamental and necessary method in the clinician-centered approach. During our shadowing of on-call residents, we meticulously documented handoff-specific data, patient-care workflow data and oncoming resident related data (similar to example provided in Fig. 2). For instance, we took handwritten notes on the resident's activities, actions performed, information flows, their interactions with other care providers, artifacts used, and locations they visited during their entire shift.

**3.5.1.3. Audio recording.** In addition to the shadowing of on-call residents, we also audio-recorded the communication and interactions between the outgoing and oncoming teams during the group handoffs. Using audio-recordings of handoffs, we were able to capture the information exchanges, assess the consistency of handoff interactions and the breakdowns or gaps in information flow. The audio recorder was carried in the coat pocket of the attending physician.

The clinician shadowing and audio recording of communication data were performed for 5 days (3 consecutive days followed by 2 non-consecutive days). During these time periods, the first author shadowed five on-call residents for their entire shifts (with short breaks during which a trained graduate student collected the shadowing data) and audio-recorded communication related to eighty separate patient handoffs (i.e., between 13 and 16 MICU patients per day for 5 days = 75 handoff episodes) (see Table 2 for the details of the data collection).

**3.5.1.4. Semi-structured interviews.** Apart from the informal conversations with the MICU team, semi-structured interviews with MICU attending, clinical fellows, nurses and residents were also conducted. Each interview lasted between 20 and 40 min. The interview questions were mainly focused on (a) handoff workflow (b) strategies and mechanisms used to support the handoff process, (c) handoff communication content and structure, (d) handoff obstacles and challenges, and (e) their recommendations for process improvement. Sample questions included:

1. What are the tasks that need to be performed before handoffs?
2. What are your information needs before handoffs? What information resources are used to meet these information needs? (People, Technology) and how do these information resources help/constrain your tasks?
3. Do you have a checklist of items that needs to be completed before handoffs?
4. What do you think is the purpose of handoffs?

5. What kind of information gets exchanged during shift changes?
6. Did you have any formal training lessons for handoffs?
7. What are some of the factors that affect handoff communication effectiveness during shift changes?
8. What are the immediate tasks that are carried out after the handoffs?

**3.5.1.5. Artifact identification and collection.** Finally, we identified a few artifacts including patients' EMR, patient chart, and progress note that were used during handoff communication. Among these, we found the progress note to be of special importance as the on-call resident used its structure as a guide for organizing information prior to the handoff and for communication during the group handoffs although it was not designed specifically for handoff communication. The progress note was developed as a generic tool for management and coordination of care process in the MICU. Based on our analysis of its content, we found that the progress note comprised of patient-case information structured using the SOAP (Subjective, Objective, Assessment and Plan) format. A sample progress note is provided below in Fig. 3.

### 3.5.2. Data analysis

Prior to the data analysis, all observation, shadowing, interview and audio-recorded handoff data were transcribed. We adopted a *two-stage mixed inductive-deductive approach* for our data analysis. In the first stage, we used an inductive method of analysis using the grounded theory approach [24], where a structured coding scheme of handoff process was developed using the data from observations and shadowing. In the second stage, we deductively analyzed the audio-recorded handoff communication data using the structured coding scheme.

**3.5.2.1. First stage.** Three sources of data (observation notes, shadowing notes and interviews) were used for the preliminary analysis. Data analysis was primarily performed using grounded theory approach [24], a well-recognized research method used to analyze data in different research fields [27,60]. The grounded theory [25] approach uses a "constant comparison" mechanism, where consistently occurring "codes" are compared in an iterative manner, eventually, leading to the development of a substantive theory or framework. The GT approach is based on the assumption that such an analysis would provide a deeper understanding of phenomena occurring in real-world contexts by creating evolving hypotheses about activities and human behavior through a systematic coding and categorizing of data. The strength of GT lies in the fact that the coding is a continuous, iterative process and codes (or categories) that emerge from the data give rise to hypotheses (e.g., themes). These hypotheses are, in turn, strengthened, modified, or discarded over several cycles of iterative coding.

The iterative process in the GT approach involved *open, axial* and *selective* coding of the transcripts [58]. *Open coding* refers to the labeling of text with fundamental open codes in an analytical manner. During open coding, transcripts were analyzed line-by-line to identify emerging codes related to the handoff processes. Examples of some open codes included handoff goals, handoff

**Table 2**  
Details of data collection in MICU.

Method	No. of participants	Type of participants	Data collection time (in hours)
<i>Clinician-centered data collection approach</i>			
Observations	Varied	MICU team	30
Shadowing	5 [5 days]	On-call residents (during their shifts)	75
Audio-recordings	5 rounds (80 handoffs) [5 days]	Attending physicians, fellows, residents, interns, medical students	15
Interviews	7	Attending physicians, fellows, nurses residents	~3
Total data collection time			123 h

Date & Time		
MICU D#	Vent D#	Antibiotics:
Problems:	Lines: PIV CVC: (IJ / Fem / SC) – R / L Arterial (Rad/Fem) – L/R Quintin (IJ / Fem) – L / R Foley NGT/OGT/PEG/DHT	Other Medications:
	Drips:	
	Nutrition:	
	GI Proph:	
	Lovenox 40mg sc daily	
24-Hour Events:	No/ Yes	Cum:
ROS: intubated	Reviewed & all negative :	I/O:
PE: T <sub>max</sub>	BP MAP HR RR	O <sub>2</sub> Sat:
Vent: No Yes	AC/SIMV/PS/PC Rate Vt PEEP FiO <sub>2</sub> P <sub>peak</sub> P <sub>plateau</sub>	
Gen: Intubated	Yes/ No Psych: Sedated/ Agitated/ Calm Neuro: Sedated/ Confused/ Alert-Awake-Oriented	
HEENT: Pupils	Equal Round and Reactive to Light- Yes/ No; GAG Yes/ No; Secretion- Yes/ No	
CV: Rhythm-	Regular/ Irregular; Rate- Bradycardic/ Normal/ Tachycardic	
Murmurs-	Yes/ No; Systolic/ Diastolic; Grade: ___/VI; Location ___; radiation ___	
Lung: Clear to Auscultate	Bilaterally- Yes/ No; Crackles- Yes/ No; Wheeze- Yes/ No; Labored- Yes/ No	
Abd: Bowel Sound-	Yes/ No; Soft/ Hard; Distended- Yes/ No; Rash- Yes/ No; Tender- Yes/ No	
Ext: Clubbing-	Yes/ No; Cyanosis- Yes/ No; Edema- Yes/ No; Pulse- Yes/ No; Integument: Rash- Yes/ No	
GU: Foley-	Yes/ No; Lesions- Yes/ No; Discharge- Yes/ No	
LABS		
Neut: Bands:	Ca: iCa:	ABG: / / FSBG:
Lymph: Monc:	Mg: Phos:	

Fig. 3. Structure of progress note used in the MICU.

activities (information presentation by the outgoing resident and feedback by the oncoming team), roles and responsibilities, hand-off methods and mechanisms and information resources used.

*Axial coding* involves refining the initial list of open codes by identifying features, relationships and connections between the open codes to derive core categories. During axial coding, open codes were evaluated to identify recurring patterns and relationships that led to the formation of higher-level categories. We derived several relevant core categories such as handoff phases (such as pre-turnover, handoff and post-turnover phases), interdependencies between phases, coordination activities, communication events, patient-care activities, information breakdowns, information problems, collaborative problem solving/decision-making, final decision on assessment and plan.

Finally, *selective coding* refers to coding around the core categories to explain a theme or phenomenon from which a theory can emerge. During the selective coding process, the core categories were reanalyzed for identify emergent concepts and themes related to the handoff process. These core categories then served as a foundation to develop a structured coding schema related to the handoff process. For instance, at the end of the selective coding, the activities in the three phases in the handoff process were

clearly identified and distinguished and a basic handoff communication activity framework was also developed.

We provide an illustration of the analysis process involved in the first stage in Table 3. The example illustrates an information exchange related to patient assessment and plan between the outgoing resident and oncoming team during handoffs.

The open codes included information exchange, actors, interaction pattern and types, feedback, and handoff tools. In the axial coding step, we identified a relationship between the information presentation by the outgoing resident and the feedback by the oncoming team, which were labeled as communication events. Finally, during selective coding, we developed a handoff communication framework that illustrates the fundamental process of handoff communication between outgoing and oncoming teams.

**3.5.2.2. Second stage.** This stage of data analysis was performed on the audio-recorded handoff communication data. Using the structured codes and the handoff communication framework that was developed in the previous stage, we coded the audio-recorded handoff communication. During this analysis, we were able to iteratively refine and modify the developed handoff communication framework. For instance, we analyzed the content and meaning

**Table 3**  
Details of data analysis using grounded theory approach.

Data example from handoff communication activity	Codes	Grounded theory steps
<p>Outgoing resident: “on <u>physical exam</u>, <math>T_{max}</math> was 98.5, but this morning he was 96.4, blood pressure 93–141 over 79, 6, MAP 68, 1, 11, heart rate 58–80, I’s 1 and 2.5 out’s 3.9</p> <p>Oncoming attending: <u>Is there any urine at all?</u></p>	<p>Information exchange: patient assessment, vitals, intubation details</p>	<p>Open Coding: Line by line analysis to derive <u>open codes (categories)</u></p>
<p>Outgoing resident: <u>there is some, he is making about 15 cc an hour</u> yesterday, average</p> <p>Oncoming attending: <u>Okay</u></p>	<p>Actors: Outgoing team, Oncoming team</p> <p>Handoff presentation format (Outgoing presents information)</p> <p>Feedback loops (Oncoming asks questions, accepts information)</p> <p>Interaction and types (attending to outgoing resident, fellow to outgoing resident)</p>	
<p>Outgoing resident: <u>vent</u> he is on AC rate 24, titre volume 24,6 Q5 80, his ABG was 7.39, 02, 21, 100 on the oxygen. <u>Blood glucose</u> 83 over 92.7 on exam, he is intubated, sedated. His <u>pupils</u> are reactive.<u>He does have a gag, he had a little bit of white secretions, regular rhythm, normal rate, no murmurs</u>. He doesn't have <u>bowel</u> sounds, he is distended but kind of firm, he is knocked out so I don't think he will react. His <u>pulses</u> are normal. Rash you saw that yesterday, it looks like <u>rucus, hyper-pigmented lesions</u> on his legs</p> <p>Oncoming attending: did they do <u>biopsy</u> as yet?</p> <p>Outgoing resident and intern: <u>va</u>.</p> <p>Outgoing resident: she is like I have no idea what that is (looks on the <u>EMR report</u>)”</p>	<p>Active participants: (attending)</p> <p>Passive participants (oncoming team)</p> <p>Handoff support tools: EMR on COW, Progress note (prepared by outgoing), patient chart</p> <p>Communication event types</p> <p>Decision choices</p> <p>No information breakdowns (gaps)</p> <p>Handoff phase is comprised of communication events</p> <p>A handoff communication framework that illustrates the team interactions in the process</p>	<p>Axial Coding: Relationships and connections between open codes (categories) and their properties are identified to develop core categories</p> <p>Selective Coding: Coding around core categories to derive an emerging phenomenon/theme</p>

of the communication events during handoffs to identify the information breakdowns and its characteristics, and the activities that are performed to workaround the information breakdowns during handoff communication. Additionally, we also analyzed the progress note artifact that structured the communication during handoffs. Based on the content analysis of the progress note, we identified fifteen distinct communication events (CE's) that occurred during each patient handoff (details are provided in Table 5). For instance, the first communication event, CE1 included basic patient information – admission information and summary of some maintenance therapies.

After the completion of analysis, a second reviewer independently evaluated a half of the transcripts. There was over 85% agreement between the reviewers.

## 4. Results

### 4.1. Clinician activities in handoff process

Using the clinician-centered data collection approach, we captured the complete sequence of the clinician activities that contribute to, and, affect the handoff process. The handoff process can be categorized into *three phases*: pre-turnover, handoff and post-turnover phases. While similar sub-categorization of handoffs has been previously reported [15], we extended prior research by identifying and characterizing core clinician activities that were involved within each of these phases.

The pre-turnover phase comprised of *coordination activities* performed by the on-call resident as preparatory steps for handoff communication. Coordination activities helped in managing

interdependencies between individual tasks [33]. Five coordination activities performed by the on-call resident in the pre-turnover phase were identified: examination of patients, gathering of information from different sources, updating of information on the patient chart, reviewing and reasoning of available information and preparation of progress notes for handoff communication (see Table 4). These were considered as coordination activities as each of them had multiple, interdependent tasks that were performed for successful completion of a particular activity. For example, examination of a patient involved several interdependent tasks such as talking to patient, getting patient vitals, assessing patient's body systems, extracting data from patient monitors and monitoring these values. The successful completion of the coordination activity was predicated on the effective management of interdependencies between its associated tasks.

The pre-turnover phase had two characteristics: (a) coordination activities as preparatory steps for handoff communication, and (b) although the responsibility of successfully completing the pre-turnover activities was solely with the on-call resident, there was an active collaboration and coordination with the various clinicians (e.g., nurses, pharmacists), for seeking, gathering and organizing the necessary information.

The handoff phase comprised of *communication events* related to specific patient cases. During this phase, the outgoing resident (or intern) communicates with the oncoming MICU team on the status of patients and their care activities. A communication event refers to the information exchange between the outgoing and oncoming teams (interaction based on give, receive and feedback of information) across a communication channel for a specific purpose [62]. For instance, a communication event (CE 15, see Table 5 for a list of communication events derived from the analysis of the



**Table 4**  
Pre-turnover phase coordination activities (CA) (adapted from [3]).

Coordination activity no.	Coordination activities	Description
CA1	Examine patient	Conduct physical assessment
CA2	Gather information	Seek information from different sources such as nurse, respiratory therapist, pharmacist, EMR and patient room
CA3	Update information	Update patient information on patient folder
CA4	Review and analyze information	Reason-out information from different sources including EMR
CA5	Prepare progress notes	Write information on progress note form

**Table 5**  
Handoff phase communication events (CE) (adapted from [3]).

Communication event no.	Communication events	Description
CE1	MICU Day #, Vent Day #, Problems, Lines, Drips, Nutrition, Prophylaxis	Present basic patient information- admission information and summary of some maintenance therapies
CE2	Events ROS	Overnight patient events, review of systems
CE3	PE: Tm, BP, MAP, HR, RR, I/O	Physical Exam – Temp, blood pressure, heart rate, respiratory rate and ins and outs (vital signs)
CE4	Vent: rate, Vt, PEEP, FiO <sub>2</sub> , %Peak P, AutoPeep  ABG Gen: Intubated – Y/N	Mechanical ventilation status and requirements and related values, arterial blood gas
CE5	Psych: Sedated/Agitated/Calm	Psych-related issues
CE6	Neuro: Sedated/Confused/Alert-Awake-Oriented	Neurological status
CE7	HEENT: Pupils equally round and reactive to light – Y/N; GAG –Yes/No, Secretion –Yes/No	Head, Eyes, Ears, Nose, and Throat related information and issues; basic reflexes
CE8	CV: Rhythm –Regular/Irregular, Rate- Normal/Tachycardic Murmurs –Y/N, Systolic, Diastolic, Location: ... Radiaton	Cardio-vascular-related issues and examination
CE9	Lung: Clear to Auscultate Bilaterally –Y/N; Crackles –Y/N; Wheeze-Yes/No, labored – Y/N	Pulmonary-related issues and examination
CE10	Abd: Bowel sound- Y/N; Soft/hard; Distended –Y/N; Rash: Yes/No; Tender- Yes/No	Abdominal-related issues and examination
CE11	Ext: Clubbing –Y/N; Cyanosis- Y/N, Edema –Y/N; Pulse- Y/N Integument: Rash: Y/N	Extremities and examination
CE12	GU: Foley –Y/N; Lesions Y/N; Discharge-Y/N	Genitourinary-related issues and examination
CE13	Labs, cultures	Lab data, culture reports
CE14	Chest X ray Other Imaging	Imaging data and reports
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	Final care decision on each of the systems  Analysis, decisions, and plan of care for the patient based on information above, organized by system or problem list

MICU progress note) includes all team interactions and information exchanges related to the patient's assessment and plan of care between the outgoing and oncoming team. As described earlier, these communication events were structured based on the progress note format (see Fig. 3). For instance, the outgoing resident presented CE1 (specifies the MICU day no, MICU Day #, Vent Day #, Problems, Lines, Drips, Nutrition, Prophylaxis) through CE15 (final assessment and plan for the next 24 h) for each patient case.

The handoff phase had two characteristics: (a) structural organization of the communication events was based on a generic patient progress note format, and (b) effectiveness of outgoing resident's communication events were often predicated on their successful completion of preparatory coordination efforts in the pre-turnover phase.

**Table 6**  
Post-turnover patient-care delivery activities (PA).

Patient-care activity no.	Post-turnover activities	Description
PA1	Complete pending and newly assigned tasks	Perform immediate patient care tasks pending from previous shift and newly assigned tasks for this shift
PA2	Review information	Analyze information/updates recorded on EMR in the previous shifts
PA3	Divide patient assignments	Making decision on assessment and plan of care (deciding on who should perform the patient tasks and their relative priority)

The post-turnover phase was composed of *patient-care delivery activities* performed by the new on-call resident (i.e., the resident from the oncoming team who took charge for the current shift) after handoff. The on-call resident first followed-up on immediate and urgent patient-care delivery activities of old patients based on decisions made during handoffs. Some of the immediate patient-care delivery activities performed by the resident included assignment of patient-care tasks to the on-call intern, division of patient assignments, searching for any information updates from the patient's EMR, review of patient-care information to fully understand the patient case, and completion of pending (incomplete tasks/orders from the prior shift) and newly assigned tasks (additional tasks decided during the prior handoff phase) (see Table 6).

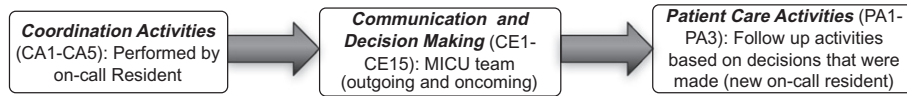


Fig. 4. Summary of the handoff phases and its related activities.

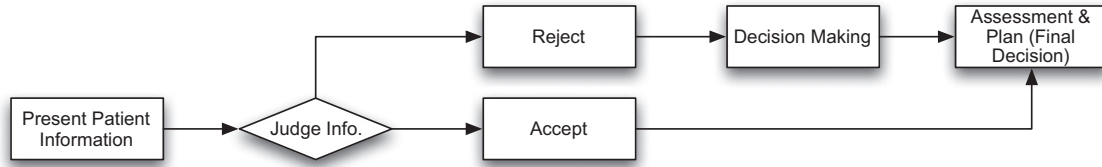


Fig. 5. Accept and reject decision during handoff communication.

During the post-turnover phase, patient-care delivery activities were performed both individually and collectively. For instance, while review of information on EMR was generally performed as an individual activity (by the on-call resident), delegation of patient assignments to the on-call intern was always performed as a group activity (i.e., by the on-call intern and resident).

The summary of the handoff phases and the related activities in each phase is provided in Fig. 4. Using our clinician-centered approach, we were able to capture and represent the three phases in the handoff process and its characteristics. Among the three phases in the handoff process, we identified that the handoff communication phase was fairly complex and therefore warranted a deeper analysis of its structure and content.

In the next section, we describe the handoff communication framework that was developed based on the analysis of handoff communication events and interactions.

#### 4.2. Handoff communication framework

The handoff communication framework was developed based on an iterative analysis of observation, shadowing, interview and audio-recorded handoff communication data. The framework consisted of interactions between the outgoing team (i.e., resident and intern) and an oncoming team (attending physician, fellow, resident and intern). The outgoing resident presented information (based on a list of CE's, see Table 5), which was then evaluated by the attending physician and the team for its accuracy and completeness. One of three decisions was made for each communication event (i.e., CE1 to CE15): *accept*, *reject* or *request* for additional information.

When the decision made was *accept*, the presented information was incorporated into the final assessment and plan without further discussion. We provide an example from our transcripts for one such “*accept*” interaction.

Outgoing Resident:	[Present Information] “MICU day no. 3, she was extubated yesterday. Her problems include altered mental status, hep C, alcoholic cirrhosis, alcoholic abuse, withdrawal, NSTEMI, GI bleed, thrombostatic leukemia.”
Oncoming Attending:	[Accept Information] “Ok”

In this example, the outgoing resident presents information on how long the patient has been in the MICU, the patient’s vent situation, an overview of the patient’s past medical history, and a

review of the patient’s symptoms. The oncoming attending accepts the information presented and incorporates this information into the patient’s assessment and plan.

When the decision made was *reject*, the presented information was ignored and a decision making cycle was often initiated. We provide an example from our transcripts for one such “*reject*” interaction and a decision-making cycle.

Outgoing Resident:	[Present Information] “We need to start her on cardiac prudent meds when her BP will allow us.”
Oncoming Attending:	[Reject Information] “Not quite yet. We checked out the art line yesterday, MAPS is still in 84.”
[Initiation of Decision Making Cycle]	
Outgoing Resident:	“Not ready?”
Oncoming Attending:	“Did we decrease the steroids or not yet? How many days has it been?”
Outgoing Resident:	Doesn't answer
Oncoming Resident:	“We go by 3 s.”
Team Member:	“More than 3 days.”
Oncoming Attending:	“Is she still on 100?”
[.....]	
Outgoing Resident:	“For FVNGI, [.....] She doesn't have any over-bleeding so we are just trying to keep her platelets above 20 and kind of go and letting her cruise it, elevated INR right?”
Oncoming Attending:	“Yes, she is not bleeding.”
Outgoing Resident:	“For ID, wound is growing yeast, we kind of already switched around the antibiotics, her lactase are down trending, [...]we sent the panel and she's on STD meds and prevacid.”
Oncoming Attending:	“What do we need to do about the sugars?”
Outgoing Resident:	“So, she got 27 units of sliding scale. So she can have, we can do 15 and 15.”
Oncoming Attending:	“Well, we went down on the steroids.”
Outgoing Resident:	“So, 10 and 10.”

In this example, the outgoing resident presented information related to the plan for the patient’s cardiovascular system, which gets rejected by the attending physician. This consequently

initiated a decision making cycle which was focused on additional team discussion about the gastrointestinal, infectious disease, and endocrine systems and what action needs to be taken next with regards to the patient. As the example highlights, the decision cycle consisted of examining the available options, establishing baseline criteria for making a decision, evaluating the available options and finally, selecting an appropriate plan of action. The selected plan of action was incorporated into the final assessment and plan for the patient (see Fig. 5 for accept and reject cycles).

When the decision was to *request* for additional information, the outgoing resident often tried to respond with needed information. The oncoming attending evaluated the new information for its sufficiency and completeness. If the presented information was sufficient, it was accepted and incorporated into the final assessment and plan.

<i>Outgoing Resident:</i>	[Present Information] “. . .PT 18 to 26, INR 1.75, PTT 15.9, ALT 101, AST 110, out plus 111, total bilirubin 6.5, direct 4.7, indirect 1.8.”
<i>Oncoming Attending:</i>	[Request Additional Information] “Those are better or not?”
<i>Outgoing Resident:</i>	[Accept Information] “Those are better.”

In the example provided above, the outgoing resident presented information on the patient’s values from the physical examination. After listening to the values, the oncoming attending requested for additional information on whether or not the values indicate an improvement in the patient’s condition. The outgoing provides a confirmation on this and the information is then incorporated into the patient’s assessment and plan.

Alternatively, if additional information provided by the outgoing resident was insufficient, it resulted in an *information flow breakdown* (i.e., a gap in information flow). In some cases, one or more of the team members volunteered to provide the missing information. If the attending physician deemed the additional information provided by the team as sufficient, the new information was processed and added to the final patient’s assessment and plan. We provide an example from one of sessions to illustrate how missing information by the outgoing resident resulted in an information breakdown:

<i>Outgoing Resident:</i>	[Present Information] “She actually took out her NG tube, Geodon and Ativan were given, that helps, but it seems like she was withdrawing from the alcohol.”
<i>Oncoming Attending:</i>	[Request Additional Information] “Do you think she can take a PO for Librium or we have to put an NG tube?”
<i>Outgoing Resident:</i>	... [No Answer]. . .
<i>Team Member:</i>	[External Information Support] “She gets a bleed from the NG tube.”
<i>Oncoming Attending:</i>	[Accept Information] “I wouldn’t put a NG tube back. I will try not to.”

In this example, an outgoing resident presented an update of the patient’s overnight events. After listening to the critical patient events that occurred overnight, the oncoming attending requested for additional information on whether or not medication or a nasogastric intubation should be used on the patient. As the outgoing resident was unable to provide the requested information, a team member in the oncoming team (who was aware of the patient’s

history from past experience with patient’s care) stepped in to fill in the requested information. This information was incorporated into the patient’s assessment and plan. The request for additional information and external information support are shown in Fig. 6.

If the information provided by the team members was insufficient, it was considered as an *information-insufficiency* problem in which case the missing information was not provided by anyone in the team and consequently resulted in an information-related problem. Under such circumstances, the MICU team tried to solve the problem through an iterative *collaborative problem-solving cycle*. We provide an example from our transcripts to illustrate how missing information from the team resulted in an information problem:

<i>Outgoing Resident:</i>	[Present Information] “So, she is MICU day 5, vent day 5, she has trach problems, hypercathnic respiratory failure, morbid obesity, OSA with obesity, hyperventilation syndrome, ulcer, UTI with ESPO, E. coli and upper respiratory sputum positive for pseudomonous, podius, pulmonary hypertension.”
<i>Oncoming Attending:</i>	[Request Additional Information] “Staph, right?”
<i>Outgoing Resident:</i>	“And staph., yeah”
<i>Oncoming Attending:</i>	“MRSA or not MRSA?”
	[Information Problem] [Initiation of Collaborative Problem Solving Cycle]
<i>Outgoing Resident:</i>	“Hmm..., actually I don’t see the staph.”
<i>Oncoming Attending:</i>	“We lost the staph. Somewhere in there? Because I need to know because there is no gram positive.”
<i>Oncoming Fellow:</i>	“Only (looking on the EMR), it doesn’t say, micro.”
<i>Oncoming Attending:</i>	“Because it says moderate staph aureus. So what happens? Let us know what that is? I think we need to ask them right? Is it a MRSA or not. I am sure it is. It always is.”
<i>Outgoing Resident:</i>	“Yeah”
<i>Oncoming Fellow:</i>	“(To another resident) Can somebody call the lab? I will talk to them.”
<i>Outgoing Resident:</i>	“Call the lab and find out if his culture was staph. They never specified it.”

In this example, while the outgoing resident presented the patient’s problem list, the oncoming attending requested for additional information on whether or not the patient has a specific type of staph infection. The outgoing resident and the other team members were unable to provide the requested information that resulted in an information problem. To resolve this problem, the MICU team initiated a collaborative problem solving cycle where they try to make sense of the problem. As the example highlights, the collaborative problem solving cycle consisted of identifying and perceiving a problem, seeking information from external

sources, reviewing obtained information, critiquing the available information based on prior clinical cases, making sense of the information collectively and finally, applying the understanding to solve the problem at hand. The output from this cycle is incorporated into the final assessment and plan. The entire sequence of the handoff communication activity is depicted in Fig. 7.

From the 80 group handoffs (over 5 days), 52% of the communication events were accepted (without any discussion), 4% was rejected and led to a decision making cycle. Of the remaining 44% that required additional information, 33% were resolved when one of the team members provided the necessary needed information. The rest 11% of communication events were not immediately resolved and went into a team-based collaborative problem solving cycle.

Using our clinician-centered data collection and mixed inductive–deductive analytical approaches, we were able to demonstrate that the handoff phase by itself was highly complex and interactive. The framework illustrated that communication complexity arises due to several factors that influenced the effectiveness of the communication activity such as multiple information flow paths and decision points, non-linear and recursive nature of decision making and collaborative problem solving activities, team interactions, and finally the pragmatic nature of the critical care environment.

Next, we discuss the implications of using the clinician-centered approach for studying the overall handoff process in view to evaluate handoff communication activity.

**5. Discussion: Evaluation of handoff communication**

Researchers have argued that there are no good outcome measures for evaluating handoff communication [42,46]. From our analysis, we identified a significant part of the evaluation challenge can be attributed to the *inadequate methodological and theoretical approaches* adopted in prior research for studying handoffs. Such limited understanding obtained by exclusively focusing on the communication activity leads to handoff intervention tools that are ill suited for the clinical environment, which consequently results in the lack of adoption and poor standardization. A more foundational integration of communication practices, theoretical frameworks and methods can lead to better handoff practices. In

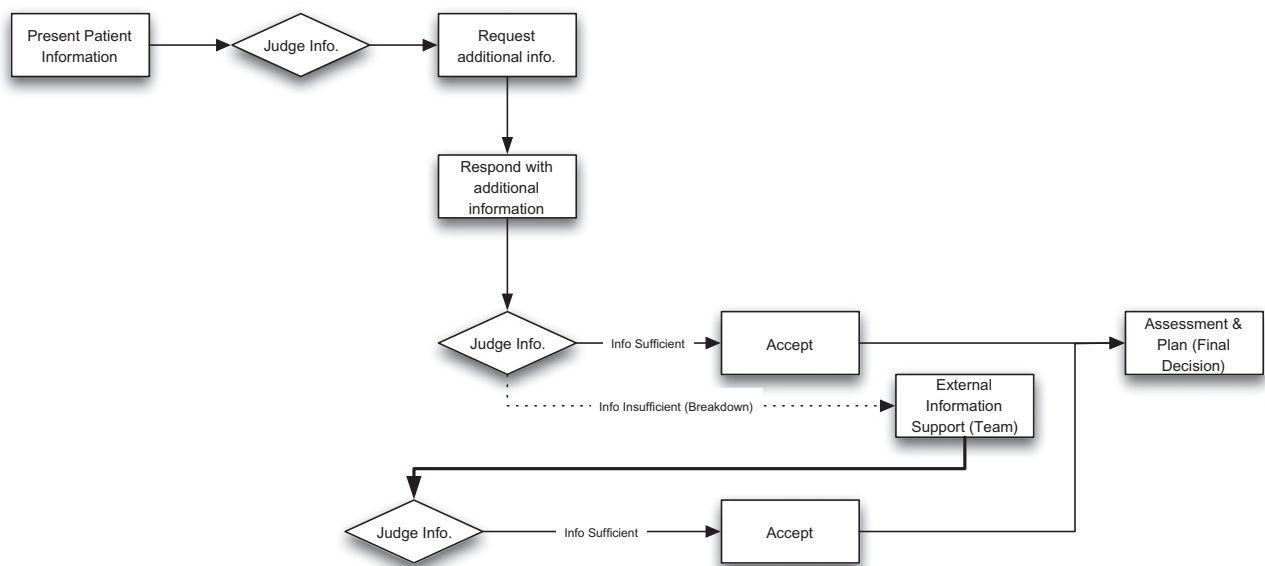
this section, we highlight two aspects that need to be considered for the evaluation of handoff communication in a critical care environment – methodological and theoretical frameworks for investigating handoffs.

*5.1. Methodological framework for studying handoffs*

As discussed earlier, most prior studies on handoffs were focused on evaluating handoff communication using patient safety measures such as the number of transition errors and related adverse events [14,42]. We argue that handoff communication cannot be considered as an independent activity and that the evaluation of handoff communication (and its challenges) requires a *clinician-centered* perspective that allows for the examination of clinician activities both prior to, and, after the handoffs. We obtained insights on the *sequential* and *temporal* organization of activities during the pre-turnover (coordination of care activities), handoff (communication of events) and post-turnover (patient care) activities. Also, by employing mixed inductive–deductive analytical method for data analysis, we were also able to identify the interdependent relationships between the phases, despite their distinct goals.

We provide an example from our data to further explain the identification of interdependencies between the handoff phases. During our shadowing of an on-call resident, we found that she had not completed two coordination activities in the pre-turnover phase for a particular patient case. This resident did not gather the patient’s information from multiple sources or review the information on the patient’s medical record [CA2 and CA4]. During the handoff, the on-call (outgoing) resident’s presentation of this particular patient case had information flow breakdowns (missing information) in two different communication events related to overnight events and, assessment and plan for the patient care [CE2 and CE15]. When we mapped and evaluated the two phases (i.e., the pre-turnover and handoff phases) during our analysis, we found that information flow breakdowns in the handoff phase were caused by the unsuccessful completion of coordination activities (i.e., missed coordination activities) in the pre-turnover phase.

Similar interdependencies also existed between the handoff communication and patient care delivery activities (post-turnover phase). We describe an example that illustrates an information breakdown (or error) that occurred during handoffs was detected



**Fig. 6.** Request for additional information: Presence of information flow breakdown problems during handoffs.



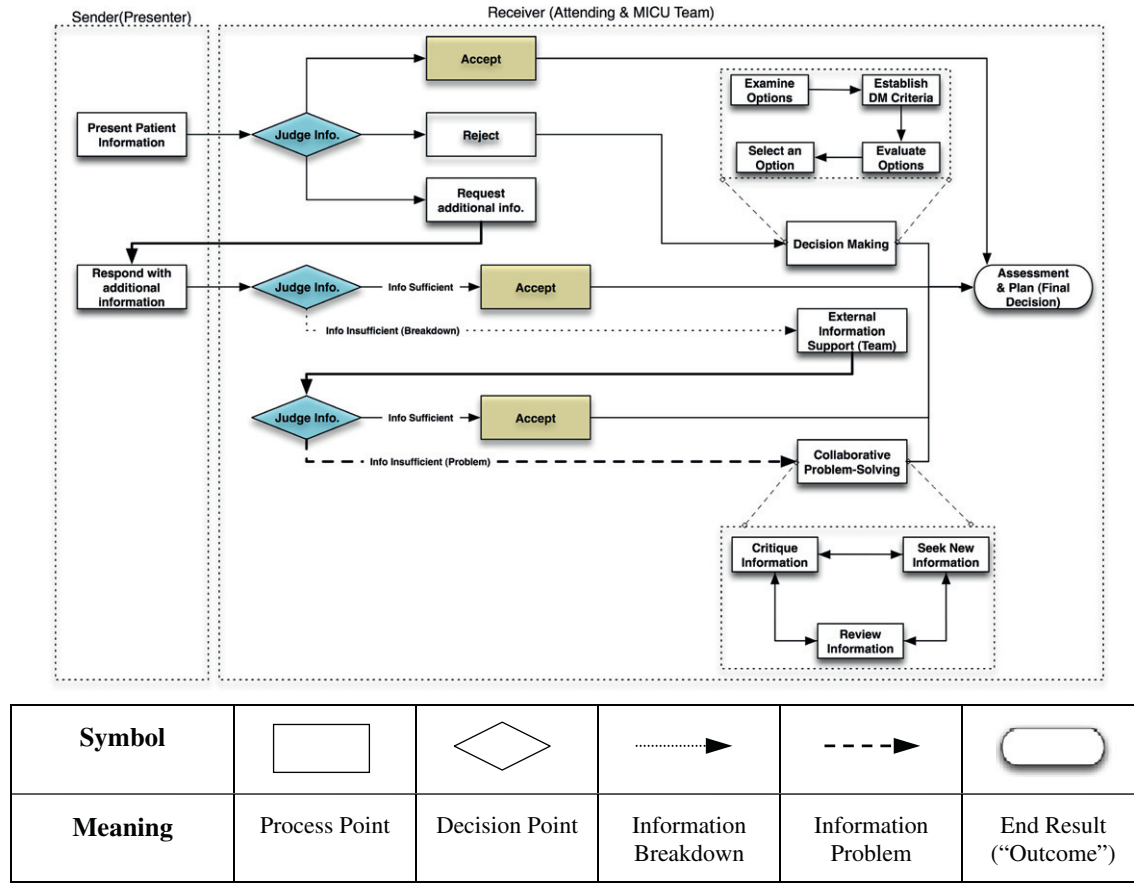


Fig. 7. Handoff communication framework in the MICU (integrated from Figs. 5 and 6; extended from [3]).

in the post-turnover phase: information that suggested a patient was thrombocytopenic (with a low platelet value of 15, and critical for the diagnosis of cancer) was missed during a handoff. The next day, a medical student (who was assisting the on-call resident) discovered this information after the discharge report was called in. Since this information breakdown was detected just before the physical transfer of the patient to another unit, and, hence recovered immediately, there was no serious impact. When asked about this incident, the on-call resident replied: “we did not talk about that during the rounds (handoffs). She could have been bleeding when she got to the other unit”. However, if the information regarding the patient being thrombocytopenic were not discovered before transfer, the receiving unit would have been creating a significantly different plan of care. For instance, the patient’s nurse in the receiving unit could administer medications such as heparin or other anti-ulcer medications that could have exacerbated the patient condition. In this particular scenario, we were able to identify that there was an information breakdown only because of the approach that we adopted that allowed for a systematic shadowing of clinician’s workflow before and after the handoff communication session. Such information breakdowns magnify the important role of handoffs in not only creating errors, but also increasing the chances of propagating these transition errors across multiple shifts (or clinicians) and even across multiple units.

Our methodological approach, adopts a holistic, workflow-focused perspective to capture some of the nuances of the handoff process including the inherent component activities in the handoff process and the interdependencies that existed between them. In addition, the mixed inductive–deductive analytical approach helps to locate the sources of communication breakdowns and explain the sources of these breakdowns and errors that occur during handoffs.

### 5.2. A theoretical framework for handoff communication

Modern clinical settings are characterized as being “complex” in their communication behaviors [6], with complexity arising out of transient patient conditions, availability (or non-availability) of clinical evidence, and distributed nature of clinical information and decision-making. Consequently, it is difficult to formulate appropriate outcome measures for evaluating handoff performance in such settings [42]. What we truly lack is a model of communication, even a descriptive one, which can be a starting step for understanding the communication process and eventually enable in isolating the factors that contribute towards complexity. Especially in the case of handoffs, the absence of models or frameworks has resulted in handoff communication being considered as a “black box.” We strongly believe that a handoff communication framework (see Fig. 7), such as the one we have developed, is a promising first step for studying and examining the communication events during transitions of care in critical care settings. While we need to further evaluate the handoff communication framework in other clinical settings (e.g., another ICU or hospital), our framework suggests that there are two critical activities that occur during group handoff communication in most academic hospital settings: first, an *outgoing team-driven information presentation* that occurs during the initial part of the handoff and second, an *oncoming team-driven learning and explanation* activity that evolves during decision-making and collaborative problem solving cycles.

In addition to being descriptive, the handoff communication framework presents several possibilities for both informatics research and clinical practice. For example, to *evaluate* handoff outcomes: both handoff communication independently, and on the effects of clinician activities on handoff communication; to *study* how handoffs contribute to workflow complexity in critical care

settings; to *explore* ways to predict information breakdowns and finally, to *identify* the different factors that result in information flow breakdowns (e.g., count of information breakdowns or collaborative problem-solving cycles is a useful metric for handoff communication efficacy). Additionally, identifying the types of information breakdowns in the framework is useful for tracing the causal contributors to the breakdowns (for e.g., an information breakdown could be traced to the incomplete preparatory work performed by the presenter). For instance, we identified two critical sources for information breakdowns: lack of standardization in handoff communication events and unsuccessful completion of pre-turnover coordination activities (details of which are not reported in this paper). These sources of handoff communication breakdowns suggest potential intervention strategies to improve information transfer between 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 [4].

## 6. Conclusion

Clinician-centered approach, based on an underlying continuity of care model, emphasizes a more holistic perspective on the handoff process and its related outcomes. Such an approach is imperative towards designing effective intervention strategies that can be effectively integrated into handoff workflow. Besides, this approach provides a viable mechanism to study handoff at a level of information granularity that has previously not been attempted.

Our approach to utilizing long-term traces of behavior is not completely novel. Similar approaches have been widely utilized in a variety of fields including Human Computer Interaction (e.g., see [50] on exploratory sequential data analysis), communication (e.g., see [22]) and cognitive science (e.g., see [48]). More recently, quantitative trace-based analysis has been used to study workflow behavior in biomedical informatics (see [63]). Nevertheless, as we have illustrated in our analysis examples, the approach provides an opportunity for researchers and practitioners to develop better understanding of the information flow process and, consequently, to design better process-based informatics tools.

One of the potential disadvantages of the clinician-centered approach is the labor-intensiveness entailed in the data collection and analysis that arises from our theoretical perspective of continuity of care. The focus on extracting the trace of clinicians' activities (including intentions, attitudes, actions and behavior) that span across time requires significant time from the researcher. Furthermore, the labor-intensiveness can also be attributed to the inherent complexity of the health care environment. A detailed and appropriate level of understanding of interdependent, dynamic activities (such as handoff) in a complex environment requires significant effort and planning [28].

We identified two further limitations of the study. First, the results from this study may not be generalizable to other settings because it was conducted at a single critical-care setting. Being a single center study, there may be relevant issues that relate to this particular context (unit protocols and model of care) that may not be applicable to other inpatient settings. However, the use of a clinician-centered approach facilitated our examination and identification of specific activities and nuances unique to this context in view to highlight how they have an impact on the fundamental handoff process. Also, the composition of care teams performing group handoffs would be similar across various teaching hospitals. 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 and

structure. However, the basic structure and model of handoff communication activity that was developed using a clinician-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 handoff communication framework that we developed can be used by researchers and practitioners to evaluate deviations during communication activities (when and where they occurred) and their contributors.

## 7. Key points

- The analysis of communication activity in high-reliability, safety-critical settings that operate around the clock require theoretically-grounded methodology that captures the entire information flow trajectory, both before and after the formal communication activity between practitioners.
- Although the clinician-centered approach for data collection is data-intensive, it helps in building a robust rubric for adequate iterative analysis using the grounded theory and the structured coding methods.
- The illustration of this method of data collection and analysis in a critical care setting to investigate the handoff communication activity demonstrates its utility to capture and represent the following:
  - Nuances and complexities of handoff process that was composed of three phases: *pre-turnover*, *handoff* and *post-turnover* phases, each associated with its own activity such as coordination activity, communication event and patient-care delivery activity respectively.
  - Interdependencies between the phases. For instance, the successful completion of coordination activities in pre-turnover phase is a pre-requisite for effective communication in handoff phase.
  - Handoff communication framework that highlights potential points and contributors of information breakdowns, can have significant implications for patient safety and quality.

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