# Team Cognition in Handoffs: Relating System Factors, Team Cognition Functions and Outcomes in Two Handoff Processes

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**Objective:** This study investigates how team cognition occurs in care transitions from operating room (OR) to intensive care unit (ICU). We then seek to understand how the sociotechnical system and team cognition are related.

**Background:** Effective handoffs are critical to ensuring patient safety and have been the subject of many improvement efforts. However, the types of team-level cognitive processing during handoffs have not been explored, nor is it clear how the sociotechnical system shapes team cognition.

**Method:** We conducted this study in an academic, Level I trauma center in the Midwestern United States. Twenty-eight physicians (surgery, anesthesia, pediatric critical care) and nurses (OR, ICU) participated in semi-structured interviews. We performed qualitative content analysis and epistemic network analysis to understand the relationships between system factors, team cognition in handoffs and outcomes.

**Results:** Participants described three team cognition functions in handoffs—(1) information exchange, (2) assessment, and (3) planning and decision making; information exchange was mentioned most. Work system factors influenced team cognition. Inter-professional handoffs facilitated information exchange but included large teams with diverse backgrounds communicating, which can be inefficient. Intra-professional handoffs decreased team size and role diversity, which may simplify communication but increase information loss. Participants in inter-professional handoffs reflected on outcomes significantly more in relation to system factors and team cognition ($p < 0.001$), while participants in intra-professional handoffs discussed handoffs as a task.

**Conclusion:** Handoffs include team cognition, which was influenced by work system design. Opportunities for handoff improvement include a flexibly standardized process and supportive tools/technologies. We recommend incorporating perspectives of the patient and family in future work.

**Keywords:** care transitions and handoffs, communication and teamwork in health care, macroergonomics and the environment, system design and analysis, team cognition

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Handoffs are a part of care transitions that include communication to transfer information, authority and responsibility for patient care between two or more health care professionals (Abraham et al., 2017; Wears & Perry, 2010) and are crucial to

**TABLE 1:** Handoff Communication Activities

| Handoff Communication Activity | Description | Cooke and Gorman's (2010) Communication Events |
|---|---|---|
| Information giving (Abraham et al., 2017; Caruso et al., 2015; Manser et al., 2013; Petrovic et al., 2012) | Communication that shares information from the sender to the receiver(s) | Sharing information |
| Information seeking (Abraham et al., 2017; Caruso et al., 2015; Manser et al., 2013) | Communication in which the sender asks for additional information from the receiver, including requests for information and clarification | Soliciting information |
| Information verification (Abraham et al., 2017; Apker et al., 2010; Caruso et al., 2015; Manser et al., 2013) | Communication that restates or paraphrases previously shared information, such as read-backs, summaries or cross-checking information from multiple sources | Negotiating |
| Assessment (Abraham et al., 2017; Apker et al., 2010; Manser et al., 2013) | Communication that synthesizes information to identify problems, underlying causes, prognosis (future conditions); this includes statements about uncertainty and missing information | Sharing information, negotiating |
| Planning and decision making (Apker et al., 2010; Manser et al., 2013; Petrovic et al., 2012) | Communication about future care goals, options, risks, treatment, tasks, anticipated needs, responsibilities or logistical issues | Reaching consensus |

patient safety (The Joint Commission, 2017). Much research focuses on improving handoffs, including a large body of human factors and ergonomics literature (Beach et al., 2012; Hilligoss et al., 2015; Horwitz et al., 2006, 2009; Patterson et al., 2005; Rayo et al., 2014; Weinger et al., 2016). Other studies focus on identifying the necessary information for the transfer and developing mnemonics (e.g., SBAR) or checklists to support that transfer (Abraham et al., 2021). This information usually includes information about the patient, from anesthesia, nursing and surgical clinicians, and role identification (Abraham et al., 2017; Apker et al., 2010; Caruso et al., 2015; Manser et al., 2013; Petrovic et al., 2012). Studies also identified key handoff communication activities, see Table 1.

We previously compared care transitions from the operating room (OR) to pediatric intensive care unit (PICU) or adult intensive care unit (ICU) (Wooldridge et al., 2022). We focused on pediatric and adult trauma patients because they are critical and unstable with complex care processes (Wooldridge, Carayon, Hoonakker, et al., 2018); trauma is also the leading cause of death in children and adults between 0 and 44years old (Stewart et al., 2003). We found care transitions include crucial work outside of handoff. The OR to ICU transition involved handoffs separated by profession (i.e., intra-professional handoff), where the OR to PICU transition included a handoff between the whole team (i.e., inter-professional handoff). Both types of handoffs are communication activities undertaken by two or more individuals interdependently, dynamically and adaptively, who share the goal of a safe transition—a team (Salas et al., 1992).

## TEAM COGNITION

Improved team cognition results in more effective team performance (Cooke et al., 2013;

DeChurch & Mesmer-Magnus, 2010). Two perspectives on team cognition have emerged: (1) shared team cognition and (2) interactive team cognition (ITC) (Cooke et al., 2013). The shared cognition perspective is heavily influenced by the information processing model of individual cognition (Parasuraman et al., 2000); team cognition is viewed as the aggregation of individual cognition. Cooke et al. (2013) described ITC as the explicit, observable communication and coordination interactions between team members, drawing on work by Hutchins (1995a, 1995b). Cooke and Gorman (2010) identify four types of communication events (i.e., team cognition functions) that are ITC:

1. Sharing information: team members share information with others.
2. Soliciting information: team members request information from others.
3. Negotiating: team members discuss information together.
4. Reaching consensus: team members decide next steps or agree.

In Table 1, we propose linkages between communication activities from handoff research and Cooke and Gorman's (2010) team cognition functions.

Team cognition is tied to context. Many studies of ITC are conducted in simulated settings (Cooke, 2015; Cooke et al., 2007; Cooke & Gorman, 2009; Gorman et al., 2020), and, therefore, do not allow for the exploration of the impact of context on team cognition. Salas et al. (2008) called for the study of team cognition in natural settings, as team cognition is shaped by the sociotechnical system in which the team works, i.e., the context. We have yet to understand how the sociotechnical system impacts team cognition, which will help to design sociotechnical systems to support teams.

## SOCIOTECHNICAL SYSTEMS

Sociotechnical system theory focuses on the need to consider technical and social subsystems within a work environment and organization to jointly optimize performance (Clegg, 2000; Emery & Trist, 1965; Kleiner, 2008; Pasmore, 1988; Waterson et al., 2002). Carayon and Smith developed the work system model (Carayon, 2009; Smith & Carayon, 2001; Smith & Carayon-Sainfort, 1989) to describe and study sociotechnical systems; work system elements are the individuals, tasks, environment, tools and technologies, and organization. We must consider interactions between elements, which shape adaptive behavior and dynamic outcomes (Pew & Mavor, 2007). The work system model is integrated in the Systems Engineering Initiative for Patient Safety (SEIPS) 3.0 model, used to analyze, model and improve both patient and worker outcomes (Carayon et al., 2006, 2014, 2020). The SEIPS model includes feedback loops to support work system changes that may come about via local adaptations in real time and changes arising from a formal design process, both described by Hutchins (1991). Figure 1 shows an adaptation of SEIPS 3.0 as a system-process-outcome (S-P-O) framework to describe how the work system (system), team cognition functions (process), and outcomes are related in handoffs.

An important implication of ITC is that interactions between team members must occur for the team cognition to take place. The design of work systems likely influences these interactions, for example, increasing or limiting frequency or quality. Implementing inter-professional (i.e., team) handoffs might encourage interactions, improving team cognition and care transition outcomes. Studies of inter-professional handoffs comparing handoff quality before and after implementation of team handoffs find decreased information loss (Agarwal et al., 2012; Catchpole et al., 2007; Joy et al., 2011; Petrovic et al., 2012), improved clinical outcomes (Agarwal et al., 2012), error reduction (Catchpole et al., 2007; Joy et al., 2011) and improved clinician satisfaction (Petrovic et al., 2012). But these studies do not investigate how or why inter-professional handoffs result in improved outcomes versus intra-professional handoffs.

## STUDY OBJECTIVE

The goal of this study is to investigate team cognition in care transitions. We first determine the

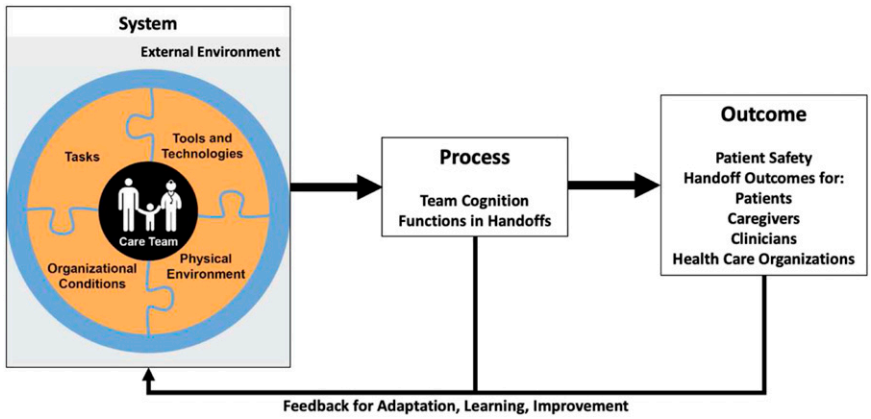


*Figure 1.* System-process-outcome framework to describe handoffs based on SEIPS 3.0 (Carayon et al., 2006, 2014, 2020).

type(s) of team-level cognitive processing that occurs during handoffs. We then demonstrate how changes in work system design—inter-professional versus intra-professional handoffs—lead to perceived differences in team cognition; this allows us to gain insight into how the socio-technical system and team cognition are related.

## METHODS

This study is part of a larger project to develop design requirements for health information technology (IT) for teamwork and care transitions in pediatric trauma care (http://cqpi.wisc.edu/teamwork-and-care-transitions-in-pediatric-trauma/). This research complied with the American Psychological Association Code of Ethics and was approved by the IRB at the University of Wisconsin-Madison and the IRB at the University of Illinois at Urbana-Champaign. Informed consent was obtained from each participant.

### Setting and Sample

The participating health system with multiple hospitals is a level 1 trauma center for both pediatric and adult patients. The pediatric hospital has 111 beds, eight pediatric operating rooms, and a 21-bed PICU; the adult hospital has 505 beds, 27 operating rooms and multiple ICUs. This study focuses on the Trauma and Life Support Center (TLC), i.e., an ICU with 24 beds. In the PICU, pediatric intensivists and surgeons are involved in patient care; in the ICU, a critical care team, led by surgeons or critical care anesthesiologists, and surgeons are involved in patient care.

We used purposeful sampling to recruit 28 healthcare professionals to interview about the OR to PICU and OR to ICU care transitions (see Table 2). Participation was voluntary.

### Data Collection

We conducted in person, semi-structured interviews to allow probing for detailed answers (Robson & McCartan, 2016). Each interview was conducted by one or two HFE researchers. The interview guide is available at: http://cqpi.wisc.edu/teamwork-and-care-transitions-in-pediatric-trauma/. We elicited detailed descriptions of the care transition process, i.e., all work system elements, examples of good care transitions (when care was not compromised and went well) and bad care transitions (when care was compromised and did not go well). Nearly 22 hours of interviews were conducted (average: 46 minutes, range: 24–65 minutes; $N = 28$ with two participants in one interview). All interviews were recorded and transcribed by a professional transcription service. After the first four interviews were

**TABLE 2:** Participating Sample ($N$ = 28)

| Transition | Attending Physicians ($n$ = 6) | Fellows ($n$ = 4) | Residents ($n$ = 6) | Advanced Practice Provider (App; $n$ = 2) | Nurses ($n$ = 10) |
|---|---|---|---|---|---|
| OR to PICU (inter-professional handoff; $n$=15) | Anesthesiology: 1<br>Surgery: 1<br>Pediatric critical care: 1 | Pediatric critical care: 2 | Anesthesiology: 1<br>Surgery: 2 | Anesthetist: 1 | OR: 4<br>PICU: 2 |
| OR to ICU (intra-professional handoff; $n$ = 13) | Anesthesiology: 2*<br>Surgery: 1* | Anesthesiology critical care: 1<br>Surgery critical care: 1* | Anesthesiology: 1*<br>Surgery: 2* | Anesthetist: 1 | OR: 2<br>ICU: 2 |

*Note.* *denotes physicians who may practice in both the OR and adult ICU; these participants were asked if they provide care in both units; if so, they were asked about the transition from the perspective of providing care in the OR and the ICU sequentially.

conducted, we iterated between data collection and analysis, monitoring for saturation.

## Data Analysis

Before analysis, all identifying information were removed from the transcripts. We conducted a qualitative content analysis (Graneheim & Lundman, 2004) of the interview transcripts and performed Epistemic Network Analysis (ENA) (Shaffer, 2017; Shaffer et al., 2016; Shaffer et al., 2009; Shaffer & Ruis, 2017; Wooldridge, Carayon, Shaffer, & Eagan, 2018) to understand the relationships in the inter- and intra-professional handoff groups.

Qualitative content analysis. Based on ITC, sociotechnical (work) system, and handoff literature, we deductively developed the S-P-O framework shown in Figure 1 to guide our analysis. Two researchers read one transcript, generating paper-based notes, and discussed the codebook to refine the coding scheme in a consensus-based process. We repeated this process for a second interview. At this point, two researchers independently coded the complete dataset using the definitions shown in Tables 3–5 following coding instructions from Wooldridge (2018). The codes are not mutually exclusive, that is, if a respondent described personal motivation (person) and team experience (organization) shaping information exchange, the codes person, organization, and information exchange were applied. Questions or concerns were resolved by consensus. We ensured rigor in our qualitative analysis as described in Table 6.

Epistemic network analysis. The underlying goal of ENA is to develop deep understandings of relationships between codes (Wooldridge, Carayon, Shaffer, & Eagan, 2018). ENA begins with high-quality qualitative data segmented according to principles of discourse analysis. We segmented our interview data by hand based on the interview guide, i.e., each numbered question on the interview guide, the response and subsequent probing questions and responses. We then uploaded the segmented data and codes to the ENA 1.7.0 Web Tool (Marquart et al., 2018). ENA uses code co-occurrence to infer relationships: ENA develops adjacency matrices of co-occurring codes, which are summed and plotted in a high-dimensional space. The vectors are normalized, and dimensions are reduced with single value decomposition, like a principal components analysis. The resulting networks are projected on a two-dimensional plot, where the $x$-axis accounts for the highest percentage of variance explained by a dimension and the $y$-axis is an

**TABLE 3:** Interactive Team Cognition Functions in Handoffs

| Type of Team Cognition | Definition | Example Quotation |
|---|---|---|
| Information exchange | Communication in which information flows between the sender(s) (i.e., healthcare professional(s) in the OR) and the receiver(s) (i.e., the healthcare professional(s) in the ICU), including requests for information, clarification and paraphrasing information. | *"[You say] medications, any sort of medications that were given…a brief sort of background of, you know, if you know any information about the patient" [anesthesia attending, intra-professional handoff]*<br>*"Usually the surgical team goes first, and they just describe what surgical procedure they did, what issues they encountered, and then the plan going forward for the next, you know, 4, 8, 10, 12 hours, however long out they can foresee it. And then anesthesia will give their handoff of what they're intubated with, what kind of respiratory support they needed, if any, what kind of medications they had to give. And then the fellow is there, so we usually kind of let them run the handoff. And if they have any questions, they can ask me questions at the time, and then nursing can ask any questions. RT kind of gets their information on what they need to set them on for respiratory support based on what they were using in the OR" [PICU nurse, inter-professional handoff]* |
| Assessment | Communication that restates or paraphrases previously shared information; communication that synthesizes information to identify problems, underlying causes, prognosis (future conditions); statements about uncertainty and missing information. This does not include assessments (i.e., skin assessments) completed by nursing on admission to the unit because that is not communication, it is a task completed by the individual. | *"Pretty much, you know, if anesthesia says, well, halfway through the case they became hypotensive, and surgery says, oh, that's when they started bleeding" [PICU, fellow, inter-professional handoff]* |
| Planning and decision making | Communication about future care goals, options, risks, treatment, tasks, anticipated needs, responsibilities or logistical issues. | *"[T]he plan is maybe go back tomorrow and wash it out and hopefully get everything closed. So it kind of helps give us an idea of, you know, where the trajectory is going" [surgical critical care fellow, intra-professional handoff]*<br>*"[I]f they're looking for specific things…they're worried about bleeding or something because of how the surgery went. Like that would be something that I would want and need to know" [ICU nurse, intra-professional handoff]* |

orthogonal dimension that accounts for the next highest percentage of variance (Shaffer, 2017; Shaffer et al., 2009, 2016; Shaffer & Ruis, 2017).

We developed ENA models to compare networks of clinicians involved in inter-professional (OR to PICU) and intra-professional (OR to ICU) handoffs. Each line formed a complete stanza, and thus the relationships depicted in the resulting network graphs show connections between the codes applied to one segment. Our model had co-registration correlations of 0.98 (Pearson) and 0.98 (Spearman) for the first dimension and co-registration correlations of 0.99 (Pearson) and 0.99 (Spearman) for the second, indicating strong goodness of fit. We compared the average network graphs of the inter- and intra-professional handoffs, that is, clinicians participating in the OR to PICU and OR to ICU handoffs, respectively, and examined differences using the network graph of the difference (i.e., subtracted network). We also calculated the centroid of the average networks and 95% confidence interval of mean centroid locations. We conducted Mann–Whitney U tests on the location of the centroids of the inter- and intra-professional networks to quantify differences between the networks.

## RESULTS

The 28 interviews with clinicians who participate in care transitions of pediatric and adult trauma patients from the OR to PICU and ICU resulted in 201 quotations describing handoff communication; 188 quotations included work system elements, while 90 included outcomes.

### Qualitative Content Analysis

Tables 3–5 include example quotations. Table 7 shows the relative percentage and frequency of code application by handoff organization.

Team cognition functions. Participants in the inter-professional (OR to PICU) and intra-professional (OR to ICU) handoff talked about the three team cognition functions (see Table 3). Both groups mentioned the information exchange function most frequently. Many clinicians in the OR described the information they convey during the handoff. Information exchange also included the receiving PICU/ICU team requesting additional information or clarification.

Assessment was described the least by both groups. Assessment was typically described as the synthesis of information, for example, by identifying the underlying cause of events. A surgery chief resident in the intra-professional handoff echoed this when describing how understanding how the patient tolerated anesthesia in the OR helps the physician in the ICU "*contextualize*" the patient and provide better longitudinal care.

Planning and decision making was also described less often than information exchange. For example, the surgeon communicating the plan for future surgeries, particularly if there were open wounds, allowed the ICU team to better understand and anticipate how care of the patient would progress. The ICU nurses also pointed out that they needed to know what the physicians want to watch closely to better perform their job.

Work system elements. Table 4 describes the work system elements that influenced the various team cognition functions with selected quotes, and Table 7 shows the frequencies that each work system element was described with a team cognition function.

**Person.** Participants in both handoffs frequently reflected on the diverse backgrounds of individuals involved in patient care, including professions (i.e., physicians and nurses), although those in the OR to PICU handoff mentioned it more frequently. The difference between physician specialties was also related to diverse backgrounds. Participants in both handoffs also mentioned motivation of individuals to participate in the handoff, such as a surgeon or anesthesia attending not wanting to come to the PICU for the team handoff.

Two system factors were related to the interaction of the person and organization work system elements. In the OR to ICU handoff, the

**TABLE 4:** Work System Elements Impacting Team Cognition in Handoffs

| Work System Element | Factor Impacting Team Cognition | Definition | Example Quotation |
|---|---|---|---|
| ***Persons*** The handoff involves clinicians and staff in the sending unit (e.g., attending, resident, nurse) and receiving unit (e.g., attending, resident, nurse) | Diverse backgrounds | How the heterogeneous backgrounds (e.g., medical specialties or healthcare professions—physicians and nurses, various services) necessary for patient care have different skills, knowledge and abilities (Cooke et al., 2013), as implied by the definition of team (Salas et al., 1992), and therefore different concerns, perspectives, information needs which result in tailored language and/or only providing information deemed relevant to the receiver in the handoff. One way of showing this is listing the professions that need to handoff without giving an impact of inter- or intra- handoff organization. | *"It's never just a nursing, you know, it's never just nurses taking care of patients. It's never just physicians taking care of a patient. It's always, I feel like it's always team-based" [pediatric OR nurse, inter-professional handoff]*<br>*"[I]f it's an anesthesia resident, just because sometime, because they're not as familiar with managing trauma patients* versus *all the second-year residents that are in the SICU do a bunch of trauma their second year, so I can just say, you know, see spine precautions, and t-, you know, they have a more, we have a more shared common language" [surgery chief resident, intra-professional handoff]* |
| | Personal motivation | The individual's motivation (Smith & Carayon-Sainfort, 1989) to participate in handoff influence communication (e.g., the sender is invested in participating and sharing information, the receiver is invested in participating and seeking information, the individuals are focused during the handoff, senders are tired and affected by emotions related to resuscitation and surgery, someone takes responsibility for ensuring there is a good handoff, etc.). This includes a culture change to switch to some of these things, for example surgeons not participating in the handoff, etc. | *"[W]hen you don't get report or you don't get someone who's invested in getting report, that's incredibly frustrating" [PICU nurse, inter-professional handoff]*<br>*"[F]atigue, irritation for something that happened in the OR, concern for another patient" [surgery chief resident, intra-professional handoff]* |
| | Large teams *(interaction: persons and organization)* | Too many clinicians involved in the handoff process can make it difficult in several ways. It is difficult to get many clinicians together at the same time. It is difficult to keep everyone engaged during the whole handoff process and if they are not engaged, they can cause distractions. Too many people can make the handoff take a long time. Team size has been shown to impact team performance (Ingham et al., 1974; Mueller, 2012). This includes explicitly stating the team is large as well as language that is indicative of this (e.g., "swarm of nurses"). | *"[U]sually a pretty big group, so it's like three MDs, and, you know, at least a couple of nurses or so…And if the patient's on a bed, there will be an RT there too" [anesthesia attending, inter-professional handoff]* |
| | Same surgery and ICU attending *(interaction: persons and organization)* | The surgery attending in the OR may be the ICU attending, particularly if the trauma patient arrives overnight when the trauma surgery attending is covering both the trauma service and the SICU service in the ICU. | *"I'm transitioning to myself. Right? So it's hard to have, like it's hard for me to feel bad about transitioning care to myself" [surgery/ICU attending, intra-professional handoff]*<br>*"[The] resident would find themselves over their head, dealing with things they don't know how to deal with, or, you know, a change in the patient's condition, and the staff is down in the ER" [anesthesia critical care fellow, intra-professional handoff]* |
| | Personnel resources *(interaction: persons and organization)* | The organization (work schedules; e.g., schedule of attendings covering various services, OR case schedule) and job demands influence availability of healthcare professionals to participate in a handoff (Smith & Carayon-Sainfort, 1989); for example, they may or may not be available immediately after the patient arrives to the receiving unit; they may or may not have a workload that requires them to tend to another patient (in the receiving or different unit) instead of participating which could lead to others being sent instead and therefore not first-hand information being passed on; many nurses to settle patient may allow primary nurse to participate fully in handoff. | *"[P]eople that were in the room the whole time, which can't always happen…Like sometimes I'll take over a case 20 minutes before it ends, so then I come upstairs, and the nurse is like, how much fluid did you give him? Like, oh, let me check, and I got to like go look it up because I don't know, I wasn't there" [surgery chief resident, inter-professional handoff]* |

*(Continued)*

**TABLE 4:** (Continued)

| Work System Element | Factor Impacting Team Cognition | Definition | Example Quotation |
|---|---|---|---|
| ***Organization*** Organizational conditions include the staff available and assigned to each patient, the sequence and organization of tasks and interruptions | Organizational voice | All care team members should be able to ask questions, share concerns, etc. to ensure patient safety; in other words, the opposite of organizational silence (Morrison & Milliken, 2000). | *"[P]eople should feel free to speak up actually promotes a culture of safety" [surgery chief resident, intra-professional handoff]* |
| | Team experience | How experienced teams are in terms of familiarity, length of time working together and how frequently they work together impacts team performance and communication (Cooke et al., 2007), including knowing who should receive handoffs. | *"[T]he anesthesia crit care…providers tend to know each other better, so it is a little bit easier to pull each other aside and have more of a frank physician-to-physician discussion. So one is the comfort and familiarity" [anesthesia critical care attending, intra-professional handoff]* |
| | Hierarchy | The hierarchical structure of healthcare can dictate who can speak, in what order, and who can ask questions (Thomas et al., 2003; Weller, 2012). | *"[T]here's often a question of which players are important, which are allowed to speak…So you have to follow the hierarchy, which would mean I would not give information unless I'm filling in spots of information." [anesthesia APP, inter-professional handoff]* |
| | Balance efficiency and information flow *(interaction organization and task)* | Healthcare professionals feel pressure to balance the need for efficiency (either delays waiting for team or long handoffs) to complete other tasks and to complete the handoff communication to achieve good information flow and shared awareness. For example, prioritizing listening to a handoff rather than completing individual work or leaving the handoff early/skipping entirely due to other cases in OR. | *"[T]he resident started asking me all these unrelated questions about like, well, what do you do when this happens, like unrelated things to this person…[I] wanted this to be more efficient than it was" [surgery resident, inter-professional handoff]*<br>*"[T]he PICU team has been a little bit funny about not wanting us to give any information until the entire team is present, which is, I understand the idea behind that, but sometimes the patient's not very stable, and you're going to need to start doing something soon." [anesthesia APP, inter-professional handoff]* |
| ***Tasks*** The activities performed during the handoff | Structured tasks | Having an information sharing process that stakeholders have agreed on, are aware of and follow can help avoid missed information (Agarwal et al., 2012); alternately, a lack thereof can increase missed information or make the process harder. For example, knowing people should stop and listen during the handoff. | *"[I]f there was like a physical form…provid[ing] a list and a consistency that everything is completed and reviewed… just a short bullet list of points that we want to make sure people know of" [surgery chief resident, intra-professional handoff]* |
| | Role ambiguity | It is unclear what some roles are supposed to contribute during the handoff communication as well as who fills that role (e.g., which nurse is the primary nurse in the ICU). Role ambiguity contributes to worker strain (Caplan et al., 1975; Carayon et al., 1995), and is positively associated with depression (Schmidt et al., 2014). | *"[T]he OR nurse will] often will repeat what we say too… it's an interesting kind of overlap of like information…I think [OR nurses are] supposed to follow a protocol, we have not been told what their protocol is, so I don't know like where to stop in my report" [anesthesia APP, inter-professional handoff]*<br>*"[I]t's confusing to figure out who the actual nurse is" [surgical critical care fellow, intra-professional handoff]* |

*(Continued)*

**TABLE 4:** (Continued)

| Work System Element | Factor Impacting Team Cognition | Definition | Example Quotation |
|---|---|---|---|
| | Work done before and after handoff | Activities related to preparation for the care transition can influence handoff communication (Wooldridge et al., 2022). | *"The organized process of the heads-up phone call, and then just the, everybody giving report at the bedside, both anesthesia and the surgical team, and having our whole team there, so that you're not essentially having three different people giving three different reports at various times." [PICU nurse, inter-professional handoff]*<br>*"[G]iven injury burden, there might be several consultants that need to be contacted regarding post-op care. I think just a brief plan included in the brief op note also can just help serve as a checkbox, or make sure that it's another form of handoff to have both an oral handoff as well as a written handoff." [surgery chief resident, intra-professional handoff]*<br>*"I usually try to just be done right there, and then I usually tell the nurse like, hey, if you need anything, I'm just right outside the room, but a lot of times that doesn't happen. I don't have a computer, so then I'll say, okay, do you need anything else? And then as soon as I kind of cross the doors, I get to a computer in our recovery room…and finish mu document." [anesthesia APP, intra-professional handoff]* |
| ***Tools and technology*** Various tools and technologies used during the handoff. These include desktop computers, computer on wheels (COW), telephones, pagers, paper documents, and so on | Communication mode | Communication modes (e.g., face-to-face, phone or written) impact how communication occurs, with different advantages/disadvantages (Beach et al., 2012). This is technology that is used during the handoff as the communication mode or before or after the handoff that communicates the same information as the verbal handoff did (or would have, if the written or phone communication is replacing the handoff). | *"[L]ike if someone has a chest tube, I try to put in there chest tube to negative 20 suction, or, you know, for disposition, if there is something else that needs to be done, like I'll try to just briefly mention it in there" [surgery resident, inter-professional handoff]*<br>*"[T]here's a lot that can be said just very matter-of-factly when you're in person as opposed to when you're on the phone" [surgery chief resident, inter-professional handoff]* |
| ***Physical environment*** The handoff occurs in a physical space, likely in the receiving unit, i.e., PICU or ICU. The physical space might include noise and other interruptions (e.g., people passing by) | Physical environment | Characteristics of the physical environment (Smith & Carayon-Sainfort, 1989), such as noise and layout, can impact how handoff communication can occur; for example, noise can be distracting, while being near the patient (at bedside or in hall) to show the location of incisions or drains can help. | *"[E]verybody giving report at the bedside, both anesthesia and the surgical team, and having our whole team there…our PICU team does a really nice job of waiting to make sure that the bedside nurse is ready" [PICU nurse, inter-professional handoff]*<br>*"[L]ines are tangled, no one can figure out like where the A-line is, or the patient is coughing and we can't find the line to bolus something through, or it's just…a lot of stuff to manage, and then people can't really focus" [anesthesia resident, inter-professional handoff]* |
| | Potential distraction | Distractions and interruptions—such as physical transfer of patient, and pages—can hinder handoff communication, even if they are warranted and important | *"[H]ook the patient up to the monitor, get a set of vitals, make sure they're okay, make sure they don't need any medications…after that like I think it's important for everybody to like stop and like listen." [ICU nurse, intra-professional handoff]* |

**TABLE 5:** Handoff Outcomes

| | Definition | Example Quotation |
|---|---|---|
| Outcome | Events and phenomena that result from the handoff, including clear, sufficient and accurate shared information. Efficiency, patient outcomes such as delays, errors, inappropriate treatment, and excessive testing. Because of the large variation in outcomes described combined we did not attempt to distinguish them in this analysis; for further detail see Wooldridge & Haefli (2019). | *"I felt like I had given this information to all of the nurses in the room and all of the residents and ICU fellow that were in the room. But then based on like the questions I had got asked the next morning by both the nurses and the residents, there clearly was a lack of understanding. And whether that was poor communication on my part, poor receipt of information, or it was the next handoff that failed" [surgery chief resident, inter-professional handoff]*<br>*"Usually the surgical team goes first, and they just describe what surgical procedure they did, what issues they encountered, and then the plan going forward for the next, you know, 4, 8, 10, 12 hours, however long out they can foresee it. And then anesthesia will give their handoff of what they're intubated with, what kind of respiratory support they needed, if any, what kind of medications they had to give. And then the fellow is there, so we usually kind of let them run the handoff. And if they have any questions, they can ask me questions at the time, and then nursing can ask any questions. RT kind of gets their information on what they need to set them on for respiratory support based on what they were using in the OR" [PICU nurse, inter-professional handoff]*<br>*"[W]e drop off the cardiac patients…spine patients and the neurosurgery patients, so we see them a lot more…if you see somebody a lot more often you have a better rapport with people" [pediatric anesthesia attending, inter-professional handoff]* |

surgery attending is often the same attending staffing the ICU, eliminating a transition between physicians. However, it could be negative: they cover other services and may not be available at handoff. Participants in both handoffs noted there must be personnel resources to allow clinicians to participate in handoffs. Ideally, these clinicians would be those who provided care or who will provide care, rather than representatives, such as charge or floating nurses in the receiving PICU or ICU or an anesthesiologist who relieved the primary anesthesiologist involved in the surgery.

**Task.** Participants in the OR to PICU handoff talked about tasks in the handoff more often than the OR to ICU. Both groups described the impact of work done outside the handoff; work *before* the handoff includes communication between units, reviewing the patient's chart, preparing equipment, etc., while work *after* includes documentation, seeking additional information, etc. While participants in both handoffs described the impact of having a structured procedure to follow during the handoff, participants in the OR to PICU transition more often described their established procedure. Some participants thought a structure, such as a checklist, would be beneficial to ensure all necessary information is conveyed in the OR to ICU handoff.

Participants in both handoffs talked about role ambiguity. Those involved in the OR to PICU handoff described the recent addition of another team member, the OR nurse, resulting in some confusion about who should report what. The OR to ICU handoff participants described not knowing who the primary bedside nurse was, since many nurses help settle the patient, but the primary nurse needed the handoff most.

Finally, both groups were sensitive to balancing the efficiency of the handoff with information flow, an interaction between the task and organization work system elements. A surgery chief resident expressed frustration when unrelated questions lengthened a handoff. Similarly, delays beginning handoff were frustrating, despite understanding the need to wait for all members to be present.

**Tools/technologies.** The handoff process at this facility was not supported by a checklist or other tool or technology. The electronic health record (EHR) was used by anesthesia as a cognitive aid when reporting the medications given. However, the EHR, phones and pagers were used for work done before and after the handoff, sometimes replacing the face-to-face handoff, for example, the postoperative note to document plans. Phones might be used when someone was unavailable for a face-to-face handoff (i.e., an interaction with organization).

**Organization.** We previously described factors resulting from interactions between the person and task work system elements above. Participants in both handoffs also described the large team involved in handoffs, although the OR to ICU participants focused on the involvement of many nurses causing confusion about who should receive handoff. Team experience, which influences team performance (Cooke et al., 2007), facilitated frank, efficient conversations.

**Physical environment.** Participants talked about the influence of the physical environment on communication in two ways. In both handoffs, the goal of the clinicians was to handoff at or near the patient bedside, so that they could show where drains were, look at the wound, etc. The team handoff in the OR to PICU was always at the bedside. However, being at the bedside could result in distractions. Distractions were mentioned more by participants in the inter-professional handoff, and are important to avoid, minimize or mitigate.

Handoff outcomes. Interviewees described a wide range of handoff outcomes (see Table 5). Participants in the inter-professional (OR to PICU) handoff talked about handoff outcomes more frequently than participants in the intra-professional (OR to ICU). The receiving team getting clear, sufficient and accurate information was a key outcome, as were efficiency and patient outcomes. For a more detailed analysis of the types of outcomes and differences between outcomes in the two groups, please see Wooldridge & Haefli (2019).

## Results of the ENA

We used ENA to visualize, explore and compare relationships between work system elements, team cognition functions and outcomes. Figure 2 shows the average network for participants in the inter-professional handoff (OR to PICU), intra-professional handoff (OR to ICU) and the difference of these networks. The node size on the network graph represents the frequency of that code. The thickness of the lines between nodes represents the strength of the relationship between those codes, that is, frequency of co-occurrence. The squares are the centroids of the average networks, with dashed lines representing the 95% confidence interval of

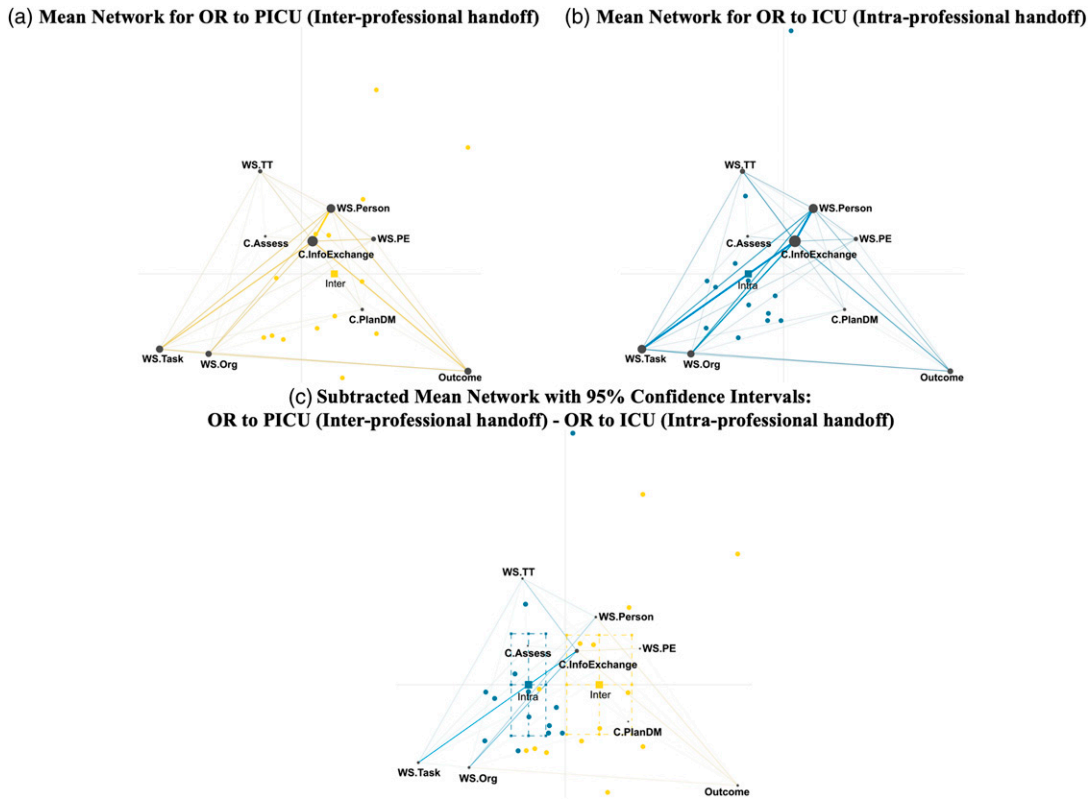


*Figure 2.* Mean ENA Networks for (a) OR to PICU (inter-professional handoff), (b) OR to ICU (intra-professional handoff) and (c) Subtracted Mean (OR to PICU—OR to ICU). *Note.* Network centroids of interviewees participating in the inter-professional, OR to PICU handoff are significantly different along *x*-axis from the interviewees participating in the intra-professional, OR to ICU handoff ($p < 0.001$), but not significantly different along the *y*-axis ($p = 0.72$). Abbreviations are as follow. OR = Operating room. ICU = Intensive care unit. PICU = Pediatric intensive care unit. C.InfoExchange = Information exchange. C.Assess = Assessment. C.PlanDM = Planning and decision making. WS.Person = Persons work system element. WS.Task = Task work system element. WS.TT = Tools/technologies work system element. WS.Org = Organization work system element. WS.PE = Physical environment work system element. Outcome = Handoff outcome.

centroid location, while the circles are centroids of the network for individual interviews. The codes for the work system elements and team communication functions (i.e., processes) are generally to the left side of the graph, intertwined and inseparable. The outcome code is to the right side of the graph.

Information exchange is the largest node in both networks. The interprofessional handoff participants made strong connections between information exchange and outcome and person. An anesthesia resident in the inter-professional handoff described a repeating information (an outcome) caused by distractions (physical environment) and lack of focus (personal motivation) stemming from trouble untangling IV lines:

> *"[I]t's lines are tangled, no one can figure out like where the A-line is, or the patient is coughing and we can't find the line to bolus something through, or it's just a lot of, like usually that happens in situations where there's like lots of lines and tubes and things going all over the place, and can just be a lot of stuff to manage, and then*

**TABLE 6:** Strategies to Enhance Rigor of Qualitative Analysis

| Strategy | Criteria for Rigorous Qualitative Research Impacted (Devers, 1999) |
|---|---|
| **Triangulation between multiple analysts** The entire dataset was coded by two researchers independently; they then met and reviewed differences, discussing each difference until they mutually agreed on the coding. The analysts were trained to follow instructions for coding in Wooldridge (2018). | • Credibility<br>• Confirmability |
| **Search for disconfirming evidence** The first author searched for disconfirming evidence, negative cases or data that do not fit with patterns, theory or results. | • Credibility<br>• Confirmability |
| **Member checking** The results were shared with team members of the larger research project who were not involved in the analyses but who represent the groups of participants. | • Credibility |
| **Skeptical peer review** The second author acted as a skeptical peer reviewer. | • Confirmability<br>• Dependability |
| **Detailed audit trail** A detailed audit trail of our analysis is available (Wooldridge, 2018). | • Confirmability<br>• Dependability |
| **Detailed description of research context** We provide a detailed description of the work system involved in the handoff in our results; additional detail regarding the broader care transition process is available (Wooldridge et al., 2022). | • Transferability |

*people can't really focus on what they're trying to tell each other." [anesthesia resident, inter-professional handoff]*

On the other hand, participants in the intra-professional handoff made less frequent connections between the system elements or processes and handoff outcomes. Instead, they focused on the influence of work system elements, particularly the person, task and organization on information exchange. One of the ICU nurses described having worked with the surgical fellows (team experience) impacting whether the surgical fellow speaks to her. She goes on to describe the availability of the ICU resident (personnel resources) can result in a handoff outside the room after the initial discussion (work after handoff).

*"I will sometimes know a lot of like the like at least the surgical fellows, if they were in the case and stuff, if they come back with the patient like I know them. And so they like are, like I'm a familiar face…So sometimes like they'll talk directly to me as well…sometimes the SICU resident isn't even in the room right away because they didn't even know the patient was coming at that time… they show up later, and then they'll do like a brief overview" [ICU nurse, intra-professional handoff]*

The subtracted network highlights the difference between the two groups, with the inter-professional handoff participants integrating handoff outcomes with work system and process codes. The Mann-Whitney U tests showed a significant difference in the location of the centroids of the networks along the first dimension ($U=160.00$, $p<0.001$) but not the second dimension ($U=83.00$, $p=0.72$). Participants in the intra-professional handoff made significantly stronger connections between work system elements, particularly task and organization, and

**TABLE 7:** Frequency of Code Application (*N* = 201)

| Theme | OR to PICU (Inter-professional handoff) Relative frequency [n] | OR to ICU (Intra-professional handoff) Relative frequency [n] | Total relative frequency [n] |
|---|---|---|---|
| **Team cognition functions** | **100% [79]** | **100% [122]** | **100% [201]** |
| Information exchange | 99% [78] | 98% [119] | 98% [197] |
| Assessment | 18% [14] | 15% [18] | 16% [32] |
| Planning and decision making | 20% [16] | 16% [19] | 17% [35] |
| **Work system elements** | **92% [73]** | **94% [115]** | **94% [188]** |
| Persons | 73% [58] | 61% [74] | 66% [132] |
| Task | 63% [50] | 62% [76] | 63% [126] |
| Tools/technologies | 32% [25] | 26% [32] | 28% [57] |
| Organization | 47% [37] | 51% [62] | 49% [99] |
| Physical environment | 28% [22] | 20% [24] | 23% [46] |
| **Handoff outcomes** | **59% [47]** | **35% [43]** | **45% [90]** |

information exchange; in other words, the handoff is something they do, with fewer reflections on outcomes, pulling their centroid in the negative direction.

## DISCUSSION

### Team Cognition in Handoffs

Participants described three separate communication events in handoffs of pediatric and adult trauma patients from the OR to the PICU and ICU: (1) information exchange, (2) assessment and (3) planning and decision making. All three represent team-level cognitive processes, that is, team cognition. Information exchange, including or clinicians giving report and PICU or ICU clinicians asking questions, was most reported. As argued in the literature, handoffs are not telegrams, and interactive, two-way communication for information exchange (i.e., asking questions) is a crucial part of handoffs (Cohen et al., 2012; Cohen & Hilligoss, 2009; Patterson & Wears, 2010). Our study further supports this argument, with two other crucial functions identified as follow. Assessment, e.g., synthesizing information from multiple sources to contextualize the patient, was reported less frequently, as was planning and decision making, e.g., developing care plans, deciding what to monitor. Frequency is not necessarily indicative of importance and training about handoffs as opportunities to transfer information may artificially inflate the prevalence of information exchange.

### Impact of Work System on Team Cognition

This study suggests work system design influenced team cognition in handoffs. Participants in the inter-professional handoff described positive impacts of inter-professional handoffs on communication processes, e.g., information exchange, and outcomes: the inter-professional handoff facilitated interactions by bringing the team together to provide their unique perspective and role-specific information. However, this resulted in many people present, potential distractions and tension between efficiency and information flow; these were negative aspects of the work system. Negative impacts of intra-professional handoffs included missing

**TABLE 8:** Summary of Recommendations to Improve Handoffs

| Recommendations | Applicable to Inter-professional Handoffs | Applicable to Intra-professional Handoffs |
|---|---|---|
| Develop a well-understood care transition process that handoff participants agree on, including reconciling expectations of sending and receiving clinicians and agreeing on communication to occur during the preparation phase (Wooldridge et al., 2022). | X | X |
| Enhance organizational awareness of the care transition process through simulation and/or process mapping, ideally with handoff participant interaction to simultaneously increase team experience (Wooldridge et al., 2022). | X | X |
| Develop a flexibly structured handoff with clear roles, supported by low- (e.g., checklist) and/or high-technology (e.g., shared displays) cognitive aids. | X | X[1] |
| Develop tools and technologies to support awareness in distributed team members, for example, supportive aids that synthesize information and present it in a useful way without increasing workload. | X | X |
| Provide strategies to facilitate inter-professional communication, for example, tailoring language based on role of handoff receiver, communicate at all levels of clinicians involved in care etc. | X | X[2] |
| Develop a culture that supports organizational voice and values questions from all team members. | X | X |
| Reduce potential distractions, for example, change monitors and stabilize patient prior to beginning handoff, conduct handoff in a quiet environment, etc. | X | X[3] |
| Conduct handoff at or near the patient bedside to show receiving clinicians drains, incisions, injuries, etc. | X | X[4] |
| Manage team size and arrangement to facilitate handoff participation while minimizing distractions and improving communication. | X[5] | |
| Implement inter-professional handoffs where feasible unless strong justification for intra-professional handoffs exists (e.g., personnel constraints cannot be addressed, culture is not yet supportive of organizational voice, etc.). | | X |
| Ensure needed handoffs occur, for example, ICU nurses need to communicate with surgery and anesthesia providers even if not together. | | X[6] |

Notes.
[1]In intra-professional handoffs, this may essentially be agreeing upon the information to be communicated, since the team will not interact as a group.
[2]In intra-professional handoffs, nurses still need to hear from surgeons and anesthesia; this may not happen simultaneously in a group but is still inter-professional communication.
[3]In intra-professional handoffs, different distractions may need to be addressed, for example, team size is smaller but multiple conversations may be happening at once.
[4]In intra-professional handoffs, handoff may need to occur outside of the patient's room if nurses have already begun settling and bathing the patient.
[5]For example, arranging handoff participants in two circles (the inner circle including key clinicians and outer circle including learners, additional staff, etc.) may help manage team size and the challenges associated with large teams (e.g., minimize distractions and improve efficiency) while being inclusive. Developing a clear, structured handoff process with clear roles may also address the challenges associated with large teams in our data.
[6]It may not be possible for personnel to be present for a team handoff, but that communication still needs to occur.

information, but fewer people and distractions were involved. Intra-professional handoffs also facilitated tailoring information to the receiving clinicians as they were conducted separately for physicians and nurses. Role ambiguity, particularly identifying which nurse should receive handoff, was a challenge in the intra-professional handoff and could lead to the OR clinician delaying handoff or beginning too early.

The underlying tension between the benefits and shortcomings of inter-professional handoffs is due in part to limited education focused on interprofessional communication, professional silos and hierarchy (Weller et al., 2014). In this study, participants in the intra-professional handoff described *"tailoring information" [Surgery/ICU attending, intra-professional handoff]* based on the background of the person they were speaking to; for example, the surgeon might discuss wound care with the bedside ICU nurse but discuss the surgical procedure and plans in detail with the ICU attending. Tailoring information and language may represent a strategy to facilitate inter-professional communication in separate handoffs, but requires clear, shared understanding of what information is needed by whom to be effective. Without shared understanding, useful information maybe inadvertently withheld. Physicians and nurses described the importance of being able to ask questions in both handoffs, reflecting the importance of not allowing hierarchy to stifle organizational voice. Professional silos and hierarchy in health care may dictate who can ask what questions to whom, negatively impacting patient care and leaving key questions unasked. Alternate strategies to improve inter-professional communication, for example, enhanced inter-professional training and curriculum, could prove more effective than tailoring language in separate handoffs.

## Work System-Based Interventions to Improve Team Cognition in Handoffs

Historically, recommendations for improving team cognition tend to focus on team training strategies or stable team membership. In this study we show how the design of work systems impacts team cognition. So, the question becomes how to design work systems to support team cognition. This could help to avoid the additional burden or workload of team training, which has not been robustly demonstrated to have long-term impact (Weaver et al., 2014). Stable or fixed team membership, another strategy to improve team cognition, does not adequately support the flexibility that health care requires. This study provides guidance for how to improve care transitions by redesigning the work system, as follows.

Participants in both handoffs described benefits of a well-understood process and the challenges of role ambiguity. Therefore, increasing organizational awareness, that is, awareness of their roles fit in a thoughtfully-designed, understood process (Schultz et al., 2007), is an opportunity for improvement. Process mapping and process simulation are approaches that may increase organizational awareness and help design handoffs. Simulating the current process is a way for stakeholders to gain a more complete understanding of the process as it is actually done, not as it is imagined to be done (Barcellini et al., 2014). It also provides a useful opportunity to test and refine process redesigns in an iterative, participatory design approach (Barcellini et al., 2014). These strategies are in line with the meta-principles of sociotechnical system design proposed by Clegg (2000), specifically that design is a systemic, extended, contingent and socially-shaped process that involves making choices that should support the needs of the humans involved in the handoff. Further, embedded in our notion of process mapping and process design are all six process principles of Clegg (2000), augmented by ideas from participatory and constructive ergonomics (Falzon, 2014; Wilson et al., 2005). While we recommend process design that includes representations of the system (i.e., process maps), reflection and intentional implementation of changes but with participation of workers (i.e., insiders), the work system should also support adaptation of workers to emerging, unpredicted circumstances which may not include representations of work (Carayon et al., 2006, 2014, 2020; Holden et al., 2013;

Hutchins, 1991). Future work could study the impact of participatory, constructive design practices on organizational awareness, in addition to linkages to process outcomes.

Another potential improvement identified by this study is developing tools and technologies to support clinicians during handoffs. Examples include simple, low-fidelity tools such as a laminated paper checklist of information to discuss, similar to that developed for multi-disciplinary rounds (Cox et al., 2017). The use of checklists in multi-disciplinary rounds addressed organizational voice issues by empowering the nurse through a leadership role in rounds; this could address the concerns voiced by the PICU nurse about the inter-professional handoff being less nurse friendly. Agarwal et al. (2012) found a structured handoff process improved perceived handoff quality, reduced information loss and improved four clinical outcomes: cardiopulmonary resuscitation, mediastinal reexploration, placement on extra-corporeal membrane oxygenation and early extubations. However, care must be taken to avoid over-standardizing the process, which can have negative impacts (Patterson, 2008) and remove the ability of healthcare professionals to adapt as needed (Vincent & Amalberti, 2016), drawing on Clegg's (2000) principle of flexible specification. While our participants did highlight the benefit of structured handoff process, seeming to conflict with the idea of flexible specification, the underlying benefit was from improved shared awareness discussed previously. Technology-based solutions, including information technology (IT), could also be developed to support handoffs (Bass et al., 2013; Flanagan et al., 2009; Van Eaton et al., 2004), particularly if they are designed to support teams, not individuals. For example, shared displays support situation awareness in resuscitations (Parush et al., 2017; Wu et al., 2017); similar displays could be developed to support care transitions. When implementing inter-professional handoffs, effort must be taken to support organizational voice, particularly of traditionally less powerful roles. Emphasizing and addressing inter-professional communication in the training of clinicians-to-be may decrease challenges in the future.

Table 8 summarizes our recommendations to improve handoffs by supporting team cognition.

### Limitations

This study was conducted in one healthcare system and compares only two cases (OR to adult ICU and OR to PICU care transitions), necessarily limiting generalizability. While this study represents a step toward conducting rigorous, situated field research on team cognition, it examines team cognition using interviews rather than observations. Interviews were useful to gain in-depth understanding of perspectives of clinicians and let us study transitions of trauma patients, which occur under time pressure and present logistical challenges to observe, but they may be subject to recall bias and under-emphasize assessment, planning and decision making. A more pressing limitation is that this study does not include the perspective of the patient or their family/caregiver. As health care progresses toward being more patient- and family-centered, it is increasingly important to include patients and their families (Valdez et al., 2015).

## CONCLUSION

It is particularly important to study team cognition *"in the wild"* to learn how the sociotechnical (work) system can support improved team cognition with minimal added burdens. Using interviews, we examined team cognition and the sociotechnical system in which handoffs occurred. This is a unique approach to studying team cognition. Handoffs in care transitions constitute team cognition by the ITC definition (Cooke et al., 2013), with participants describing information exchange, assessment and planning and decision making as team-level cognitive processes involved in handoffs. Organization of handoffs (one work system element), that is, inter-professional versus intra-professional handoffs, impacted team cognition processes and outcomes. Inter-professional handoffs can enhance and hinder ITC. The presence of the inter-professional care team facilitated

information exchange, improving perceived handoff outcomes; conversely, it hindered communication because the larger group of individuals resulted in logistic challenges and the diverse audience necessitate sometimes less precise communication strategies. We recommend future work investigate team cognition *in the wild* as it occurs during handoffs, leverage our findings to develop systems-based solutions to support team cognition in care transitions and develop methodologies to assess and predict the impact of changes to work system design on outcomes.

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## KEY POINTS

- Care transitions, in particular handoffs, are characteristic examples of team cognition.
- A change in sociotechnical system design—interprofessional handoffs versus intra-professional handoffs—influenced relationships between work system elements, team cognition, and outcomes.
- Opportunities to improve care transition outcomes include changes to the organization of handoffs, increasing organizational awareness through simulation and participatory process analysis, and designing supportive tools and technology for teams.

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