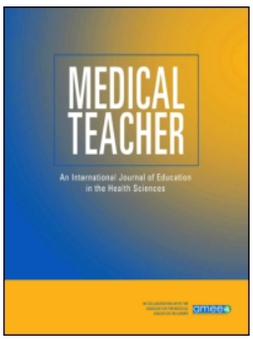

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Interprofessional collaborative reasoning by residents and nurses in internal medicine: Evidence from a simulation study

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ABSTRACT

Clinical reasoning has been studied in residents or nurses, using interviews or patient-provider encounters. Despite a growing interest in interprofessional collaboration, the notion of *collaborative reasoning* has not been well studied in clinical settings. Our study aims at exploring resident-nurse collaborative reasoning in a simulation setting. We enrolled 14 resident-nurse teams from a general internal medicine division in a mixed methods study. Teams each managed one of four acute case scenarios, followed by a stimulated-recall session. A qualitative, inductive analysis of the transcripts identified five dimensions of collaborative reasoning: diagnostic reasoning, patient management, patient monitoring, communication with the patient, and team communication. Three investigators (two senior physicians, one nurse) assessed individual and team performances using a five-point Likert scale, and further extracted elements supporting the collaborative reasoning process. Global assessment of the resident-nurse team was not simply an average of individual performances. Qualitative results underlined the need to improve situational awareness, particularly for task overload. Team communication helped team members stay abreast of each other's thoughts and improve their efficiency. Residents and nurses differed in their reasoning processes, and awareness of this difference may contribute to improving interprofessional collaboration. Understanding collaborative reasoning can provide an additional dimension to interprofessional education.

Introduction

Clinical reasoning of physicians is a process initially studied by cognitive psychologists. The process starts with a chief complaint, and the clinician uses strategies to identify relevant features of the history, physical examination and ancillary testing in order to diagnose and treat their patients (Higgs & Jones 2000). Recent publications have also reported on this process in nurses (Cappelletti et al. 2014; Chiffi & Zanotti 2015). However, it has not been examined as a team effort. In most studies, clinicians are either asked to explain their reasoning while working-up a case (think-aloud strategy) (Ericsson 2007; Durning et al. 2011), or they are asked to comment a video or audio recording of a case, providing explanations to their decisions and actions (stimulated recall strategy) (Norman 2005; Nendaz et al. 2006). In both of these approaches, the focus is on the clinical reasoning of an individual clinician. Such an approach is less suitable for cases where patient care is provided by a team of health care professionals.

Patient care in hospital settings is most often the result of collaborative teamwork and numerous studies have focused on teamwork competencies and interprofessional collaboration (Baggs & Schmitt 1997; Ferguson 2008; Muller-Juge et al. 2013; Wingo et al. 2015). The notion of "collective competence," (Anderson 2012) suggests an individualist and collectivist discourse to competence. Our paper focuses on the collectivist discourse, based on differences and similarities of perceptions of the situation by individuals and the resulting shared mental models among the various team members. We will use the term *collaborative reasoning* to describe the process of reaching a shared mental model (Mason 1996).

Studies conducted in non-health care settings suggests that team mental models can help enhance team coordination and effectiveness through anticipation of other members' responses, particularly in complex, unusual or urgent situations (Marks et al. 2000; Mathieu et al. 2000). Furthermore, the degree to which team members share team mental models is correlated with team performance

Practice points

- Collaborative reasoning is a team process to reach a shared mental model about the patient's problem and its management.
- Collaborative reasoning is expressed across the dimensions of diagnostic reasoning, patient management and monitoring, providing explanations to the patient, and team communication, powered by situational awareness.
- Dimensions of collaborative reasoning should be more explicitly included in future interprofessional education programs.

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(Lim & Klein 2006). Better understanding the process of collaborative reasoning could benefit future patient care, and may represent an additional dimension to interprofessional education.

In this paper, we focus on patient care in general internal medicine wards. Our goal was to explore the characteristics and strategies of collaborative reasoning in the setting of internal medicine and their relationship to interprofessional collaboration.

Methods

The design of this parallel mixed methods study (Fereday & Muir-Cochrane 2006) uses part of a data set collected in the Division of General Internal Medicine at the University Hospitals of Geneva, Switzerland (Muller-Juge et al. 2013, 2014). After obtaining an exemption status from the state ethics committee, we enrolled 14 volunteer residents and 14 volunteer nurses who were randomly paired in 14 resident-nurse teams for a high-fidelity simulation study with a manikin.

We created four prototypical internal medicine patient cases, based on acute situations that occur in the wards. These situations were hemorrhagic shock (G-I bleed), septic shock, congestive heart failure, and inferior myocardial infarct (MI). The G-I bleed and MI cases were randomly attributed to four teams, and the septic shock and heart failure cases were randomly attributed to three teams. Each resident-nurse team was asked to manage one hospitalized patient who becomes unstable, requiring urgent care. Scenarios began with the patient feeling ill and calling for the nurse, who then called in the resident. The scenarios ended with the arrival of and hand-off to the supervising physician, either because (a) the patient was stabilized, (b) the team needed more support from a supervising physician, or (c) duration of the scenario was over 15 min. Our study wanted to reproduce this sequence, as is commonly encountered during acute events among hospitalized patients in internal medicine wards.

After each simulation, each participant was interviewed in an individual, semi-structured stimulated-recall session to explore their thoughts and actions while reviewing the videotaped simulation scenario (Calderhead 1981). Both the simulation and the interview were transcribed verbatim and de-identified for subsequent analysis.

Two senior physicians and a head nurse (M.N., K.B. and F.M.) independently coded the transcripts of the simulations and stimulated-recalls using an inductive approach (Crabtree & Miller 1999; Fereday & Muir-Cochrane 2006) to explore collaborative reasoning. Based on this qualitative analysis and on the literature about tasks in clinical reasoning (Goldszmidt et al. 2013), we created a template of five dimensions of collaborative reasoning: diagnostic reasoning, patient management, patient monitoring, team communication, and communication with the patient. Table 1 lists and provides definitions of these dimensions. These dimensions were used to better frame our description on how they arise in practice to serve collaborative reasoning.

The investigators (K.B., M.N., F.M.) then scored the quality of the individuals and of the team performances across these dimensions, using a five-point Likert scale (1 = weak, 5 = strong) to assess how well each dimension contributed to collaborative reasoning during the encounter. They also gave a global assessment score, which took into consideration the effectiveness of the team in terms of patient work-up and management, based on validated expectations for each case at the time of scenario construction. We used descriptive statistics to analyze the scores by case and averaged over cases (individual resident, nurse, and team performances). We used a two-sided Mann–Whitney *U* test to assess differences between residents and nurses, and the Kruskal–Wallis H test for differences among cases. Inter-rater agreement (kappa) among the coders was 0.76.

Table 1. Common dimensions with opportunities for collaborative reasoning (inductive analysis).

Common themes	Definitions
Diagnostic reasoning	All elements related to the diagnostic process, such as precisions about symptoms, testing of suspected etiologies, associated findings or past medical history
Patient management	Includes the work-up strategies, equipment preparation (second i.v. access) and any treatments: these could be a symptom-based treatment (pain for example), stabilization of current state (i.v. hydration), or etiology-based (antibiotic)
Patient monitoring	Following-up on any finding that was previously assessed: monitoring of vital signs, or of the way the patient is feeling, or of the state of medication administrations or other medical orders
Communication	All interprofessional communication: hand-offs from nurse to doctor, nurse to nurse (when requesting assistance), or doctor to doctor (to supervisor or consultants), as well as interprofessional communication during the simulation. Includes an analysis of content, as well as the manner in which it was said (organization and style)
Explanations to patient	Includes all explanations to the patient by the nurse or doctor, either about the current process (putting in a second i.v. catheter), suspected diagnoses, or planned work-up or treatments.

Table 2. Participant characteristics.

	Residents ($n = 14$)	Nurses ($n = 14$)	Total ($n = 28$)
Median age, y (range)	31 (25; 36)	38 (27; 48)	32 (25; 48)
Sex (female:male)	4:10	10:4	14:14
Place of education	CH (10); Other (4)	CH (4); Other (10)	CH (14); Other (14)
Median total experience, y (range)	3.3 (0.5; 7)	9 (2; 25)	5 (0.5; 25)
Median experience in Internal Medicine, y (range)	2.8 (0.5; 5)	1.9 (0.5; 13)	2.3 (0.5; 13)

Results

Four of the 14 residents were female, whereas 10 of the 14 nurses were female (Table 2). The participants' mean age was 34 years (residents 31 years, nurses 37 years). Residents had less postgraduate experience on average than the nurses (4 years versus 10 years), although the mean number of years in the Division of General Internal Medicine was similar (3 years for residents and 4 years for nurses).

Scenario duration was on average 18 min (SD 1.4). Each of the 28 simulations lasted on average 18 min (SD = 1.5, range 15–21), The mean duration of the 56 stimulated-recall sessions was 46 min (SD = 6.3, range 28–74).

Quantitative results

Based on the themes derived from the qualitative analysis, Table 3 reports the individual reasoning scores for

Table 3. Mean quality scores (1 = weak, 5 = strong) of collaborative reasoning dimensions for residents, nurses, and teams averaged across four cases.

	Resident scores ($N = 14$)		Nurse scores ($N = 14$)		Team scores		Mean of resident and nurse scores	
Dimension	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Diagnostic reasoning	3.54	0.63	3.40	0.37	3.31	0.36	3.47	0.48
Patient management	3.20	0.84	3.25	0.38	3.19	0.30	3.22	0.60
Patient monitoring	3.26	0.95	3.05	0.55	3.19	0.62	3.16	0.73
Communication	3.05	0.58	3.28	0.17	3.13	0.42	3.17	0.41
Explanations to patient	3.38	0.72	2.92	0.14	3.06	0.42	3.15	0.32
Global assessment	3.22	0.70	3.46	0.29	3.06	0.16	3.34*	0.17

*$p = .03$ for the difference between team versus mean of resident and nurse scores. All other analyses were non-significant statistically ($p > 0.05$).

residents, nurses, and for the team, averaged over the four cases. The mean of individual resident and nurse scores are presented in the last column. The lowest score for residents was for team communication, whereas nurses scored lowest for explanations to the patient. In the analysis of the mean scores per case, the mean G-I bleed score was 3.57, the mean septic shock was 3.53, the mean congestive heart failure was 2.92, and the mean MI was 2.86 ($H = 17.1$, df = 3, $p < 0.001$).

Overall, we did not find a significant difference between resident and nurse performances for any theme ($p = 0.57$). The global assessment score differed significantly from the mean of the individual resident and nurse scores ($p = 0.03$). Reasons for these differences in team performance were explored in the qualitative analyses.

Qualitative results

Diagnostic reasoning

Collaborative reasoning to reach a diagnosis was observed in all teams, meaning that all resident-nurse teams explored the etiology of the current acute episode at some point during the simulation. Nurses participated in the diagnostic reasoning process in various ways, such as communicating their initial assessment, including or not an explicit hypothesis, and providing timely additional information during the resident's assessment, showing that they were following the evaluation of various hypotheses raised about the case. Some nurses, however, considered their role as simply presenting findings and concerns to the resident, without any further involvement in reaching a diagnosis or making management decisions.

The nurse's initial assessment could affect subsequent management. When patients called for help, nurses were the first health care professional to assess them. Nurses then decided whether or not to alert residents, and gave their assessment with indications about the degree of urgency. Although some nurses with strong initial assessments made suggestions about patient management to the resident, the quality of the initial assessment in itself was not sufficient to predict strong collaborative reasoning. Team11, in particular, showed low collaboration despite a good initial assessment and management by the nurse.

Patient assessments by both the resident and the nurse may reflect the complementarity resulting from interprofessional collaboration. After nurses provided residents with a brief summary of their assessment (often during the phone call, or upon the resident's arrival at the bedside), residents performed their own clinical assessment of the patient. Despite some repetition, double assessment helped avoid reasoning biases and premature closure: when nurses remained at the bedside during the resident's assessment, they had the opportunity to provide additional information or make suggestions from their own initial assessment. For example, Dr14 discussed the patient's anticoagulant for the patient with suspected G-I bleed, and Nurse14 added: "He is also on aspirin." Thus, the joint presence of the resident and nurse can enhance the sharing of a team mental model.

Diagnostic reasoning differed between residents and nurses. Residents used hypothetical reasoning to understand constellations of findings, with a strong focus on etiology. Nurses had clinical diagnoses, based on physiological concepts: it was about understanding the symptom and its impact on the patient. Their management approach therefore aimed at improving the main symptom. Although there was some overlap in their approaches, differences were reflected in patient management (see below).

Individual knowledge and competence were prerequisites of strong reasoning skills. In the case of the G-I bleed, for example lack of pain was erroneously associated with lower urgency, despite abnormal vital signs.

Overall, diagnostic collaborative reasoning happened during (1) the sharing of initial nurse assessment, (2) the sharing of resident-nurse individual approaches, and (3) resident reasoning with timely and purposeful nurse input. Furthermore, we identified areas with weaker collaborative reasoning, either through a lack of a global approach or an over-mechanistic approach, or through a lack of knowledge (e.g. reassurance by lack of pain despite abnormal vital signs).

Patient management

Patient management was observed to be a collaborative task in all teams, with all participants, and nurses more particularly, viewing it as part of their role. Nurses contributed to the resident's management process through anticipation and suggestions, and through critical responses to medical orders.

Participants agreed on the interdependence in patient care, with medical decisions and orders given by the resident, then administered by the nurse. It was also clear that residents strongly relied on nurses for many different aspects of management. For example, Dr9 fiddled with the switches, saying: "I need a blood pressure – how does this work?" then turned to Nurse9 and asked: "Has this patient had a chest X-ray?" Not only did this resident request technical help with the blood pressure (BP) monitor, he also expected the nurse to provide information about her patient, in particular for exams that had been run.

Nurses participated in the reasoning process by anticipating, or by making suggestions for patient management. Often, these suggestions arose from prior experiences in similar situations, or were symptom-based and did not take into consideration case specificities. For example, Nurse4 called Dr4 during the initial phone call: "[The patient] says he has stomach pain, he mentioned it was oppressive for a

bit, but then when I asked him if it was at the chest level, he said no. So I'll take his pulse as you requested and then I'll start him on diclofenac. Okay?" This symptom-based approach reflected low use of diagnostic hypotheses and etiology-based reasoning, and led to erroneous reasoning (i.e. "pain – needs a pain killer," without considering that diclofenac could aggravate a potential stomach ulcer). Nurses often anticipated the residents' orders, presented as a suggestion: Nurse9 prompted Dr9 about an intravenous (i.v.) access (MI case with low BP): "Do you want me to start an i.v. drip?" and Dr9 pondered, then accepted the suggestion: "Okay, yes, a second i.v. drip, please." Suggestions occurred throughout the scenario, from the initial phone call to the report to the attending physician.

Residents assessed the relevance of nurse suggestions in the context of each patient. As mentioned in the diagnostic reasoning process, relying on symptom-based suggestions or "usual practice" was often valid, but could also lead to erroneous reasoning. For example, Nurse9 proposed nitroglycerin for the patient chest pain and suspected MI, without considering his low BP, which the resident critically declined.

Residents and nurses who share a mental model can collaborate better. Nurses can anticipate management decisions more easily, prepare for new orders, or make suggestions. When residents and nurses do not share a mental model, however, errors can occur. Nurse11 had an unusual approach:

> One thing I do in the wards [...] is that I turn off all the beeping sounds and alarms because I've noticed that just hearing the "beep, beep" sounds stresses people out. So if a person is already tachycardic, no need to stress them any further. (stimulated-recall)

Dr11 did not share this approach and during the scenario and had low awareness about the decreasing BP. A huddle (King et al. 2008), that is a shared moment to analyze the situation during the scenario could have helped adjust awareness for both the BP and the silenced alarms.

The need for assistance by the medical emergency team (MET, i.e. usually physician and nurse teams from the ICU or anesthesia departments) generated discord. Calling the MET created discomfort, in particular for the more experienced nursing professionals. These individuals later expressed that they did not wish to be reprimanded for an unnecessary MET call. Despite a loss of consciousness in a patient with signs of hemorrhagic shock, participants were hesitant about calling in the MET: for example, after having called the MET, one team even decided to pretend that they had not called when the patient finally regained consciousness.

An early phone call to a supervising physician bolstered indecisive teams. Discussing the situation and sharing the responsibility helped participants establish a plan, which allowed the team to proceed with patient management.

Overall, we found a clear consensus among participants about nurse and resident interdependence for patient management, with nurse participation through anticipation and suggestions, and huddles to keep the team up to date with the general approach. We identified a need to clarify the criteria for calling in METs and to encourage earlier calls to supervisors, in particular for the more junior or indecisive residents.

Patient monitoring

Monitoring is an important component of patient management, particularly in more acute situations, before a patient's state is stabilized. Yet in the urgency of acute management, monitoring can be overlooked, leading to the late detection of clinical changes. In this section, we examine which and how parameters were monitored. We also explore who did the monitoring in the team.

Efficient teams monitored the vitals, whereas teams with lower performance sometimes were unaware of clinical changes until late into the simulation. Although both the nurses and the residents across the various teams discussed vitals, the nurses performed the measurement more frequently. Dr14 sees that Nurse14 is starting an i.v. drip: "I'll check the BP if you're busy."

The choice of parameters varied across teams. Although all teams measured BP, pulse, and saturation, few teams measured the respiratory rate, even in the case of dyspnea. Teams typically depended solely on the saturation rate to assess the respiratory function. For the pulse, teams typically used a saturometer to read the heart rate rather than manually assessing the pulse, and therefore did not assess for regularity of the heartbeat. Pain was often monitored, more effectively when using a visual-analog scale. The teams had variable use of ECG (electrocardiogram) and blood gas analyses, even in cases where these were considered essential according to expert consensus.

Nurses tended to also monitor how the patient was feeling, and actually focused more on the patient's emotions and general condition than on the vitals. Tachycardia, for example, was sometimes interpreted as a sign of anxiety and stress, rather than an indicator of severity.

Overall, although teams monitored vital signs to detect early changes in the patient's state, they underused respiratory rate and direct heart rate frequency measurements. Furthermore, higher use of the visual-analog scale to assess pain could have allowed better assessment of pain and its trends over time.

Team communication

Although communication is not a marker of reasoning in itself, it is an essential tool for collaboration and shared vision. Communication was important during the whole interaction, and imprecision in communication directly affected team performance and quality of care. At the bedside, communication helped the team stay focused on common goals, anticipate next steps, and remain aware of the situation. Communication also occurred when a new health care provider entered the room, such as the attending physician at the end of the simulation. The residents' lowest score was in this area.

The initial phone call set the scene for the resident. Nurses used key words to get the resident come urgently. Residents relied on the nurse's assessment, using the elements presented by the nurse to "get a picture" of what to expect. This was illustrated by the phone call in Team2:

> Hi, this is Nurse2. I'm calling about Mr. Lopez, who just went to lie down, he wasn't feeling well. He was feeling dizzy, um, he said he passed stools – two black very soft stools – and then he had low blood pressure, just 10 over 6, which is unusual for him. Um, well, the pulse was just about 100. Sats were at... 94%. So he has had melena, I'd like you to take a look at this

> patient [...] Oh, and he has a history of heart disease, [...] he had a stent put in three months ago.

Role perceptions clearly influenced the content of resident-nurse communication. In the initial phone call, nurses identified abnormal findings, assessed the degree of urgency and sometimes proposed management, but often did not provide diagnostic hypotheses. They preferred to rely on the resident's competence to diagnose. Nurse2 was clearly thinking of a G-I bleed as a hypothesis, but only provided cues rather than the diagnosis. Dr2 did not pick up on this during the phone call, and had to figure this out herself later during the encounter.

Communication often lacked precision. Imprecisions could lead to misunderstandings and errors in management. For example, when calling out vitals, Nurse9 said: "He's at 90," which could be interpreted as a value for heart rate, systolic BP or oxygen saturation level. Lack of precision in the use of terms could also lead to decreased efficiency, due to the delay until the participants reached an understanding. Nurse3 was asked to prepare an i.v. drip, but had to ask Resident3 about the substance, rate, and amount in three separate questions. Medical order lack of precision sometimes incited nurses to make suggestions about patient management, or anticipate what the resident meant. For example, Nurse2 foresaw the need for a perfusion, and initiated a perfusion rate before Dr2's specifications: "So what's the saline drip going at?" Nurse2 replied: "I let it flow freely." Dr2 acknowledged: "Okay, you let it flow freely. That's good." Nurse2 explained her reasoning: "It will help correct the low blood pressure."

Team members communicated respectfully with each other, using closed-loop communication (i.e. repeating the message of the sender) (King et al. 2008) and verbalization of their thoughts (thinking aloud). These tools helped teams make sure they were on the same wavelength throughout the scenario. Dr14 went through a mental list of orders and tests: "So let's see, have we ordered all that we needed to?" Nurse14 suggested: "We ordered the blood stat." Dr14 closed the communication loop: "Okay, hemoglobin, blood type, that's ordered." And continued: "And the saline is flowing freely. Hm, you need to stay at the bedside."

The residents typically would tend to think aloud to share their thoughts with the nurse. For example, Dr14 said:

> So, an upper G-I bleed with melena. Do we have his coagulation results? He was anticoagulated for AF. He had an INR of 3.3, but that was yesterday. He took his acenocoumarol ... [...] Okay, an INR of 4.5. Ok. So he's supra-therapeutic this morning, but only a bit.

Verbalization could, however, lead to lower team performance through information overload. In the individual interview, Nurse14 observed: "The resident was giving too many explanations, and I had many things to remember already, especially because I needed to act rapidly, it was just too many things all at once."

Finally, communication was less effective when intermediary persons were involved, particularly for phone calls. For example, Nurse14 was asked to call the MET when the patient became unconscious. She began: "Hi, we're calling about a 74-year old patient who is feeling unwell, and has lost blood." Resident14 added from the other side of the room: "Clearly hypovolemic," and added "... due to an upper G-I bleed," which the nurse repeated word for word. The time spent on repeating was offset by the use of key words to alert the MET. Likewise, when Dr1 asked Nurse1 to call the supervising physician, Nurse1 said: "We need a supervising physician in Mr. Lopez's room please." and provided no further information, and the team waited for the supervisor. When the other residents called their supervisors, they received suggestions and gave orders before the supervisor's arrival at the bedside. These examples underline the importance of choosing the proper interlocutor.

Team communication supports collaborative reasoning by keeping the team members on the same page, thus allowing for anticipation and coordination. Precision and choice of the speaker were areas for improvement.

Communication with the patient

Explanations to the patient provided opportunities for the resident or nurse to verbalize parts of their reasoning with the other participants. Explanations differed between residents and nurses: Residents mainly provided explanations helping to confirm the management plan, while nurses tended to explain procedures. This difference may explain the low score for nurses on this dimension.

Residents seemed to provide more general management information than the nurses. For example, Dr14 explained:

> We think you have been bleeding, because of the color of your stools. [...] And what we're going to do now – you have lost fluids – is give you some... some salt serum to try to help your blood pressure to increase a bit. And then the medicine to stop the bleeding. And then we're also going to call the G-I team to see if we need to do anything more for the bleeding.

Nurses focused more on procedural explanations: "Now I'm going to draw blood" (Nurse2), but did also provide some of their reasoning to patients. Nurse4 said: "[...] Sometimes these treatments have rather important side effects that can give you nausea. [...] And it's your second cycle of chemo... How did you feel last time?" Likewise, Nurse11 explained: "So now your blood pressure is a little low, and your heart is beating fast. [...] I can see you are quite uncomfortable. I'm going to call the doctor."

We observed low use of verification of patient understanding. Although nurses remained at the bedside, sometimes repeating what the resident had said, none of the teams verified whether the patients understood what they had been told.

Contributing factors and work organization

The perception and expectation of roles could influence the way the participants behaved, beyond the diagnostic reasoning process discussed above (Muller-Juge et al. 2013). Some residents did not expect nurses to contribute to the reasoning process, and some nurses felt they were only executors of residents' decisions. Perception of competence, such as lack of self-confidence might also have discouraged some individuals from making suggestions.

Knowledge is a prerequisite for efficient reasoning, but does not predict efficiency. During the debriefing session, Dr11 displayed good medical knowledge, but had low efficiency during the simulation. Teams faced a similar challenge, as was seen with Team4: despite many good ideas

generated during the simulation, few were applied, and as results, the team did not make much progress in its patient management.

In each team, there were signs of task overload. The residents tended to place many orders in a very short period of time, often too many for the nurses to handle adequately. Residents did not realize that nurses were having trouble. Nurse11 reported in the stimulated-recall:

> Some residents place a series of orders, four or five at the same time. [...] In stressful situations, I tend to focus on something that I'm doing – like giving the patient oxygen I was looking for the face masks – and then [...] I'm given two or three completely different tasks, in different places. Like, the oxygen's at the patient's head, I need to go to the nurses' room to prepare for a second iv, and finally get a drip going... It's hard to be so organized, to not forget anything.

Residents not only placed orders, but they also asked nurses for numerous other things, such as "Do you know where the needles for an [arterial blood gas] are?" or information about the patient's medications, often interrupting the nurses. Then, when residents changed their management plan, reorganized the priority tasks, and placed new orders, nurses were expected to keep up with it all.

Discussion

This study aimed to explore the notion of collective competence particularly regarding clinical reasoning, and to better describe the dimensions of collaborative reasoning, that is, the process of reaching a shared mental model about the patient's problem and its management. Using a qualitative methodology, we first identified five dimensions supporting collaborative reasoning: diagnostic reasoning, patient management, patient monitoring, team communication, and communication with the patient.

Our quantitative analyses about the quality of collaborative reasoning assessed across these dimensions showed that team assessments were lower than the assessment of the individuals. This result reflects prior findings by Hodges and Lingard, where collective competence of a team may differ from the simple average of individual competences (Hodges & Lingard 2013). The addition of individual competence is thus not a guarantee of efficient team performance, because all ingredients favoring good collaboration are not necessarily gathered.

In all five dimensions of collaborative reasoning, we found supportive elements to reach a shared mental model. For diagnostic reasoning, although residents and nurses used different approaches to understand the patient's condition, we found that a strong initial assessment by the nurse can lay the groundwork for better team collaboration, but did not necessarily predict a better team performance. When the nurse remained at the bedside with the resident, there were more opportunities to share their findings.

During patient management, we saw collaborative reasoning through the use of timely and purposeful suggestions, mainly by nurses. These suggestions were often based on prior experience, as a response to an isolated finding. However, their timely and purposeful occurrences indicate that they were the reflection of an autonomous line of reasoning that could influence decisions about the patient management, which goes beyond representing a mere situational context for the physician's own reasoning (Durning & Artino 2011). Residents need to critically assess suggestions before accepting them as a part of patient management. This contextualized assessment was valid in many situations, and was similar to "sensemaking" described in other fields (Mamykina et al. 2015). We also saw the use of huddles to optimize patient management. According to the TeamSTEPPS® framework (Ferguson 2008), huddles are "Ad hoc meeting to reestablish situational awareness, reinforce plans already in place, and assess the need to adjust the plan." Residents and nurses who are on the same wavelength can collaborate better, and can anticipate future actions.

Early detection of patient state changes requires close patient monitoring. Yet, monitoring tended to be low among the teams, who seemed to overlook this dimension. In the case of vital signs, although both professionals can decide and take vitals, residents were more likely to order the monitoring and nurses were more likely to carry out this measurement. Furthermore, monitoring can be improved by the use of standardized measurements, particularly for subjective features like pain. Trends in pain were difficult to assess when the visual-analog scale was not applied.

Our analysis of communication raised two main points. First, nurses tended to communicate their findings to the residents without naming the diagnostic hypotheses. In some cases, this led to a delay until the resident reached her own hypotheses. Although some caution is needed to avoid premature closure, suggesting a diagnostic hypothesis to a resident may improve the team's performance for accuracy. Second, improving the precision of medical orders may also improve efficiency, by avoiding additional questions necessary to explicit them. The teams took time to explain procedures or next steps to the patient, which at times even served as a huddle. However, team collaboration should also enquire about patient comprehension, rather than just providing information.

The contributing factors and work performance analysis show how our general previous findings about roles and conditions for team performance (Muller-Juge et al. 2013, 2014) also apply specifically to collaborative reasoning. For example, residents often displayed low situational awareness. This led to task and order overload for the nurse, who often did not mention this. Similarly, we also found information overload among the teams. Creating a more open atmosphere, where expressing one's difficulties is not perceived as incompetence, and stronger mutual support could be helpful. Besides increasing awareness and mutual support, developing better anticipation could also help address these difficulties. Finally, our teams sometimes had low performance despite good medical knowledge. In prior literature, individuals with this behavior were labeled "vagabond diagnostics," because they generated many diagnoses, jumping from one to another with each new piece data, without an overview of the data (Rudolph et al. 2007).

Team performance across the five dimensions varied considerably, and may be due to several factors: case specificity (teams assessed on a single, albeit common and prototypical scenario), levels of experience, both overall and in internal medicine (range from 6 months to 25 years), level of confidence (calls to supervising physicians did not provide much guidance during the scenarios) and the

simulation setting itself, in particular in terms of knowledge about the patient.

Strengths and limitations

Using high-fidelity simulation provided a unique opportunity to compare the teams in standardized, urgent situations. Our sample was representative of the actual workforce in terms of gender, age and experience. The investigators' backgrounds as physicians and nurse provided insights into legitimate expectations about clinical reasoning and competencies for each professional. Finally, our inductive approach allowed for an exploratory approach in the notion of collaborative reasoning in clinical settings.

Our study has limitations. First, the generalizability of our findings is limited, as our data were collected in a single center. Second, the use of a manikin could have prevented some participants to fully act as they intended, in term of collaboration, communication with the patient, or individual actions such as patient positioning or use of some materials. Third, participants only had little knowledge about their patient for the scenario, so that some expectations could hardly be met (e.g. residents' expectations of nurses' knowledge about the patients). Finally, although the raters assessed the quality of collaborative reasoning based on a strong definition and with good inter-rater agreement, the conceptions of the observers could nevertheless have influenced the assessment of the teams. Basing the assessment of reasoning processes on stimulated recall may also present the limitation of not accessing all cognitive working.

Conclusions

Our findings show evidence of collaborative reasoning between residents and nurses, expressed across the dimensions of diagnostic reasoning, patient management and monitoring, providing explanations to the patient, and team communication, powered by situational awareness. They also point to different reasoning processes used by nurses and residents. Awareness about specificities in the reasoning approaches of each profession and better understanding of collaborative reasoning can provide additional dimensions to interprofessional collaboration and education. Additional studies are needed to further explore the clinical collaborative reasoning process and how it differs from each individual's reasoning.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Glossary

Collaborative reasoning: a team's process of reaching a shared mental model about the patient's problem and its management.

Mason L. 1996. Collaborative reasoning on self-generated analogies: conceptual growth in understanding scientific phenomena. Educ Res Eval. 2:309–350.

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