Acceleration to Expertise in Healthcare: Leveraging the critical decision method and simulation-based training

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ABSTRACT

Introduction: This study at a Children's Hospital applied the critical decision method (CDM) to identify pediatrician's expertise in recognizing sepsis. **Method**: Fourteen CDM interviews were conducted with pediatric residents and faculty. **Results:** We identified critical cues used by expert and novice physicians to recognize sepsis. Using contextual information from critical incidents, the critical cues articulated by expert physicians were integrated into simulation-based training scenarios for novice physicians to accelerate the prompt recognition and early treatment of sepsis.

KEYWORDS

Expertise; Health; Decision Making; Cognitive Task Analysis; Situation Awareness/Situation Assessment

INTRODUCTION

Naturalistic Decision Making methods and models are being used at Cincinnati Children's Hospital Medical Center (CCHMC) to drive the development of simulation-based training for resident physicians. New duty hour restrictions aimed at reducing sleep deprivation, along with increases to resident supervision, have the unintended consequences of limiting exposure to certain cases and closed loop learning within one case. Simulation-based training offers a potential strategy to increase resident exposure to critical illnesses, such as sepsis, over a range of presentations. Sepsis can present in relatively subtle ways and is easily confused with other less urgent and more common conditions. Unless detected and treated quickly, sepsis can be deadly.

Innovation

Critical decision method (CDM) (Crandall, Klein, Hoffman, 2006; Klein, Calderwood, & MacGregor, 1989) data are being used to advance the development of realistic simulation-based sepsis scenarios, leveraging a high-fidelity medical simulation facility that allows for short-duration, high-impact training experiences. This is a novel application of CDM data to generate training scenarios for healthcare simulations. The CDM was designed to aid experts in articulating tacit knowledge, aspects of expertise that are not easily described. In this study, we conducted CDM interviews with both experienced (emergency room and critical care) and novice pediatricians about patients with sepsis. The aggregate set of critical incidents provided realistic cues, cue clusters, and contextual detail to create novel simulation-based training for sepsis recognition. This research extends an earlier study focusing on sepsis cues in neonates (Crandall and Getchell-Reiter, 1993) to include all of pediatrics.

METHODS

Preparation

The principal investigator and core research team were pediatricians and qualitative researchers who were familiar with high reliability methods but were not experienced in CDM interviewing. In preparation for the data collection, three pediatricians and two qualitative researchers attended two half-day workshops conducted by experienced CDM interviewers.

Participants

Fourteen paediatricians, including 8 resident, 3 emergency and 3 critical care pediatricians, participated in individual CDM interviews conducted by trained study team members.

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Interviews

Interviews were conducted by interview dyads containing one experienced pediatrician and one qualitative researcher. Interviewers asked each interviewee to describe a challenging incident involving sepsis. Each interview lasted approximately one hour, was audio recorded and then transcribed.

Coding

The objective of the coding was to identify cues and strategies to be incorporated into simulation-based training. We used a card sorting technique to organize and prioritize the potential coding categories. The resulting coding scheme included seven large categories and subcategories within each. One experienced emergency pediatrician and three qualitative researchers coded the remaining data. For each code, we noted whether the category was mentioned as well as the type of cue (increased/decreased suspicion of sepsis, confusing/misleading) and the type of judgment (normative, ipsative or cue discrepancy).

FINDINGS

A total of 23 patient-based sepsis incidents were discussed in the 14 interviews, 12 incidents relayed by residents and 11 by faculty. Table 1 depicts a subset of the coding categories most relevant to simulation design.

Table 1. Sample coding categories

Categories	All interviews		Residents		Faculty	
	Freq.	% of interviews	Freq.	% of interviews	Freq.	% of interviews
Classic Indicators of Sepsis:						
Consensus Criteria:						
Fever or Hypothermia	18	78.26%	8	66.67%	10	90.91%
Tachycardia or Bradycardia	20	86.96%	10	83.33%	10	90.91%
Tachypnea or Bradypnea	10	43.48%	5	41.67%	5	45.45%
WBC abnormalities (high, low)	6	26.09%	4	33.33%	2	18.18%
Experienced-based Criteria:						
Distal perfusion	15	65.22%	7	58.33%	8	72.73%
Mental status changes	19	82.61%	11	91.67%	8	72.73%
Ill appearance	13	56.52%	7	58.33%	6	54.55%
Hypotension	13	56.52%	8	66.67%	5	45.45%
Other lab abnormalities	14	60.87%	7	58.33%	7	63.64%
Rhythm disturbances	2	8.70%	1	8.33%	1	9.09%
Patient's interaction w/parent	4	17.39%	1	8.33%	3	27.27%
Risk factors for sepsis:						
Medical history						
Obvious source of infection	12	52.17%	6	50.00%	6	54.55%
Chronic medical illness	15	65.22%	8	66.67%	7	63.64%
Age less than 2 months	1	4.35%	1	8.33%	0	0.00%
Indwelling plastic	7	30.43%	4	33.33%	3	27.27%
Lack of immunizations	0	0.00%	0	0.00%	0	0.00%
Fever of unknown origin	0	0.00%	0	0.00%	0	0.00%
Source of Information:						
Family or caregiver concerns/anxiety	11	47.83%	7	58.33%	4	36.36%
Non-physician healthcare provider concerns	6	26.09%	3	25.00%	3	27.27%
Strength of data	3	13.04%	2	16.67%	1	9.09%
Personal trust/respect	4	17.39%	2	16.67%	2	18.18%
Disparity between trainee and faculty impression	5	21.74%	3	25.00%	2	18.18%
Cue clusters	16	69.57%	7	58.33%	9	81.82%

The left column contains coding categories. Frequency counts and percentages for each category are depicted in the columns to the right. If a category was mentioned in an incident, it received a count. For example, *Fever or Hypothermia* was mentioned in 18 out of 23 incidents, or in 78.26% of the incidents. Frequency counts and

percentages are further broken down by experience level with residents being the least experienced participants and faculty representing the experts. Items highlighted in red were mentioned by at least two thirds of the interviewees. . These critical cues became the focus of the scenario design. We have not yet analysed the data for expert-novice differences.

Classic indicators/Consensus Criteria

As expected, the classic indicators of sepsis appeared frequently in the critical incidents related by interviewees. These indicators are traditionally associated with sepsis and can be considered the "textbook signs" of sepsis. Signs of fever and tachycardia or bradycardia were the most frequent classic indicators, with tachypnea or bradypnea and white blood cell count abnormalities appearing less frequently.

Experience-based Criteria

Experience-based criteria require more judgement and intuition to recognize the clinical importance of the cue. For example, abnormal distal perfusion was described frequently in the critical incidents, in a range of different ways. Some physicians described color change as a cue while others mentioned cool or mottled extremities. Figure 1 provides a list of descriptors used to describe important changes in distal perfusion.

Distal Perfusion Descriptors			
Skin color Pale Pale-ish gray Pasty Pallor (African Amer.) Yellowish No nice flush on cheeks Mottled Flushed Purple Reticulated pattern	Extremities Mottling, especially lower extremities Hands were mottled Extremities were cold Pale extremities Nose was yellowish	Temperature Cold Mottled + warm Sweating Perfusion was warm	Other Delayed cap refill Decreased peripheral perfusion Poor peripheral pulses Vaso-constricted Pulses were thready

Figure 6. Distal perfusion descriptors

Mental status changes were another frequently mentioned experience-based cue. These can be subtle and often depend on a comparison to a "normal" or baseline state for that patient. Mental status is particularly difficult to assess in patients who have comorbidities or may be on medications that alter mental status and activity level.
Ill- appearance was mentioned frequently by first-year residents. In this category, we included any mention of an impression or gestalt of well, ill, toxic, or unable to explain/non-descript "not normal."

Medical History

Chronic medical illness is a risk factor for developing sepsis that appeared consistently in the critical incidents. Often this was in the context of a discussion that children with chronic medical conditions are more likely to have infections, represent a population where it is more difficult to discern altered mental status due to medications or developmental delays, and routinely exhibit some of the consensus criteria such as difficulty breathing or rapid heart rate, which could be used to reject sepsis as a possible diagnosis.

Source of information

Interestingly, the least experienced physicians in our sample, first year residents, frequently mentioned *family or caregiver concerns* as an important cue in the critical incidents they discussed (75% of interviews). Parent identification of a change in baseline, that the child "just isn't himself", often cued a resident to begin to consider more serious conditions such as sepsis.

SCENARIO DESIGN

Scenarios

Critical cues identified in the CDM interviews drove the design of five scenarios presenting challenging sepsis cases, including one garden path scenario. The intent was to design scenarios that would accelerate the recognition of sepsis in novice physicians. Junior residents often observe and provide support functions; they are rarely the primary team leader. As a result, they generally gather information based on assessments and interpretations made by other healthcare professionals rather than experiencing the cues directly. The simulation facility represents a safe environment in which we would be able to place residents in that leadership role where they would have to seek, interpret, and make meaning from the cues available without the help of a more senior physician.
We chose to focus on critical cues and cue clusters frequently mentioned in the interviews as important indicators of sepsis. In more traditional scenarios, it is common to provide the participant with findings from radiographs, ECGs, or distal perfusion by simply reporting the results. For this project, we wanted to present the

patient with the raw data to support the development of perceptual skills and pattern recognition in the context of a challenging incident. Rather than having an actor provide radiographic findings over the phone, we presented the participant with the image so that s/he could interpret them first-hand. Some cues required innovative strategies such as placing the feet of the mannequin in ice prior to training to simulate cold extremities. To improve the fidelity of mental status cues, we used a voice modulator that allowed adult actors to speak through the mannequin in the voice of an adolescent male, a 2-year old girl, 6-year-old boy, depending on the requirements of the scenario. Videos and screen shots were used to depict changes in skin appearance and capillary refill and required the physician to interpret the image and independently draw their conclusions.

Cognitive artifacts such as medical history and lab results were incorporated into the simulation. Scripted comments from support staff and family members were included to simulate cues identified in the interviews. We also incorporated verbatim comments from the critical incidents into scenarios to make the actors playing the role of support staff more realistic. Scripted telephone responses from consulting physicians and radiology techs were embedded to increase realism while limiting the number of actors required to conduct the simulation.

Another innovative approach integrated into the scenarios was more realistic timing and urgency. Often scenarios are focused on emergent crisis situations, such that the patient has impending or actual cardiorespiratory failure leading to a medical code. Several of the CDM incidents included situations in which a patient's condition slowly deteriorated, making it easy to miss the sepsis cues. In order to address this, we designed scenarios that are more representative of the way a situation is likely to unfold on the unit..

To illustrate, one scenario involves a 6-year-old boy with developmental delays who is recovering from surgery for a broken arm. Initially, the child has a normal temperature, but develops labored breathing and an increased heart rate (tachycardia). His eyes are closed and he cries intermittently. He is slightly blue around his lips and chin. As the pediatrician examines the child, the child becomes agitated and inconsolable. Capillary refill is delayed. As the scenario unfolds, the patient's condition changes depending on the intervention(s) performed by the pediatrician. However, even if the pediatrician intervenes quickly and appropriately, signs of sepsis become more evident (i.e., heart rate increases and blood pressure drops, respiratory rate goes down, level of consciousness decreases). In this scenario we incorporated a number of cues mentioned in critical incidents including a chronic medical illness (developmental delay), delayed capillary refill (visible on video), and changes in activity level and mental status in addition to standard consensus criteria (tachycardia and bradypnea).

CONCLUSIONS & NEXT STEPS

CDM interviews revealed a set of critical cues and cue clusters that were successfully integrated into scenarios used in a simulation environment. The rich detail elicited in the CDM interviews drove the use of innovative strategies for presenting raw data to residents in the simulation so that they would be challenged to notice and interpret the cues without the help of more senior personnel.

At the time of this submission, we are testing the scenarios to distinguish novice and expert differences in recognition of sepsis. Using the scenarios developed based on critical incidents, a cohort of pediatric residents and faculty were recruited to participate in the study. Measures include an adapted version of the situation awareness global assessment technique (SAGAT) (Endsley & Garland, 2000) to assess each participant's understanding of the situation at three points in each scenario. Following the testing process, a full simulation-based curriculum for the recognition of sepsis will be implemented for all first year pediatric residents.

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