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Applied cognitive task analysis methodology: Fundamental cognitive skills surgical nurses require to manage patient deterioration

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Abstract

This study's aims were twofold: firstly, to identify the cognitive skills required of surgical nurses to rescue the deteriorating patient; and secondly, to elicit insight into the potential errors in decision-making inexperienced nurses commonly make in the same situation. An exploratory qualitative design used applied cognitive task analysis. A series of three in-depth interviews with six experienced surgical nurses were employed to collect the data. Applied cognitive task analysis interviews are sequential to identify different aspects of expert knowledge: the task diagram interview; the knowledge audit interview; and the simulation interview. Five difficult cognitive demands were identified when a patient is deteriorating: early recognition of physiological deterioration; confirming physiological deterioration; initiating rescue; securing medical assistance; and rescuing the patient. Nurses require the following cognitive skills to respond effectively to these cognitive demands: decision-making; leadership and management; patient advocacy; situation awareness; and planning. Educators should be aware of these cognitive demands and the specific cognitive skills required to manage patient deterioration and design initiatives to help accelerate nurses' cognitive expertise and consequently reduce errors. The study also highlights the importance of adequate shift coverage with highly skilled nursing staff.

Keywords / Ngā kupu matua:
cognitive task analysis/te tātaritanga mahi hirikapo tūturu; cognitive skills/ngā pūkenga hirikapo; decision-making/te whakatau take; deteriorating patient/te tūroro e taumahatia ana; surgical nursing/te tapuhi poka tinana

Te Reo Māori translation

He kaupapa tikanga tātaritanga mahi hirikapo: Ko ngā pūkenga hirikapo me mātua whai ngā tapuhi poka tinana hei whakahaere tika i te tūroro kua taumahatia

Ngā ariā matua

E rua ngā whāinga o tēnei rangahau: tuatahi, kua tautohutia ngā pūkenga hirikapo me mātua whai ngā tapuhi taiwhanga poka tinana hei whakarauora i te tūroro kua taumahatia; tuarua, kia kitea he māramatanga mō ngā hapa tērā pea ka pā pūputu i roto i te whiriwhiri take a ngā tapuhi tauhou i ngā āhuatanga ōrite. I whakamahia te tātaritanga mahi hirikapo tūturu i tētahi hoahoatanga tūhura inekounga. I whakamahia ētahi uiuinga hōhonu e toru ki ētahi tapuhi poka tinana tokoono tautōhito hei kohi i ngā raraunga. I whai tētahi o ngā uiuinga tātaritanga mahi hirikapo tūturu i tētahi atu, hei tautohu i ngā momo mōhiotanga mātanga: te uiuinga hoahoa mahinga; te uiuinga mōhiotanga arotake; me te uiuinga whakataruna. E rima ngā mahi hirikapo uaua i tautohutia, i te wā e taumahatia ana tētahi tūroro: te kite wawe i te hēnga o te tinana; te whakaū i taua hēnga o te tinana; te tīmata ki te whakarauora; te rapu āwhina tākuta; me te whakarauora i te tūroro. Me mātua whai ngā tapuhi i ngā pūkenga e whai ake nei hei urupare ki ētahi karanga hirikapo: te whakatau take; te hautū me te whakahaere; te tū hei kaikōrero mō te tūroro; te mārama ki ngā āhuatanga o te wā; me te whakamahere. Me mātua mōhio ō rātou kaiako ki ēnei pūtake hirikapo me ngā pūkenga hirikapo motuhake e hiahiatia ana hei whakahaere i te taumahatanga tūroro, me te hoahoa tikanga hei whakapakari wawe i ngā pūkenga hirikapo, hei kaupare hoki i ngā hapa. Kei tēnei rangahau hoki ka kitea he mea nui kia maha ngā kaimahi mō ia wā mahi, kia whai pūkenga tiketike hoki ngā kaimahi.

Introduction

A key challenge for surgical nurses is the early recognition of patient deterioration and rescuing the patient (Bacon, 2017; Marshall, 2016; Mushta et al., 2018). This requires making complex cognitive decisions, often in time-constrained situations. Nurses' poor performance of cognitive skills such as problem-solving and decision-making have been linked to delays in recognising and managing physiological deterioration, which may lead to an adverse event (Massey et al., 2014; Verrillo et al., 2019). Other factors such as environmental issues and inadequate staffing levels have also been associated with failure to rescue a patient (Bacon, 2017; Pandit et al., 2019). Evidence shows that expert nurses make clinical judgements more effectively than their less experienced colleagues who are more prone to errors in decision-making (Benner, 2001; Marshall, 2016; Saintsing et al., 2011). However, when asked to recall how they make judgements and decisions during a complex task, experts often omit critical information mainly because they rely on knowledge that has often become automatic and bypasses conscious processes (Crandall et al., 2006). This has significance for nursing education as novice nurses rely on the ability of mentors to teach them the necessary actions and decisions associated with managing safe and effective patient care. Identifying the knowledge and cognitive skills that expert nurses use when managing patient deterioration may provide insights for nurse educators to accelerate nursing students' cognitive skills and improve their decision-making when a patient is deteriorating. Identifying cognitive skills can be challenging however, as this knowledge is often difficult to articulate, formalise and describe (Gore et al., 2018). Cognitive psychology techniques such as cognitive task analysis (CTA) provide an opportunity to yield information about this unconscious knowledge (Schraagen et al., 2000). In this study, an Applied Cognitive Task Analysis (ACTA) (Militello & Hutton, 1998) was undertaken to identify the cognitive skills required of nurses in the context of managing early deterioration in surgical patients.

Background

Cognitive skills

Cognitive skills are the core skills we use to think, learn and reason with and are crucial for processing new information (Crandall et al., 2006). They are non-technical skills and "complement technical skills and contribute to safe and effective task performance" (Flin et al., 2008, p. 1). Cognitive skills include situation awareness and decision-making. Situation awareness comprises three components: gathering information, interpreting information, and anticipating future states. It can be explained as people's cognitive processes for continuously monitoring what is happening around them and foreseeing future events based on past and present knowledge (Endsley, 1995). Situation awareness is the first stage in the decision-making process and necessary for identifying potential problems and intervening before they escalate (Flin et al., 2008). Decision-making is the cognitive process of choosing a course of action from several alternative options to meet the demands of a given situation (Klein et al., 2010). Decision-making comprises four components which are as follows: situation assessment/defining the problem; generating and considering one or more response options; selecting and implementing an option; and outcome review (Flin et al., 2008). Depending on the situation, different techniques may be employed to choose an appropriate course of action. Four decision-making techniques used to generate a response option are recognition-primed (intuitive); rule-based; choice through comparison of options; and creative (Klein, 1997). The appropriateness of the method selected will depend on the level of expertise of the decision maker (Miller & Hill, 2018). A critical final step in decision-making is checking that the desired result is achieved.

In the surgical ward, the specific cognitive skill set required of nurses for safe and effective care has not been identified. Although decision-making by medical-surgical nurses has received attention (Benner, 2001; Parker, 2014; Thompson & Dowding, 2009), situation awareness, has not been investigated. However, it may be a cognitive skill nurses require as it is the first step in decision-making (Klein, 1997). If knowledge of the cognitive skills used by experienced nurses to manage a deteriorating surgical patient can be identified and disseminated to less experienced nurses, it may strengthen their ability to identify potential problems early and escalate care appropriately.

Applied cognitive task analysis

In safety critical domains such as aviation and engineering, experts' thought processes that enable them to make critical decisions in complex situations have been explored through CTA methods (Gore et

al., 2018). Researchers do this by studying prior critical incidents to see what made them so difficult and why decision-makers succeeded, thereby exposing the specific cognitive skills needed to make better decisions to perform a task proficiently. These CTA methods also explicitly reveal differences in expert and novice performance by identifying the knowledge and cognitive skills that experts draw on and how these differ from those used by the less experienced (Militello & Hutton, 1998). This information has been useful in identifying cognitive training requirements for novices (Yeung et al., 2017). However, traditional CTA methods require extensive training and resources to implement and provide limited understanding of cognitively complex tasks (Salas & Klein, 2001).

Applied cognitive task analysis (ACTA) is a modified CTA approach developed by Militello and Hutton (1998) that can be applied easily in time-constrained settings and designed so that little prior training is required for implementation. Derived from a naturalistic decision-making approach (Klein, 1997) ACTA seeks to understand and improve real-world decision making by accessing the experience-based cognitive skills of experts. Its primary goal is to produce outputs that can support training development in applied settings. Researchers have successfully used ACTA in experiential work in the health care domain to elicit critical information for effective decision-making in neonatal resuscitation (Pickup et al., 2019) and liver transplantation (Morozova et al., 2017). It has also enabled potential sources of error in decision-making to be identified in the financial domain and has high levels of validity and reliability in generating consistent data across participants (McAndrew & Gore, 2013).

The ACTA process provides an extensive exploration of key cognitive elements required to perform a challenging task competently. It specifically examines the difficult cognitive demands and why they are difficult, the critical cues and cognitive strategies used in decision-making by experts, and aspects a novice or less experienced person may find difficult. In contrast to other CTA methods, ACTA utilises a range of techniques to elicit and represent "task-specific, expertise-based knowledge" (Gore et al., 2018, p. 557). The knowledge elicitation techniques utilised in ACTA examine macro-cognitive processes by generating mental models (Crandall et al., 2006) that provide a visual representation of tacit knowledge gained from experience.

The ACTA process comprises three data collection phases of complementary knowledge elicitation interviews: the task diagram interview; the knowledge audit interview; and the simulation interview. After conducting the interviews, a cognitive demands table is constructed to enter and analyse the data. An ACTA 'toolkit' of detailed instructional materials is provided to guide the researcher in the use of the three interview techniques and data analysis.

The first interview is the task diagram interview designed to provide a surface-level representation of the challenging task or situation being explored. A flow diagram is constructed during the interview to present a mental model of the physical tasks involved. It also identifies the difficult cognitive components of the task that require assessment, judgements or problem solving. This information provides the focus for the knowledge audit interview.

The purpose of the knowledge audit interview is to obtain domain knowledge about the task that requires cognitive expertise. It explores how experts perform proficiently and the potential errors a novice may make in the same situation. This information is gained from a set of eight cognitive probe questions based on aspects of expertise. They include: "past and future" probe (diagnosing and predicting), "big picture" probe (situation awareness), "noticing" probe (perceptual skills), "job smarts" probe (developing and knowing when to apply tricks of the trade), "improvising" probe (taking advantage of opportunities), "self-monitoring" probe (meta-cognition), "anomalies" probe (identifying unusual or atypical events), and "equipment difficulties" probe (compensating for equipment limitations) (Militello & Hutton, 1998, p. 1621). The elicited responses are presented in a knowledge audit table which documents aspects of expertise and the significant cues and strategies experts rely on. This is followed by a discussion of the difficulties a novice or less experienced person might face in a similar situation.

The simulation interview is based on the simulation of a scenario of the situation. This could be presented, for example, in the form of a pen and paper exercise or video. Following the simulation, participants are asked to identify the major events that occurred and how they would think and act in that situation. Each event is probed for situation assessment, actions,

critical cues, and potential errors related to that event. This technique provides a deeper understanding of the cognitive processes used when making decisions within the context of the situation and provides information not identified during a knowledge audit.

Finally, all interview data from across the three interviews undergoes analysis and synthesis and a cognitive demands table is constructed to present the findings from the ACTA. This table focusses on problem solving and decision making and presents the difficult cognitive demands pertaining to the situation and why they are difficult. The cues and strategies used by experts and the errors made by novices associated with the cognitively challenging situation or task are also presented.

The advantage of ACTA is that it presents results that can be used in an applied setting (Pickup et al., 2019), however, there is limited literature related to ACTA methodology and a lack in the nursing domain. This study endeavours to fill this gap and take a critical look at the usefulness of ACTA for identifying the cognitive skills required to effectively manage patient deterioration.

The study

Aim

The aim of this study was to identify the tasks involved and the cognitive skills required of general surgical nurses when making critical decisions in challenging situations such as patient deterioration. It also sought to elicit insight into inexperienced nurses' potential errors in the same situation.

Design

This study employs an exploratory qualitative research design using ACTA to understand nurses' decision-making expertise. Semi-structured interviews were used to collect rich data and capture insights into nurses' real-world decision-making in challenging clinical situations. This approach provides an understanding of the cognitive skills required of nurses to effectively manage the challenging situation and the differences in expert and novice performance. The research questions guiding this study were as follows: What cognitive skills do nurses use in challenging situations in a general surgical ward? What are the differences in the level of performance of cognitive skills between experienced and less experienced nurses?

Participants

Nurses were recruited from acute general surgical wards in a large metropolitan hospital and a smaller private surgical hospital. Following meetings with charge nurses of four potential study wards, flyers explaining the study were posted on ward notice boards. The researcher attended staff handovers to introduce the study to the nurses and provided the opportunity to have any questions answered before inviting them to participate. Participants were eligible for the study if they were registered nurses of any level in their organisation's Professional Development Recognition Programme (PDRP) and worked full or part-time on adult general surgical wards. Registered nurses employed in managerial roles were excluded. Those who were eligible and who volunteered to participate were provided with a participant information sheet outlining the study and informing them of their rights.

As the ACTA process requires highly skilled subject matter experts as its data source a purposive sampling technique (Etikan et al., 2016) was employed to ensure a sample that included at least three highly experienced nurses. This sample size is consistent with ACTA protocols in which three to five experts are sufficient for an ACTA. Including participants with differing levels of experience can also provide a contrast of expert and novice perspectives (Militello & Hutton, 1998). The sample included two expert nurses and one at proficient level transitioning to expert level. Their length of experience in general surgery ranged from eight to 50 years. Three less experienced nurses at the competent level, whose length of experience in general surgery ranged from three to five years were recruited to provide a sample that was representative of the skill base on the surgical wards.

Ethical Considerations

Ethics approval for this research was granted by a regional ethics committee (reference NTY/09/07/059) and the ethics committee of the participating district health board. Participants were given oral and written information about the purpose of the study. They were informed interviews would be audio recorded and assured of confidential and secure storage of data. Written informed consent was obtained from all participants prior to the commencement of interviews. Participants were

given the opportunity to have any questions answered before signing the consent form and were aware of their right to withdraw consent at any time. Anonymity was maintained during the transcription process and pseudonyms were used in reporting the findings.

Data Collection

Data were collected using semi-structured interviews guided by the interview protocols provided by the ACTA toolkit (Militello & Hutton, 1998). Each participant was interviewed individually three times at a time and place convenient to them between January 2013 and June 2015. During the interview, diagrams and tables were constructed as specified by the ACTA protocol. Brief notes were also taken by the researcher as a prompt to seek further clarification or for further discussion during or after the interview. Each interview lasted 30–50 minutes and then was transcribed verbatim and checked for accuracy against the audio recordings. All participants were invited to review the recordings and/or transcripts.

Task Diagram Interview

For the task diagram interview, participants were asked to recall a time they recognised a patient was experiencing a serious postoperative complication. They were then asked to give a brief overview of the problem and their actions and to break this down to three-six steps. The information was summarised in a task diagram which provided a simplified mental model of how the participant viewed the situation. Participants then identified the steps that required problem solving or decision-making skills and these steps were circled on the diagram to be probed in the knowledge audit interview. Figure 1 presents the task diagram of an expert nurse's recognition and response to a patient with a postoperative bleed following tonsillectomy.

Knowledge Audit Interview

Each cognitive probe used in the knowledge audit interview produced data that illustrated aspects of expertise, cues and strategies, and difficulties for novices. For example, to elicit data for the 'past and future' probe, participants were asked: Is there a time you walked into the middle of a situation and knew exactly how things got there and where they were headed? To provide the 'big picture' of the situation they were asked two probe questions: Can you give me an example of what is most important about the big picture for this situation? What are the most important factors you need to know and keep track of? Narrative excerpts from Participant C's responses to the knowledge audit probes of 'past and present' and 'big picture' are provided below.

Past and future

You can kind of tell when they have been back to the ward for a while and something's not quite right … like an hour or two later. Like walking in the room … It's usually pretty obvious. You know it's not anaesthetic related … they're restless, something's happening … these sorts of things [bleeding] normally happen a bit later on …

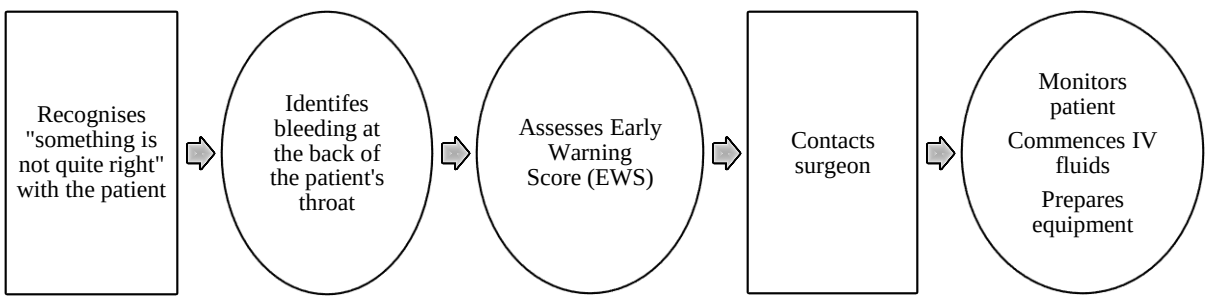
Big picture

I think the biggest thing is what they look like or are demonstrating. You know their manner, like how restless they are. How they're sweaty, pale and restless …, increasing heart rate, nausea, pain are all concerns.

Simulation interview

The simulation interview was based on the task of recognition and rescue of a deteriorating patient. A patient scenario involving haemorrhage following a laparoscopic hysterectomy was presented to each participant in written format. Each participant was

Figure 1: Participant C: Task diagram of an expert nurse's early recognition and response to a patient with a postoperative bleed following tonsillectomy



asked to imagine they were the nurse in this situation. A set of five simulation interview probes from the ACTA toolkit asked participants to identify the following: key events, the actions they would take, assessments and critical cues for managing the situation, as well as errors an inexperienced nurse would likely make. For example, participants were asked: as the nurse in this scenario, what actions if any would you take at this point in time? One of the key events participants identified in the simulation interview was: "The patient is pale." Narrative excerpts from the simulation interview transcript relating to the event of "The patient is pale" are provided to illustrate the actions, situation assessment and the critical cues noted by participants as well as potential novice errors.

Actions

She's very pale, anxious, that's a flag. Re-do the recordings because sometimes there's just a minimal change, even if they're bleeding ... even at this stage I'd be ringing them [the doctor]. [Participant E]

Check if it's patent [wound drain], if it's draining, how much has drained and in what period of time, what does it look like? Is it thick blood or just washing? Look at the abdomen. The shape, how it feels, depress it ... quite firm or hard, swollen, tight. Is it distended? Press on the wound or around the wound, see if it causes pain or you feel pressure like a haematoma ... [Participant C]

Situation assessment

Well I think ... a fairly brisk bleed or a haematoma forming because she feels so terrible ... the reason her blood pressure's still not concerning, is maybe she had a lot of fluid in theatre. [Participant E]

If they are pale the first thing that would come to mind would be blood loss. [Participant F]

Critical cues

Visually obviously pale, clammy ... usually shows something going on physiologically ...

it's not something you want to ignore for too long. [Participant C]

Potential errors of novices

Not perhaps looking at the patient. Yes, just not aware, not walking into a room and thinking "oh, she doesn't look very well" ... not picking up on that and just looking at the monitor ... the most important thing is, they've really got to touch and look. [Participant F]

I think the recordings would put them off looking any further. [Participant E]

Data analysis

Task diagram interview

On completion of the interviews each cognitive element identified in the six task diagrams was analysed for commonalities across the data set and a master task diagram was created to provide a mental model of the difficult cognitive components of recognising and responding to patient deterioration.

Knowledge audit interview

Analysis of the knowledge audit interviews involved working with the individual interviews and

Table 1: Extract from the master knowledge audit table

Probe	Aspects of expertise	Cues and strategies	Why difficult? (for novices)
Past and future	Recognising the development of a postoperative complication and knowing there is the potential for further decline and risk to patient safety	Know what cues and patterns to look for relative to the time elapsed since surgery	They lack experience and do not recognise the significance of early cues and patterns
		Do not hesitate to call for assistance	
Big picture	Knowing the expectations of a normal recovery for the surgical procedure and being responsive to patients' changing needs	Conduct regular assessments and observations of the patient to determine progress. Increase frequency if indicated	They may be overwhelmed and do not think to look beyond the immediate problem
		Get to know the patient through continuity of care	
	Knowing how to manage the patients' changing needs safely and when to seek assistance from medical staff	Identify priorities and the actions required to minimise further decline	They tend to wait and see as they do not understand what is happening
		Initiate collaborative management when required	

deconstructing the data to identify information about the cognitive elements. This process was guided by questions posed by Crandall et al. (2006, p. 114) to bring cognition and context into view and to think about the relevance to the research question. The first pass of data provided an orientation to the data set before identifying the cognitive elements on subsequent passes which were undertaken until no new insights were gained. As cognitive information was identified it was entered into individual knowledge audit tables which were then summarised into a master knowledge audit table. Table 1 presents an extract from the 'past and future' and 'big picture' probes in the master knowledge audit table.

Simulation interview

Analysis involved systematically examining the six simulation interviews and analysing each event identified in the scenario by the participants. Analysis was again guided by questions posed by Crandall et al. (2006, p. 114). Multiple data passes were implemented until no new insights were gained. As elements of cognitive information were elicited from the data they were entered into individual simulation tables which were then analysed for commonalities and summarised into a master simulation interview table. Table 2 presents an extract from the master simulation table for the event, "the patient is pale." which participants identified as significant in the scenario with which they were presented.

To complete the analysis a cognitive demands table was constructed to synthesise and amalgamate the task diagrams, the knowledge audits, and the simulation interviews. The series of three interviews generated copious data. Analysis involved working systematically through the interview findings for common themes and conflicting data. Information relevant to the aims of the study was then coded and categorised according to the following categories offered in the ACTA toolkit: difficult cognitive demands; why difficult; critical cues and cognitive strategies; and novice errors. Items were coded for whether they addressed a cognitive skill or cognitive challenge that a nurse encounters.

Lincoln and Guba's (1985) constructs for establishing trustworthiness and credibility were applied.

Findings

The cognitive demands table captured the tacit knowledge of the participants and provided a comprehensive view of the cognitive challenges of patient deterioration. It presents the cognitive demands required of nurses in general surgical wards when a patient is deteriorating, and the knowledge and skills nurses need to respond safely.

Furthermore, it establishes the important cognitive skills and strategies that form the core of effective decision-making. The limitations in knowledge and strategies of less experienced nurses are also revealed.

Overall, five difficult cognitive demands were identified: 1) early recognition of physiological deterioration; 2) confirming physiological deterioration; 3) initiating rescue; 4) securing medical assistance; and 5) rescuing the patient.

Cognitive Demands

1) Early recognition of physiological deterioration

Patient deterioration is the most challenging situation faced by the general surgical nurse. The cognitive demand of early recognition of physiological deterioration arises in the early compensated state of physiological decline when body systems are being maintained and vital signs are in the normal range. During this phase, there is a limited therapeutic window to prevent irretrievable harm and experienced nurses know the patient's

Table 2: Extract from the master simulation interview table

Events	Actions	Situation assessment	Critical cues	Potential errors
The patient is pale	Assess for signs of bleeding and assess oxygen saturation Increase frequency of observations of all signs and symptoms of the patient Check intraoperative blood loss Seek a second opinion from a senior colleague Request medical review	The patient may have internal bleeding or hematoma Consider physiological compensation Determine fluid replacement since surgery	Increasing pallor and clammy skin	Failing to recognise pallor as a sign of bleeding Concentrating on electronic monitoring equipment and not touching the patient's skin Delaying a response and not realising the patient is compensating physiologically and could quickly deteriorate

Table 3: Extract from the cognitive demands table for early recognition of physiological deterioration

Difficult cognitive demands	Why difficult?	Critical cues and cognitive strategies experienced nurses use	Common errors less experienced nurses make
Early recognition of physiological deterioration	Initially body systems are able to compensate when compromised and may conceal or mask deterioration	Observe for any changes in the patient's physical, behavioural or emotional status	Less likely to realise the significance of subtle changes in a patient's behaviour or appearance
		Ask patient how they are feeling, note what they say	
	Requires rapid assessment	Do not rely solely on monitoring equipment	Less likely to rigorously assess the patient allowing deterioration to go undetected
		Listen to depth and pattern of breathing	
		Feel patient's skin temperature and peripheral warmth	
		Palpate strength, volume and regularity of pulse	
		Evaluate vital signs	Continue the same care as the patient seems stable
		Anticipate there could be further deterioration	
		Keep in mind the safety of the patient	

situation can quickly deteriorate. Experienced nurses identified the difficulty for less experienced nurses as having limited exposure to patients with complex problems. Consequently, they fail to capture the problem as they do not recognise the significance of early cues of evolving physiological decline, such as restlessness, because they have been taught to assess for deterioration in a patient's vital signs. In contrast, experience with such patients leads to experienced nurses responding intuitively and promptly triggering an escalation in care for patients in the early compensated state of physiological deterioration. An extract from the cognitive demands table for the cognitive demand of early recognition of physiological deterioration is presented in Table 3.

2) Confirming physiological deterioration

Confirming physiological deterioration as early as possible is vital. Once physiological decompensation occurs and homeostasis is no longer being maintained, deterioration proceeds rapidly, further narrowing the opportunity for therapeutic intervention. This cognitive demand is time-constrained and difficult because it does not always present in the patient's early warning score (EWS), which is commonly used to detect clinical deterioration. This cognitive demand requires nurses to interpret uncertain information and make decisions under pressure. Experienced nurses reported this requires situation awareness and the ability to think critically and quickly process the patient's verbal and non-verbal cues to understand the situation. They also reported that in contrast, less experienced nurses can display tunnel vision, only focussing on the patient's vital signs as they do not recognise what they are observing. Consequently, they fail to comprehend the urgency of the immediate situation which has implications for the safety of the patient.

3) Initiating rescue

Once it is determined that the patient's condition is deteriorating, the patient's survival is threatened. Initiating rescue is a cognitive demand that requires an in-depth understanding of the factors contributing to the patient's physiological deterioration. During this phase, experienced nurses do not waste time as they know they have a limited window of opportunity to intervene and minimise the potential for further physiological decline. Experienced nurses know the protocols, their resources, and when to call for medical intervention. They have mastered therapeutic communication techniques, can provide an empathetic understanding of the patient's experience, and know the importance of supporting the patient to reduce their stress. In contrast, the experienced nurses reported that less experienced nurses tend to 'wait and see' as they are unfamiliar with the situation. They also noted that less experienced nurses delay initiating rescue as they

cannot articulate their concerns or project into the future and anticipate events.

4) Securing medical assistance

When management of the problem is ascertained to be outside the registered nurse's scope of practice, medical intervention is requested. Securing medical assistance is a difficult cognitive demand that requires the nurse to advocate for the patient and make the medical team aware that prompt medical review and support is needed. However, early physiological deterioration is not always accompanied by changes in objective clinical signs to which doctors respond. Experienced nurses, through their close contact with patients, have learned to recognise patterns of subjective cues that suggest deterioration earlier than is shown in objective vital signs and therefore determine that medical attention is required. Doctors, however, do not always afford the same level of importance to these cues. To secure the response they are seeking, experienced nurses know how to provide a detailed and systematic account of the problem to inform the doctor(s) of their concerns. They clearly and concisely state what they think the problem is, what is needed, and request or recommend the assistance they require. The experienced nurses reported that less experienced nurses are reluctant to request assistance from medical staff. They have difficulty communicating their concerns and fear making mistakes because they lack knowledge of the clinical area.

5) Rescuing the patient

When a patient shows signs of physiological deterioration, increased therapeutic intervention from nursing and medical teams is required. Rescuing the patient is a cognitive demand that necessitates that nurses and doctors work collaboratively to provide effective care, and they have a common understanding of the goals they are trying to achieve. This requires nurses to contribute to the decision-making process regarding the plan of care and utilise leadership and management skills to promote the patient's well-being. If required, they coordinate the transfer of the patient to a special care unit such as intensive care or the operating room. Experienced nurses reported that less experienced nurses do not initiate interventions independently or engage in team decision-making in such circumstances.

Key cognitive skills

The study identified five key cognitive skills required of surgical nurses to meet the cognitive demands of a deteriorating patient. They are as follows: situation awareness; decision-making; leadership and management; patient advocacy; and planning.

Discussion

The current study is the first to examine the cognitive skills required of surgical nurses to manage patient deterioration utilising ACTA methodology (Militello & Hutton, 1998). This approach has provided understanding about critical information regarding the cognitive requirements, actions and potential errors for nurses when recognising and rescuing the deteriorating patient. It has systematically analysed nurses' cognitive skills specific to each cognitive demand when a patient deteriorates. This approach has shown that the development of cognitive skills is sometimes associated with errors of performance and that experience is an essential component for their development and nurses' ability to make effective decisions. These findings are consistent with earlier studies on the concept of expertise development and skill acquisition (Benner, 2001).

The study showed that when a patient deteriorates, experienced nurses used a combination of tacit cognitive skills and cognitive processes to manage safe and effective care. Depending on the nature of the cognitive demand they were responding to, the study revealed experienced nurses used both recognition-primed decision-making (RPD) or intuition (Benner & Tanner, 1987; Miller & Hill, 2018) and analytical decision-making skills (Tanner, 2006). The model, RPD, was developed by Klein et al. (2010), and proposes that skilled decision-makers use recognitional processes gained from experience to generate a rapid and effective response to a problem. They do this by quickly matching learned cues to a current situation without comparing options. This response contrasts to the slower analytical mode of thinking typical of hypothetico-deductive reasoning based on cue recognition and interpretation, evaluating information, and comparing options when deciding (Banning, 2008; Tanner et al., 1987).

The cognitive demand for the early recognition of physiological deterioration confirms that cue recognition skills (Klein, 1997) are essential nursing skills that enable the nurse to trigger a timely response to a problem. Experienced nurses were

constantly collecting information about patients using visual, tactile, and auditory cues. This provided an overall awareness of what was happening with the patient and the ability to recognise and understand the meaning of subtle subjective cues when a patient's progress was beginning to deviate from what was expected. This study revealed that the cues are context-specific, and the nurses recognised cue patterns that signalled the patient was deteriorating. The participants described this initial recognition as "intuition" (Klein et al., 2010). They explained they recognised particular cues from earlier experiences that helped make sense of events without consciously thinking about them. This enabled them to foresee what might happen and make decisions as quickly as possible to minimise harm to the patient. This finding is consistent with other studies that have identified the ability of expert nurses to make effective decisions based on pattern recognition or intuition (Hutchinson et al., 2016; Melin-Johansson et al., 2017; Tanner, 2006). This recognition, the nurses explained, is learned from years of experience which is consistent with Klein et al.'s (2010) assertion that intuition or RPD is a by-product of experiential learning. Such learning enables complex decision-making without thinking analytically. Furthermore, this finding demonstrates that situation awareness is an important cognitive skill required of surgical ward nurses to provide safe and effective care.

In contrast, less experienced nurses' decision-making was reported by the experienced nurses as being less structured and more fragmented. They explained that when less experienced nurses view the same cues indicating an unexpected change in a post-operative patient's condition, they do not recognise them as important because of their lack of experience and exposure to such situations. This finding aligns with Klein and Hoffman's (1992) assertion that "novices only see what is there; experts see what is not there" (p. 203). It shows the importance of extensive experience for making effective decisions in complex situations, as previously described by the RPD model and is consistent with Benner's (2001) findings. Bobay (2004) concluded that while experience is an important characteristic of expertise, it is not longevity, but the transformational quality of the experience that is important.

Once nurses recognised physiological deterioration, it was vital to correctly identify the problem's underlying cause and initiate a plan of action. This required the nurses to use an analytical decision-making process to verify their intuition and ascertain if the pattern of cues they had observed was for the reason they suspected. The study revealed experienced nurses responded to the cognitive demand of 'confirming physiological deterioration' by undertaking a clinical assessment of the patient and critically analysing the data trends presented in the patient's clinical records. They looked for deviations from a typical post-operative recovery to determine what was relevant. While this deliberate decision-making process is slower than pattern recognition, the nurses needed to have information readily available that supported their choice of response when they communicated their concerns to other team members. This finding is consistent with Allen et al. (2017) who reported that nurses considered objective data to reinforce any subjective or intuitive concerns when confirming deterioration and escalating patient care.

The nurses also used analytical decision-making to meet the cognitive demand of 'initiating rescue' as they considered the patient's response to the measures they used to address immediate concerns. The nurses also made analytical decisions when selecting relevant patient data to respond to the cognitive demand 'securing medical assistance'. 'Rescuing the patient' was a cognitive demand that required the nurses to work collaboratively with the medical team and share the ongoing plan of care for the patient in the decision-making process. Allen et al. (2017) noted that positive interprofessional collaborative practice can be a facilitator for effective decision-making and early response to deterioration.

Leadership and management were cognitive skills necessary for delegating responsibilities to other team members and ensuring the work environment was set up safely with essential resources readily available. Patient advocacy was a cognitive skill required to respond to the cognitive demand of 'securing medical assistance'. Gaining timely medical intervention was critical for maintaining patient safety. Additional to situation awareness and decision-making skills, the study revealed efficient planning was an important cognitive skill required for 'initiating rescue'. The nurses were required to think ahead and work promptly to develop a plan of action appropriate for the situation.

The study has revealed that experienced nurses' cognitive skills enable them to problem solve and

respond when they notice early signs of physiological deterioration, significantly influencing patients' potential outcomes. Furthermore, experienced nurses develop and implement strategies to manage the cognitive demands they face effectively. In contrast, less experienced nurses rely on the guidance of more experienced nurses during cognitively demanding situations. The difficulty for them is that they are still developing the cognitive skills they need to intervene appropriately. This finding is consistent with Hoffman et al.'s (2009) work that shows experts are proactive and collect many cues to explain anomalies, whereas novices are reactive and tend not to look beyond the immediate problem.

The nurses in this study emphasised the importance of experience for being able to make effective decisions. Uncovering how expert nurses make effective clinical decisions in the real world and the cues and strategies they use are essential for developing the cognitive skills in less experienced nurses to promote safe practice. In the interests of patient safety, and the growing shortage of nurses worldwide (Boston-Fleischhauer, 2022) and an increasing trend of replacing experienced nurses with more junior or less experienced nurses (Karlsson et al., 2019), staff in hospital management need to understand how important it is for less experienced or novice nurses to have ongoing mentoring by experienced nurses to ensure safe care. Role-modelling expert decision-making skills to rescue patients will assist less experienced nurses in developing these skills. Less experienced nurses and student nurses benefit from working alongside experienced nurses to gain the requisite experience to build the knowledge and cognitive skills to keep patients safe. This learning includes how to be proactive and think ahead to respond safely in acute situations. Furthermore, nurse educators need to provide learning strategies that promote intuitive knowledge and critical thinking to accelerate nurses' recognition of deterioration to rescue patients. Additionally, training modules that provide interprofessional education and the opportunity for collaborative decision-making would empower less experienced nurses to interact more effectively with their medical colleagues for the safety of the patients in their care.

Conclusion

This study has utilised ACTA methodology to document the cognitive demands required of nurses in a general surgical setting and the cognitive skills experienced nurses use to manage deterioration in a post-operative patient. As well, it describes the common errors made by less experienced nurses in the same situation. The study demonstrates that ACTA is an efficient approach for understanding and documenting the tacit cognitive processes and critical information that informs nurses' decision-making in challenging situations. It has shown that this readily available research methodology merits consideration by future nurse researchers to elicit the tacit decisions nurses make when solving challenging clinical problems in multiple contexts. Furthermore, nurse educators can use the cognitive demands table from an ACTA as a foundation for developing innovative training programmes to help accelerate learning of the critical skills identified as deficient during novice nurses' performance and consequently reduce errors.

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