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DISCUSSION PAPER

Detection of patient risk by nurses: a theoretical framework

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Abstract

Title. Detection of patient risk by nurses: a theoretical framework.

Aim. This paper is a description of a theoretical framework of how nurses detect and interpret patient risk signals in the context of organizational attitudes and procedures related to patient safety.

Background. The ability to detect when patients are at increased risk for harm is a challenge faced by nurses worldwide. How nurses are able to discriminate patient risk warning signals from background noise is not well understood. Also, the impact of system-level factors on nurses' signal detection capabilities has not been investigated.

Data sources. Computerized database searches were used to identify nursing, organizational science, and cognitive psychology literature from 1964 to 2009 pertinent to the framework.

Discussion. The patient risk detection theory synthesizes concepts of signal detection theory and high reliability theory. Signal detection theory explains the decision-making processes of nurses as they scan for signals of potential patient harm. High reliability theory explains how nurses' signal detection capacities are facilitated when healthcare settings operate as high reliability organizations making patient safety the top priority.

Conclusion. The patient risk detection theory facilitates understanding of both individual and organizational factors that influence nurses' ability to detect risk in complex healthcare settings. It can be used to guide research on interventions to enhance signal detection by nurses and increase patient safety in today's complex care environments. The theory can also be used to guide design of training programmes that permit nurses to develop practical skills in signal detection.

Keywords: decision-making, nurses, organizational development, patient risk, patient safety, risk detection, theoretical framework

Introduction

One of the many global challenges nurses face in delivering quality health care is the ability to detect when patients are at increased risk for harm as a result of their conditions or from medical errors that might occur in the course of their treatment. The ability to recognize warning signals is especially challenging in today's increasingly complex practice settings.

Medical errors contribute to the potential for harm in patients worldwide (World Alliance for Patient Safety 2006).

In developed countries, an estimated 10 percent of patients are harmed while receiving hospital care. For example, current estimates suggest 148,000 life-threatening medical errors occur annually in the United States of America among patients in intensive care units (ICU) (Rothschild *et al.* 2005). In Britain's National Health Service hospitals, adverse events occur in more than 850,000 admissions yearly (Department of Health, 2000). Of Canada's 2·5 million admissions, it is estimated that 185,000 patients experience an adverse event, with almost 70,000 being potentially preventable (Baker *et al.* 2004). The proportion of patients harmed during hospital care is likely to be much higher in developing nations (World Health Organization 2009).

Recognizing the need to detect early signals of potential harm as a global healthcare issue, the World Alliance for Patient Safety (2006) has emphasized the necessity for instituting multiple risk-minimizing procedures: 'Complementary actions are needed to prevent adverse events, make them visible quickly when they occur, mitigate their consequences on patients and healthcare workers, and reduce risk for future patients' (p. 10). Therefore, to minimize patient risk, nurses must not only have the capacity to detect and respond to signals, but healthcare organizations must have policies and procedures in place that will foster that capacity.

Nurses are the healthcare providers most likely to be aware of changes in a patient's status or to determine that a medical error has occurred (Rothschild *et al.* 2005). Thus, they are the front line for preventing or allaying a large number of medical errors by immediately responding to institute corrective measures. The ability of nurses to detect and respond to potential medical errors is strongly influenced by the environment in which they function. For example, ICU nurses must often observe and attend to the needs of more than one critically ill patient. Each patient is usually connected to multiple monitors that provide continuous auditory and visual output about the patient's physiological status. These nurses must be constantly aware of information these devices are delivering while carrying out other care-related, record-keeping, or administrative work. They must be able to retain focus in the face of interruptions such as phone calls, electronic pagers, and conversations. The result is an environment in which myriad stimuli compete for nurses' attention. From among these stimuli, nurses must be able to detect and appropriately respond to true signals of an impending or actual medical error.

The healthcare literature has primarily addressed the issue of patient safety at the organizational level, examining how organizational attitudes, structures, and dynamics have an impact on healthcare providers' ability to detect and avert patient harm. Singer *et al.* (2009) examined the relationship between hospital safety climate and performance on patient safety indicators, finding that front line staff perceptions of a better patient safety climate predicted a lower risk of incidents. Other investigators have examined patient risk in relation to nurse staffing levels, including how staffing affects specific types of medical errors, finding that increased nursing staff numbers lower mortality and reduce the occurrence of adverse events (Kane *et al.* 2007, Elnour *et al.* 2008).

By contrast, little attention has been given to how individual nurses scan for and detect threats to patient safety. Much of the healthcare literature regarding detection of medical errors has focused either on retrospective audits to capture these phenomena or ongoing surveillance of specified triggers that indicate that a medical error is occurring or has already occurred (Szekendi *et al.* 2006, De Wet & Bowie 2009). There is a dearth of literature addressing methods by which nurses scan for problems or intercept errors. In particular, little is known about how nurses are able to discriminate among multiple stimuli to identify those warning of real patient harm; likewise, how nurses are able to recognize and intercept potential medical errors has not been well investigated. Finally, little information is available on how organizations enhance or impede nurses' ability to detect signals. A recent World Health Organization report has emphasized the need for more research on how organizational factors help or hinder the ability of individual healthcare providers to ensure patient safety (Reason 2008).

To begin to address these questions, we introduce a multiparadigmatic model to identify organizational and individual attributes that impact nurses' capacity to successfully detect patient risk signals. The patient risk detection theory integrates two theoretical frameworks, high reliability theory and signal detection theory, to provide a theoretical basis for explaining how nurses working in complex healthcare environments such as ICUs are able to monitor for and identify risks to patients. Signal detection theory is a decision-making theory that explains how individuals differentiate signals from noise when bombarded with multiple and varied stimuli. Signal detection theory can therefore help explain how nurses discriminate signals that a patient may be in danger. High reliability theory is based on the idea that accidents can be prevented or contained through proper organizational design and management. High reliability theory can clarify how organizational attitudes toward patient safety, policies about reporting problems, and other contextual factors can operate to facilitate nurses' detection of adverse events.

The purpose of this paper is to describe the patient risk detection theory and to offer suggestions for its testing and verification. In the paper we also describe the implications for

nursing in terms of how the theoretical framework can be employed to test interventions aimed at reducing patient risk.

Background

Many medical errors and deterioration in a patient's clinical status are presaged by subtle signals that are misinterpreted by healthcare providers including nurses. One of the vital functions of a nurse is ongoing vigilance for the early detection and prevention of potential problems. This requires both behavioural and cognitive skills (Page 2004). The patient risk detection theory is based on the idea that identification of problems that endanger patients in hospital settings occurs primarily at the level of the individual nurse.

Individual differences and organizational culture have an important influence on whether a nurse detects such problems. Organizational commitment to vigilance for potential errors and the detection, analysis, and remedying of these errors when they occur is a key factor in patient safety (Page 2004). The patient risk detection theory further proposes that the capacity for individual nurses to perceive problems is dependent upon the environment in which they work. Organizational structures, dynamics, and attitudes about patient safety may function to either facilitate or hinder individual nurses' capacity to detect warning signals. To explain how individual and organizational attributes impact patient safety, the theory synthesizes concepts from two theoretical frameworks: signal detection theory and high reliability theory. The theories are summarized below, with emphasis placed on features most salient to the proposed theoretical framework.

Signal detection theory: how nurses can detect when patients are in danger

Signal detection theory was developed to explain how observers identify signals in the presence of other interfering information and background noise (Wickens 2002). Signal detection theory is a conceptual portrayal of the decision-making process in uncertain or ambiguous situations when an observer must answer 'Yes' or 'No' to the question of whether a signal has occurred (Wickens 2002, MacMillan & Creelman 2005).

This decision-making process involves correctly classifying stimuli into either relevant signals or irrelevant background 'noise'. A key concept of signal detection theory is *sensitivity*. Sensitivity is the measure of an individual's ability to successfully distinguish signals from among a large number of different stimuli (Wickens 2002, MacMillan & Creelman 2005). Correct classifications of stimuli as signals or background noise are categorized as hits and correct rejections; incorrect classifications are misses and false alarms (Table 1; Wickens 2002, Harvey 2003). A correctly identified signal is termed a hit, whereas correctly identified noise is termed a correct rejection. Misidentifying a signal as background noise is referred to as a miss, whereas misinterpreting noise as a signal is referred to as a false alarm. An individual's ability to detect a signal is dependent upon how distinct the signal is against the backdrop of ambient environmental noise, as well as upon the individual's level of training and degree of fatigue (Wickens 2002).

Another important aspect of signal detection is *responder bias*, which is the willingness of the individual to acknowledge a stimulus as a signal (MacMillan & Creelman 2005). This willingness is influenced by the individual's goals with regard to signal detection (Wickens 2002, Harvey 2003, MacMillan & Creelman 2005). Those aiming to maximize the number of hits will err on the side of interpreting stimuli as signals even when they are not. In this scenario, as the number of hits increases, so does the number of false alarms. Individuals who feel pressured to get other unrelated tasks accomplished may be reluctant to categorize a stimulus as a signal to avoid wasting time responding to a false alarm; this results in more missed signals. Those wishing to maximize the number of hits while minimizing the number of errors (i.e. both false alarms and misses) will be more judicious about categorizing a stimulus as a signal. An example of this decision-making process as it applies to patient monitoring is given in Figure 1.

High reliability theory: the role of the organization in reducing patient risk

Whether a robust patient safety culture exists within the practice environment can influence nurses' ability to detect and respond to warning signals. A theoretical construct that may assist in understanding how safe practice environments are created and sustained is high reliability theory. High reliability theory has been useful in examining why inherently high-risk worksites such as nuclear power plants, air traffic control centres, and missile launch facilities nevertheless have relatively low accident rates (Weick *et al.* 1999).

Table 1 Types of stimulus identification

Hit	Stimulus correctly identified as a signal
Miss	Signal is incorrectly identified as background or environmental noise
False alarm	Background or environmental noise is incorrectly identified as a signal
Correct rejection	Stimulus correctly identified as background or environmental noise

		Stimulus: Cardiac monitor indicates patient's heart rate is higher than earlier.	
		Yes, this is a signal	No, this is not a signal
Decision: Is the cardiac monitor indicating a real change in the patient's status?	Yes	Hit	False Alarm
	No	Miss	Correct Rejection

Figure 1 Signal detection theory decision matrix for a nurse's response to a stimulus.

According to high reliability theory, a combination of attentive-cognitive processes and responsive actions produce high reliability organizations (HROs) that are able to manage unexpected events effectively. These cognitive processes involve actively processing information with the assumption that the unexpected will occur during the performance of routine tasks (Weick *et al.* 1999, Weick & Sutcliffe 2001, 2006, Weick 2002). A number of authors have suggested that high reliability theory could offer a basis for organizational changes in healthcare settings to improve patient safety (Weick 2002, Page 2004, Weick & Sutcliffe 2006).

Weick and Sutcliffe (2001) have identified five characteristics common to all HROs: preoccupation with failure, reluctance to simplify, sensitivity to operations, resilience, and deference to expertise (Table 2). *Preoccupation with failure* refers to an organizational mindset of focusing on errors or malfunctions that occur during routine operations. With this mindset, quick saves, close calls, and near misses are viewed not as indications that the safety features built into the system are working properly, but rather are signs that they need improving. HROs are always scanning for potential failures, and manage any 'slip' as a symptom of trouble and an opportunity to improve. HROs encourage staff to report problems or mistakes, viewing these events as data that can be analyzed to identify shortcomings in the organization's ability to operate safely.

Preoccupation with failure by HROs engenders in them a *sensitivity to operations*. HROs strive to identify any problems in the routine workings of a system that could lead to problems or errors. HRO leaders are consequently highly aware of how operational attributes such as employee workload and shift length in and of themselves can result in errors. They therefore monitor employees for signs of overload because of its adverse affect on performance and judgment. Sensitivity to operations also refers to placing emphasis on examining processes not as they should be, but as they actually are, all the while being mindful that what is happening now can determine what might happen in the future. HROs accordingly develop in their employees an awareness of the connections between their immediate actions and more distal outcomes.

Reluctance to simplify is an acknowledgment that complexity is an inherent attribute of the system, and that failures can occur by any number of methods, only some of which may be predictable. When things do go wrong, HROs are unlikely to attribute problems to a single, simple cause. They will often seek multiple independent reports of an event in order to obtain as complete a picture of what happened as possible (Weick *et al.* 1999, Weick & Sutcliffe 2001, 2007). Because of the range of things that can go wrong, HROs avoid over-reliance on rigid protocols but instead remain open to modifying procedures to fit the particular needs of the situation.

Resilience refers to the ability of HROs to quickly contain problems so that operations can continue and not deteriorate to the point of catastrophe. The assumption is that systems may fail in unpredictable ways despite numerous safeguards. HROs therefore train staff to respond quickly to situations, to make rapid assessments, and to improvise when necessary in order to keep systems functioning (Weick *et al.* 1999, Weick & Sutcliffe 2001, 2007).

The fifth important attribute of HROs is *deference to expertise*. HROs recognize that the individual who has the

Table 2 Attributes of high reliability organizations

Preoccupation with failure
Constant scanning for incipient failures
Attention to small discrepancies that could be early warning signs of failure
Reluctance to simplify
Close attention to what is happening here and now
Avoid over-reliance on protocols or theories
Refusal to make broad generalizations
Sensitivity to operations
As much or more attention to operations than strategy
Ongoing awareness of connections between immediate actions and distal consequences
Resilience
Mindful acceptance that errors or problems will occur
Capacity to improvise when problems arise
Deference to expertise
Underspecification of hierarchy of decision-making
Awareness that expert decision-making can arise spontaneously where needed

most information critical for responding to a crisis may not necessarily be the most experienced person or one at the top of the organizational hierarchy. Top-down decision-making is de-emphasized, and leaders are comfortable with receiving guidance from those with less seniority. In HROs, all staff members are trained in problem-solving on an ongoing basis (Weick *et al.* 1999, Weick & Sutcliffe 2001, 2007).

These five attributes allow HROs to operate effectively with a low accident rate despite their catastrophic potential. With safety as their first priority, HROs invest heavily in procedures that allow them to sustain a high level of sensitivity to errors, unexpected events, and subtle cues that are harbingers of larger system failures (Weick & Sutcliffe 2001). This ongoing attention to detail coupled with the ability to respond rapidly to problems and to modify those responses as the situation warrants provide the basis for preventing malfunctions and mistakes from evolving into disasters (Weick & Sutcliffe 2001, Levinthal & Rerup 2006, Weick & Putnam 2006).

Data sources

We used a deductive approach to integrate components of signal detection theory and high reliability theory into our theoretical model of patient risk detection. To achieve this, we examined classic works on signal detection theory and high reliability theory as well as pertinent empirical research reports and narrative reviews from the organizational, cognitive psychology, nursing, critical care, and patient safety literature. We identified these materials by searching the electronic databases PsychInfo, Medline, ABI/Inform, and the Cumulative Index to Nursing and Allied Health for English-language papers published between 1964 and 2009. The search terms were high reliability theory, high reliability organizations, signal detection theory, mindfulness, patient safety, alarms, goals, and critical care.

Discussion

Overview of the patient risk detection theory

Although signal detection theory can explain how and why individual nurses detect patient risk signals, this theory does not take into account the impact that the organizational environment can have on nurses' sensitivity to signals or their biases in interpreting them. However, high reliability theory can help explain how organizational attitudes, policies and procedures affect nurses' ability to detect, correctly interpret, and appropriately respond to patient risk signals in complex healthcare settings such as an ICU. According to this theory, healthcare settings that set a priority on patient safety will have the attributes of HROs (Weick 2002).

We therefore constructed a theoretical framework of patient risk that combines signal detection theory with high reliability theory (Figure 2). Our framework of patient risk detection incorporates the attributes of preoccupation with failure, sensitivity to operations, and reluctance to simplify because they relate to an organization's capacity to monitor for problems and explain the impact of the organization on nurses' capacity to detect and correctly interpret stimuli that may be indicators of patient risk (Weick *et al.* 1999). Although resilience and deference to expertise are also important to minimizing patient risk, they are not included in our model because these attributes relate to management of adverse events after they have occurred rather than to identification of signals that may portend these events.

Nurses' sensitivity to signals and their biases in interpreting them are both influenced by an organizational mindset in which safety is the first priority. These organizations will focus on any failures within the system, and will address those failures by gathering information from multiple sources to learn as much as possible about the problem to avoid missing any important information. These organizations will also be highly sensitive to how daily operations affect safety, and will make procedural changes as necessary to ensure patient safety.

Factors having an impact on nurses' sensitivity to patient risk signals

The ability of nurses to accurately identify signals can lead to early interventions so that harm to patients is minimized or circumvented. However, if nurses inaccurately identify signals as normal environmental noise (misses), medical errors might result. On the other hand, if nurses inaccurately identify noise as signals, the result will be an inefficient use of their time or unnecessary interventions (Wickens 2002, Harvey 2003, MacMillan & Creelman 2005).

Individuals' level of training and experience will influence their capacity to detect and correctly interpret signals (Wickens 2002). With repetition over time, individuals become more adept at correctly identifying stimuli as signals or noise, and the cognitive processes involved in signal detection become more automatic. As a result, fewer mental resources must be allocated to scanning for harm signals and are freed up for attending to other stimuli (Allen *et al.* 2004, Slagter *et al.* 2007). Thus, nurses with more experience or training in signal detection will be able to scan for patient risk signals while also being able to carry out other tasks.

A number of factors may limit nurses' ability to discriminate warning signals. One factor is how distinct the signal is

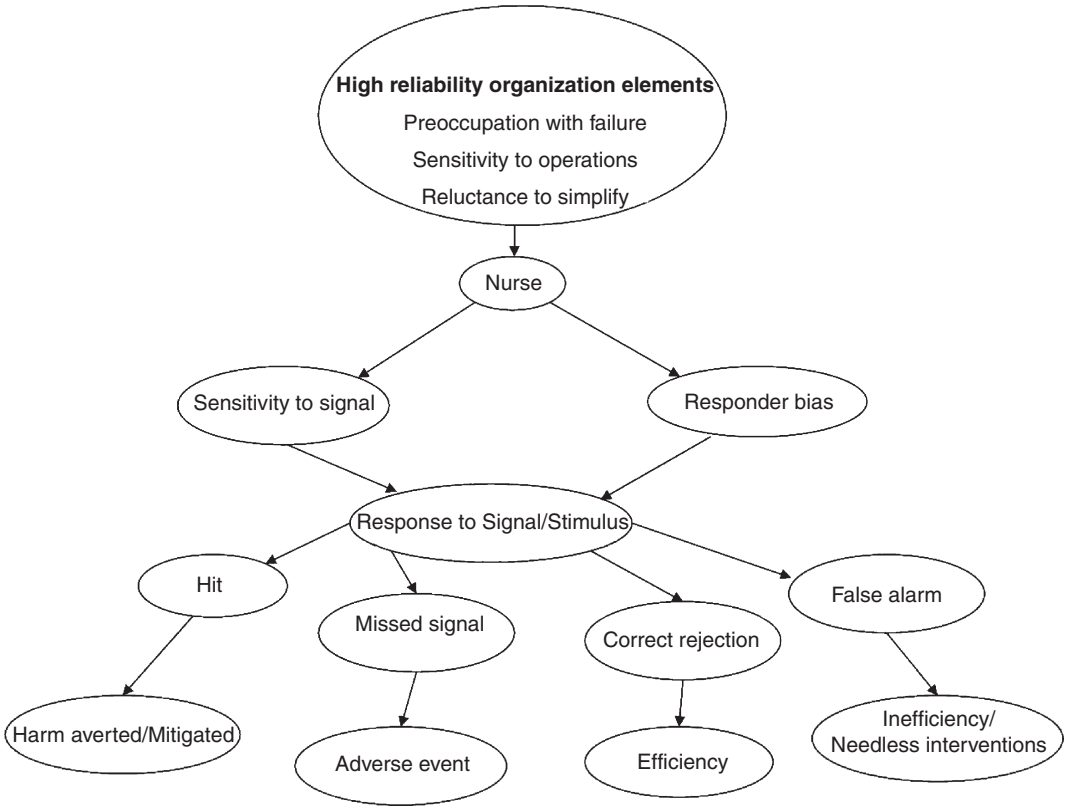

Figure 2 Patient risk detection.

against the backdrop of background noise (Lisper *et al.* 1972). The number of misses will be greater in environments where signals are relatively indistinct or in which ambient sound levels are very high. In an examination of working conditions in neurological ICUs, Ryherd *et al.* (2008) found that noise levels reached 53–58 decibels—well above the recommended 30-decibel maximum for patient care settings (Berglund *et al.* 1999)—and that 49% of nurses surveyed indicated that they lowered the volume levels of patient alarm monitors simply to reduce the noise levels in the ICU. These investigators also found that excessive noise levels in the ICU were associated with fatigue, difficulty concentrating, irritability, and tension headaches. Fatigue has been shown to have a potent negative effect on signal sensitivity (Wickens 2002). Therefore, even highly trained, experienced nurses may have difficulty discriminating warning signals if they are tired or must work in an environment with high noise levels.

Misses may also be greater where the number of false alarms is disproportionately high. Frequent false alarms have been shown to decrease the detection rate of actual signals (Jerison & Pickett 1964). Alarms from patient monitors indicate that the patient's vital signs have deviated from the monitor's preset limits. Deviations from monitor presets may be indicators that a patient is decompensating, but they also may be related to recent routine care, for example suctioning or turning. Alarms may also result if the monitor has not been set to correctly reflect the patient's normal baseline range of values. By some estimates, 65–95% of monitor alarms are in fact false alarms (Xiao *et al.* 1998, Seagull & Sanderson 2001). If patient monitor alarms are continually sounding for non-significant reasons, nurses will evidence a reduced sensitivity to the relatively rare alarm that is a true warning signal.

The patient risk detection theory indicates that nurses' signal sensitivity will also be influenced by organizational structures and processes that affect the work environment. An organization that is sensitive to how operations impact nursing staff's risk detection capacities will be highly cognizant of how patient load, shift length, and the number of shifts worked per week are influencing nurses' fatigue levels. This sensitivity to operations will also be reflected in how patient handovers are handled during shift changes. Recognizing that previous actions may have distal effects, standardized procedures that fully communicate a patient's status to the next nurse responsible for that patient's care will improve the ability of nurses on the next shift to distinguish hits from false alarms.

An organizational attitude that problems must be anticipated and averted rather than reacted to (preoccupation with

failure) necessitates programmes of ongoing training of staff on how to monitor properly and effectively for patient risk signals. Staff mix is another important factor to which organizations must be attentive in order avert adverse events. Needleman *et al.* (2002) showed that the risk of mortality from complications such as pneumonia, shock, and cardiac arrest was less in institutions in which more of the nursing care was provided by Registered Nurses than Licensed Practical Nurses.

Factors having an impact on nurses' signal detection bias

In an environment in which signals are hard to discern or in which they have a high likelihood of being false alarms, responder bias will play a significant role in the decision-making process about whether a stimulus is a true indicator of patient harm. Nurses who are focused on getting all their work done by the time the shift ends will be more likely to decide that a stimulus is noise rather than a signal in order to avoid wasting time responding to false alarms. By contrast, nurses concerned that they might miss a warning signal will be more willing to identify a stimulus as a signal even when it is not. In both scenarios, the number of hits will be proportional to the number of false alarms. The crucial distinction between the two scenarios is the goals of the nurses. If safety is a primary concern of the nurse, as it would be in a HRO organization, a higher number of false alarms are acceptable if it means that true risks to patient safety are also being detected.

According to our Patient Risk Detection Theory, nurses will be more likely to detect risk signals if they are working in an organization that conveys to its staff the value it places on safety (Hassin *et al.* 2005). This value is communicated to nurses by encouraging and rewarding them for reporting errors. In an organization preoccupied with failure, errors are viewed as teaching moments. When nurses are given the opportunity to learn from mistakes, they will be more likely to scan for signals.

Likewise, the willingness of organizational leaders to listen to and correct problems that nurses bring to their attention further encourages nurses to scan and identify signals indicative of patient harm. Critical to effective patient risk detection is the presence of daily executive safety rounds in which staff members are questioned about any concerns they have about the patients under their care that day. This periodic communication and monitoring conveys to staff members the organizational expectation that they should be continuously scanning for possible problems and warning signs (Morath & Leary 2004). The multiple perspectives that staff members provide on any problems or medical errors will give organizational leaders complex, detailed information to ensure that no important data are overlooked that might be critical in preventing a recurrence of a safety incident. Overall, if nurses feel confident that organizational leaders are paying attention to and acting on staff concerns about patient safety; then nurses will be more willing to recognize stimuli as signals.

Implications for nursing

The patient risk detection theory offers a theoretical framework to facilitate future research into the individual and organizational factors affecting patient safety. The theory can be used to develop interventions aimed at reducing patient risk. The theory implies that nurses' signal sensitivity is a learned process that is influenced by internal factors (such as fatigue), as well as by the physical and organizational environment in which they work. It can therefore be used as basis for teaching practical skills in signal detection to nursing students. For example, students could be placed in simulated settings in which their capacity to detect signals is hindered by noise or distractions. Such simulations could also be used to train new employees prior to assigning them to patient care. Bias can likewise be influenced if students and employees are educated to place a high value on patient safety.

The theory will also be useful at the organizational level. Viewing medical errors as opportunities to consider individual and organizational roles in signal detection could help healthcare managers to identify areas in need of patient safety quality improvement. For example, analysis of medical error reports in the context of the theoretical framework might determine that ambient noise levels in the ICU were so high that nurses simply could not hear alarm signals when they occurred, and that physical changes to the area are necessary to increase the signal-to-noise ratio. Or analysis might determine that fatigue was a contributing factor, which should prompt managers to examine and possibly modify staff workloads and work schedules. Because the patient risk detection theory is grounded in high reliability theory, any hospital that employed it would be taking a positive step toward becoming a HRO with regard to the safety of its patients.

Conclusion

The patient risk detection theory was developed from the synthesis of concepts from two non-nursing theories for which there is much existing research. We believe that the proposed theoretical framework will help to explicate the intrinsic and extrinsic factors related to nurses' detection of

What is already known about this topic

- Nurses are the healthcare staff most likely to detect patient risk and intercept medical errors in an intensive care unit.
- Little research in the nursing literature addresses how nurses detect and interpret patient risk signals.
- Several studies have that suggested fewer medical errors would result if hospitals functioned as high reliability organizations.

What this paper adds

- A theoretical framework to explore how nurses detect patient risk signals in the context of highly reliable organizations.
- Medical errors are viewed as missed signals that occur because nurses' ability to detect and correctly interpret stimuli is hampered.
- The attributes of high reliability organizations that can create a patient safety culture in which nurses are more likely to detect patient risk signals include preoccupation with failure, reluctance to simplify, and sensitivity to operations.

Implications for practice and/or policy

- Once validated, the theory can be used to guide both organizational and individual interventions for improving patient safety.
- The theory can be used to develop training programmes aimed at improving nurses' practical skills in patient risk signal detection.

patient risk and thus prevention of patient harm; however, the theory requires empirical testing and validation within the nursing realm. For example, the impact of fatigue, training, and responder bias on stimulus detection and interpretation has been validated with volunteer participants in laboratory settings, but whether these conclusions can be extended to nurses working in clinical settings needs to be tested. A key component of our theory is the idea that organizational attitudes and practices related to patient safety will have an impact on nurses' capacity to detect and interpret patient risk signals correctly. One way to test the validity of this premise is to compare the signal sensitivity of nurses working in high reliability healthcare organizations to those who are not. Another important area to be investigated is the impact of the organization on the responder bias of nurses. For example, do organizations that score well on instruments measuring high reliability also have nursing staff who are more likely to respond to patient monitor alarms regardless of whether they are true signals? Is this bias related to nurses' perception that the organization they work for places a premium on patient safety? Also not known are the relative influences of individual vs. organizational factors on sensitivity and bias. For instance, are fatigued nurses working in HROs more sensitive to signals than those working in non-HROs? Identifying the relative contributions of these factors will result in more effective decision-making with regard to the best ways to improve patient safety.

The patient risk detection theory proposes that patient harm occurs because individuals responsible for monitoring patients (i.e. nurses) are not readily able to detect signals that warn of impending danger. In order to detect warning signs, individuals must be able to discriminate signals from noise, which may be difficult in today's complex work settings in which nurses must filter out signals from stimuli emanating from many different sources.

Increasing nurses' capacity to detect warning signals will depend on certain critical factors being in place at the levels of both the individual nurse and the organization. The theory proposes that the organizational attitudes, structures, and processes will have a significant impact on signal sensitivity and bias, and that nurses who work in hospitals possessing key attributes of HROs are more likely to be successful in detecting signals portending patient harm.

Healthcare environments will become increasingly complex and challenging as patient monitoring technologies become more advanced. While improved technologies hold the promise of further reducing patient harm, the responsibility for deciding whether patients are truly at risk will continue to rest with nurses. The patient risk detection theory offers a framework for examining factors that can help or hinder nurses in making potentially life-saving decisions.

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Conflict of interest

No conflict of interest has been declared by the authors.

Author contributions

LAD & JSC were responsible for the study conception and design. LAD, JSC & JNR were responsible for the drafting of the manuscript. LAD, JSC & JNR made critical revisions to the paper for important intellectual content.

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