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EMPIRICAL RESEARCH MIXED METHODS

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The impact of the use of continuous pulse oximetry monitoring to monitor patients at high risk of respiratory depression on nursing practice

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Abstract

Aim: To describe the impact on nursing practice of using continuous pulse oximetry monitoring to monitor patients at high risk for respiratory depression after surgery.

Design: A convergent mixed method design.

Methods: Thirty (30) hours of non-participant structured observation and explanatory interviews were conducted with 10 nurses from the surgery care unit and intensive care unit.

Results: We found that nursing practice to evaluate and monitor at-risk patients through continuous pulse oximetry monitoring is mainly linked to technical care. Nurses generally meet the frequency of bedside monitoring required by established protocols. During the structured non-participant observation periods, it was observed that 90% of the alarms were false (unsustained desaturations). This was confirmed by the nurses during the explanatory interviews. Noisy environments, high number of false alarms, poor communication between nurses and various operational failures might have a negative impact on nursing practice.

Conclusion: Several challenges must be overcome for this technology to achieve the desired outcomes of continuous surveillance and rapid detection of respiratory depression episodes for post-surgical patients.

No Patient or Public Contribution.

KEYWORDS
nurse surveillance, nursing practice, oximetry, postoperative monitoring, respiratory depression

1 | BACKGROUND

Due to the global nursing shortage and the cost of intensive care unit (ICU) hospitalization, managers are looking for alternative ways to monitor patients on regular units, while maintaining optimal safety. Acute respiratory depression is an incident that has attracted the attention of healthcare professionals, due to it being a preventable cause of death (Lee et al., 2015; Vermersch, 2014). Respiratory depression can occur following surgical procedures, and the risk is increased by opioid use and comorbidities, such as obesity and chronic obstructive pulmonary disease (Ishikawa & Sakamoto, 2019). Evidence shows that most respiratory depression events occur during the first 24h following surgery and could be prevented with close monitoring (Lee et al., 2015).

Continuous pulse oximetry monitoring has been proposed as a potential solution to ensure continuous surveillance (Ishikawa & Sakamoto, 2019). It mainly functions through an alarm which is triggered when oxygen saturation drops below the established threshold and notifies nurses via a monitor or a pager. Based on this, some healthcare facilities in Quebec, Canada, are in the process of adopting a widespread use of continuous pulse oximetry monitoring systems. However, these facilities have opted to split the monitoring and follow-up activities between nurses working on different care units. Specifically, they are planning to have the monitoring system for the continuous pulse oximetry device in the ICU and remotely monitor the condition of postoperative patients hospitalized in the surgery care unit. Monitoring and follow-up in these facilities are therefore distributed among nurses working on two different care units who must collaborate remotely via a landline telephone.

The potential negative risks and impact of this use of continuous pulse oximetry monitoring on nursing must be studied to better inform the nursing managers' decision-making process. In addition, there is a lack of research on the direct impact of the use of continuous pulse oximetry monitoring and on the potential risk and implications on nursing care. Also, there is no valid scientific research on the safety of nursing care when the use of continuous pulse oximetry monitoring is divided between two units. Thus, this study aims to describe the impact on nursing practice of using teams of nurses working on different units to monitor patients at high risk for respiratory depression after surgery by continuous pulse oximetry monitoring.

1.1 | Framework

The model of grand nursing functions proposed by Dallaire and Dallaire (2008) distinguishes between five major nursing functions, namely the care function, the education function, the coordination function, the collaboration function and the supervision function. First, the care function includes general direct care activities and technical care activities. According to the authors, general care encompasses everything that makes life possible, which includes, without being limited to, activities related to breathing, drinking, eating, washing, connecting with others and so on. On the other hand, technical care refers to activities that require a tool or specific skills such as vital sign monitoring, injections, drug administration or specific relational skills. Secondly, the education function consists of providing information on health and disease. As for the third function, Dallaire and Dallaire (2008) distinguish clinical coordination that makes it possible to harmoniously organize and combine the clinical action for a small group of patients. The functional coordination in turn means ensuring that the healthcare facility supports the care provided. The collaboration involves actions decided and undertaken jointly with other healthcare professionals and shared responsibilities. Finally, the supervision function is carried out when the nurse remains legally responsible for the care provided by certain team members under her direct supervision, such as nursing assistants and orderlies.

2 | METHODS

2.1 | Design

This study uses a convergent mixed method design (Creswell & Plano Clark, 2018).

2.2 | Participants

A convenience non-probabilistic sampling technique was used to recruit nurses from the surgery care unit and ICU of a hospital in Quebec, Canada. The inclusion criteria were:

- Being a nurse on the surgery care unit or ICU;
- Having the required knowledge of the procedure of using, managing or monitoring continuous pulse oximetry monitoring;
- Being responsible for the care of a client with continuous pulse oximetry in the surgery care unit or monitoring the condition of a client with continuous pulse oximetry monitoring remotely from the ICU.

2.3 | Data collection methods

The data collection process combined periods of structured non-participant observation and explanatory interviews. Structured non-participant observation allows the researcher to observe the daily activities and behaviours of participants in their natural environment (Creswell & Plano Clark, 2018). Structured non-participant observation used two pretested observation grids. The observation grids were used to collect data on nursing care practices provided to patients who were monitored through continuous pulse oximetry monitoring in the first 24h after surgery at the surgery care unit or the monitoring activities of nurses at ICU. They targeted specific events such as alarms, episodes of respiratory depression, monitoring activities, nursing interventions and documentation. The explanatory interview consisted of a set of questions that were asked following a situation to fully understand the experience and the actions initiated by the nurse (Vermersch, 2014). Sociodemographic data of the observed nurses were also collected through a questionnaire.

2.4 | Data collection process

The planning of structured non-participant observation periods was undertaken in collaboration with the head nurse of the surgery care unit. The head nurse informed the research team about the possibility to do structured non-participant observation using the list of surgeries scheduled for the next day, patients for whom a continuous pulse oximetry monitoring was ordered by the physician and the availability of the surgery care unit and ICU nurses who had agreed to participate in the study.

The structured non-participant observation periods were undertaken simultaneously on the two units by two members of the research team. Consistency in data collection was obtained through discussion between the observers. Several 4-h observation periods were performed, for a total of 30 h. The evening shift was favoured to increase the chances of observing patients' sleep periods and episodes of acute respiratory depression. Explanatory interviews with the observed nurses were used throughout the observation periods.

2.5 | Data analysis

A deductive approach was used to categorize the nurse's activities from structured non-participant observation following the grand nursing functions model (Dallaire & Dallaire, 2008). First, two members of the research team analysed the data, independently. Then, they met to discuss and agree on the classification of the activities. The nature of the continuous pulse oximetry monitoring alarms was divided into two categories (false or true). In addition, averages, standard deviations, frequencies or percentages were computed for the categorized data. Observational data were used to describe the structural characteristics of the units as they may influence nursing interventions and outcomes. Afterwards, triangulation between qualitative and quantitative data was done to get a better understanding of how continuous pulse oximetry monitoring impacted nursing activities. A further step in data analysis provided a reconstruction of the sequence of assessment and monitoring activities of ICU nurses, their follow-up and care activities after a continuous pulse oximetry alarm.

Preliminary results were discussed with clinical experts (the unit head nurse, nurses, anesthesiologists and the director of nursing) to ensure further clinical validity of the data. Following this validation step, a targeted literature review was carried out, allowing for better understanding and interpretation of the results and the identification of several evidence-based recommendations for the use of this technology.

3 | RESULTS

3.1 | Sociodemographic data

A total of six surgery care unit nurses and four ICU nurses were observed. The descriptive analysis of sociodemographic data is presented in the following table (Table 1).

TABLE 1 Sociodemographic data of the nurses.

Variables	Sample N = 10
Female gender, *n* (%)	8 (80)
Age, average (min-max)	34 (23–53)
Number of years of experience, average (min-max)	10 (2–30)
Practice environment, *n* (%)	
Surgical unit	6 (60)
Intensive care unit	4 (40)
Position type *n* (%)	
Full-time	9 (90)
Part-time	1(10)
Level of education, *n* (%)	
Collegiate	7 (70)
Undergraduate	3 (30)

3.2 | Nursing activities

The data collected at the surgery care unit show that nurses generally meet the monitoring frequency required by established protocols until clinical stability, followed by close monitoring thereafter. In terms of documentation activities, our results show that nurses meticulously record vital signs. However, false alarms from the continuous pulse oximetry monitoring are not documented in the patient files, although nurses acted on them by going to the bedside, assessing the patient's condition and observing his/her respiratory status. Our results also show that patient monitoring and evaluation after opioid administration did not follow the institutional protocols in most cases.

Table 2 shows the nursing activities observed in the surgery care unit according to the grand nursing functions model (Dallaire & Dallaire, 2008).

At the ICU, one head nurse assistant supports nurse's care and oversees the coordination of the unit's activities for each shift. Moreover, the head nurse assistant could have to simultaneously monitor up to 14 telemetry and continuous pulse oximetry devices for inpatients throughout the hospital. The nurse looks at the tracing data (telemetry and oximetry) on the monitor and records a summary of the tracing data on a tracking sheet. If he/she notices anything abnormal in the waveform, the head nurse assistant communicates by phone with the patient's nurse to obtain additional clinical information or to announce a respiratory event.

Differences between the day shift and the evening or night shift were noted. Indeed, during the day shift, the environment is very noisy and hectic. The monitor alarms are continuously triggered, and many interruptions were observed in nurse surveillance. For the evening and night shifts, the care environment is much quieter. In the absence of the head nurse assistant, bedside nurses monitored the various waveform tracing of the monitors “from a distance”. The nurses can consult the waveform tracing to identify

TABLE 2 Observed nursing activities.

Observed nursing practices and nursing functions	*n* (%)
Care function	39 (62.9)
Technical care	34 (54.9)
Assessment of vital signs and pain	14 (22.6)
Direct visual observation of the patient	6 (9.7)
Verification of care devices	6 (9.7)
Technical adjustment of the continuous pulse oximetry device	4 (6.5)
Bedside assessment following a device alarm	1 (1.6)
Readjustment of nursing care practice according to the patient's condition	3 (4.8)
General care	5 (8.1)
Care to stimulate breathing	5 (8.1)
Coordination function	16 (25.8)
Clinical coordination	16 (25.8)
Documentation on vital signs monitoring sheet or in the patient's file	16 (25.8)
Education function	5 (8.1)
Teaching the patient/family how to use the continuous pulse oximetry device	5 (8.1)
Collaboration function	2 (3.2)
Communication with the intensive care nurse and other healthcare professionals	2 (3.2)
Total	62 (100)

past or missed alarms. A higher number of alarms related to telemetry was observed compared with continuous pulse oximetry monitoring. It should be noted that with each prescribed continuous pulse oximetry monitoring, a telemetry device is automatically installed, even if the patient's condition does not require it.

3.3 | Alarms

During the determined periods, 22 alarms were observed over 30 h. In 21 cases, the waveform tracing showed a drop in oxygen saturation levels for a few seconds followed by an almost immediate return to normal levels. Results indicate an average of 12 alarms, related to non-sustained desaturations (between 5 and 10 s), during each 4-h observation period. No sustained desaturation was observed during data collection. For 18 of the alarms, the nurse quickly checked the waveform tracing, observed a spontaneous return of blood oxygen levels to the normal threshold, and thus no intervention was undertaken. During three false alarms, the nurse was not at the monitoring station. Only one alarm among the observed 22 (sustained desaturation less than or equal to 90%) required intervention, i.e., communication with the surgery care unit nurse for immediate intervention at the patient's bedside.

From the data collected by the exploratory interviews, nurses perceive that 90% of alarms are false alarms (unsustained desaturations). As mentioned by the nurses and observed during the structured non-participant observation periods, the main reported causes of these false alarms are technical and hardware issues, such as a poor transmission quality of the adapter pinched at the end of a patient's finger. Another reported cause was a defective, misplaced or non-secured sensor that moved or fell off the patient's finger during care activities or movements. Other causes of false alarms are related to the batteries in the device needing to be replaced or to a faulty device. Some of those technical issues are caused by routine care activities, for example, when moving a patient or when they get up for the first time after surgery, saturation frequently drops, only to return quickly to normal when patients catch their breath or reposition the device. Data of structured non-participant observation show that nurses in the surgery care unit did not notify ICU nurses in advance of these alarm-causing care activities. ICU nurses mentioned that if they had advance notice of these activities, they would be able to analyse alarms differently and more effectively, at these times. Alternatively, the most common observed nursing interventions at the bedside and related to false alarms were to give information about the device to the patient and to solve technical problems (changing the battery or the device, repositioning the sensor, etc.).

4 | DUSCUSSION

Our aim through this study was to describe the impact on the nursing practice of the use of continuous pulse oximetry monitoring to monitor patients at high risk of respiratory depression after surgery. Based on the model of grand nursing functions of Dallaire and Dallaire (2008), we can conclude that nursing practice while monitoring post-surgical patients through continuous pulse oximetry monitoring is limited to two of the five functions, namely the care function and the coordinate function. For the first one, we found that nursing practice for evaluating and monitoring at risk patients through continuous pulse oximetry monitoring is mainly linked to technical care. As recommended in the literature, our results show that bedside monitoring for early signs of respiratory depression is performed adequately. Results from observation have shown that monitoring should be more rigorously carried out following the administration of opioids. For the second observed nursing function, coordination, due to the chosen method of operation of continuous pulse oximetry monitoring involving nurses on two care units, the results suggest that efficient communication between nurses of the two units is an essential element to ensure patient safety. However, this will require some changes in the care practice on both units to incorporate, for example, the need to warn those in charge of monitoring of upcoming activities and of the coordination of the activities on each unit to ensure continuous monitoring. Besides, the difficulties and challenges faced by the nurses of the two units were mainly associated with a noisy environment, a high number of false alarms, poor communication between the two units and various operational failures.

4.1 | Increased volume of alarms on nursing practices

Our results show that an average of 12 alarms, related to non-sustained desaturations (between 5 and 10 s), were detected during each 4-h observation period (three false alarms/hour). This is consistent with the findings of several other studies such as approximately 45 alarms per patient in an hour (Cho et al., 2016) or an average of 187 alarms per patient per day (Drew et al., 2014). On the other hand, 90% of the observed alarms were false (unsustained desaturations), as confirmed by the nurses themselves. Once again, our findings are aligned with those in the scientific literature, where 55%–99% of critical care alarms are considered nuisance alarms, that is, false alarms or alarms with no clinically significant content (Cho et al., 2016; Ruppel et al., 2018). This could have serious consequences as the nursing literature suggests an array of potential problems such as nurse desensitization to alarms (Drews et al., 2019; Monteiro et al., 2018) and delays in care caused by these alarms (Berry Jaeker & Tucker, 2017; Tucker, 2004, 2016; Tucker & Edmondson, 2003; Tucker & Spear, 2006).

In this respect, our results show that the number of continuous pulse oximetry monitoring alarms alone exceeds the recommended maximum number of alarms that a single nurse can handle and differentiate. This number varies in the literature between 9 and 14 (Cho et al., 2016). Exceeding the maximum recommended number could have consequences on care as evidence shows that exposing nurses to an excessive number of alarms results in an interruption in the deployment of care activities which can lead to omissions, distractions or inattention in the provided care (Cvach, 2012; Tanner, 2013). In fact, some studies have shown that the risk of delays in care (more than 60 min) and patient safety risks (occurrence of adverse events) are 16.1 times higher when nursing care activities are interrupted by alarms compared with activities that were not interrupted (Drews et al., 2019; Monteiro et al., 2018). In addition, there is sensory overload of those continuous pulse oximetry monitoring alarms, through the phenomena of alarm fatigue that occurs when healthcare professionals are overwhelmed by excessive noise from alarms, especially when most of them are false (Cho et al., 2016; Torabizadeh et al., 2017). False alarms may produce the 'cry wolf' effect in the sense that nurses might start to disregard alarms and thus fail to respond properly. This could lead to a form of desensitization (Cvach, 2012), in the sense that it would contribute to desensitizing nurses to clinical alarms in general which might put patients at risk. An excessive number of alarms also contributes to elevating ambient noise sometimes even beyond recommended levels with the potential of negatively impacting provided care. In fact, several studies show a sustained decrease in staff performance in a noisy environment (Drews et al., 2019; Monteiro et al., 2018). A higher number of errors and a longer reaction time are noticed, compared with what is observed in a workplace where the noise level is within recommended standards (Drews et al., 2019; Monteiro et al., 2018).

Therefore, the fact that 90% of the observed alarms were false seems to suggest that time is taken from nurses to deal with issues that do not relate to care so that the use of continuous pulse oximetry monitoring might have a negative impact on nursing practice. In addition, they constitute a distraction, which could result in errors by omission or delays in nursing care. All these factors make false alarms, and indirectly, the alarms themselves to have a negative impact on nursing practice in the ICU and surgery care unit.

4.2 | Continuous pulse oximetry monitoring and operational failures

Tucker (2004) defines operational failures as the inability of the work system to reliably deliver information, services and resources when, where and to whom they are needed. Several studies have shown that hospitals rely on a highly skilled professional workforce, i.e., nurses, to compensate for operational failures that may arise during the process of providing patient care, but which do not require the expertise of a skilled workforce (Tucker, 2004, 2016; Tucker et al., 2008, 2014a, 2014b; Tucker & Edmondson, 2003; Tucker & Spear, 2006). Our results show that this is precisely the case in the two units where our study was conducted. We found that most false alarms were without any clinical significance since they resulted from equipment failures (such as loose adapters, wrongly attached to the device case, or batteries that need to be replaced). Based on Tucker et al. (2014a, 2014b) definition, it is possible to suggest that some of the nurses' time in the two observed units was used to repair operational failures. In other words, monitoring patients through continuous pulse oximetry monitoring adds to the operational failures that nurses compensate for instead of concentrating on direct care.

Tucker's research results indicate that the time nurses spend managing and resolving operational failures largely diminishes the time available for care. This is because these failures monopolize the nurses' attention in such a way that they are unable to meet the patients' needs, provide necessary care and achieve the desired outcomes (Tucker, 2004, 2016; Tucker et al., 2008, 2014a, 2014b; Tucker & Edmondson, 2003; Tucker & Spear, 2006). Moreover, several of her studies have shown that the lack of support staff (ward aides, receptionists) was the cause of many operational failures, where the care is interrupted for the nurses to perform the support functions themselves. Tucker's findings were largely reflected in our results, where we observed that the nurse responsible for monitoring patients with continuous pulse oximetry monitoring must also go back and forth to pick up a new device, put the device back into place, change the batteries, call the ICU nurse back to confirm information and so on. Based on our observations and on Tucker's work, monitoring through continuous pulse oximetry seems to add more tasks to the nurses' already very busy schedule on these two units.

4.3 | Limits of the study

The limited number of participants, of hours of observation and the moments of observation chosen can be considered as the biggest limits of this study. A larger number of participants would have allowed for a greater number of hours of observation, with greater emphasis on hours of sleep, which would certainly have contributed to data quality. However, the mixed data analysis approach based on the model of Dallaire and Dallaire (2008) and the triangulation of qualitative and quantitative data allowed for an understanding of the impact of continuous pulse oximetry monitoring on nursing practice. In addition, the validation step has promoted the study's validity and credibility.

5 | CONCLUSION

This study aimed to describe the impact of the use of continuous pulse oximetry monitoring to monitor patients at high risk of respiratory depression after surgery on a nursing practice. The fact that the monitoring and follow-up of patients through continuous pulse oximetry monitoring were divided between two different care units dictates that, in addition to their care-related tasks, nurses must sustain continuous circulation of information between the ICU and surgery care unit to ensure patient safety. However, as shown by our results, this is not always possible, as the noisy environment, high number of false alarms, poor communication channels between the nurses are some of the challenges faced in the ICU and the surgery care unit when providing continuous monitoring and rapid follow-up, as intended. In addition, false alarms have been found to constitute the majority of the observed and nurse-reported alarms of continuous pulse oximetry monitoring. The results of this study show that continuous pulse oximetry monitoring could end up adding to the various organizational failures to be managed by nurses, which could have a significant impact on the quality of care and the intended outcomes. This seems to suggest that bedside patient monitoring could be more effective in detecting respiratory depression and responding quickly to postsurgical patients then monitoring through continuous pulse oximetry monitoring.

6 | IMPLICATION FOR NURSING MANAGEMENT

The results of this study raise several challenges that must be overcome for this technology to achieve the desired outcomes of continuous surveillance and rapid detection of respiratory depression episodes for post-surgical patients. To reduce false alarms, it is suggested to customize the alarm system parameters (number of alarms, thresholds, alarm delay) based on each patient's status and history. In other words, individualizing the parameters of an alarm, according to age, medical history, diagnosis, pharmaceutical treatment and level of stability (Cho et al., 2016). In addition, the literature shows that reducing the alarm thresholds for a drop in oxygen saturation from 90% to 88% allows a reduction of 43%–45% in the rate of false alarms (Graham & Cvach, 2010; Welch, 2011). However, a reduction in the threshold from 90% to 85% has been shown to have a greater chance of reducing false alarms of 75% and up to 82% less (Welch, 2011).

In addition, the results of several studies show that the introduction of an alarm triggering delay while maintaining an alarm triggering drop in oxygen saturation threshold at 90% makes it possible to considerably reduce the false alarm rate (Cvach et al., 2020; Welch, 2011). The proposed delay time before the alarm is triggered varies from 5 to 19 s. Modifying the parameters by adding such a delay allows a reduction in the frequency of false alarms, varying between a minimum of 50% and a maximum of 82% of false alarms (Cvach et al., 2020; Welch, 2011). With a lowered threshold, a transient drop in the level of oxygenation or temporary poor uptake can be resolved, avoiding an alarm. Finally, studies show that the best results observed in terms of reduction of the false alarm rate are achieved by combining the two previous recommendations. This could eliminate up to 85% of false alarms (Cvach et al., 2015, 2020; Welch, 2011).

As for the organizational failures, we found that most of them could be resolved through simple changes such as those suggested above. Moreover, any purchase of equipment should be done carefully. A thorough assessment of the available devices could be done by first comparing their performance and deficiencies and choosing those that require the least maintenance.

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CONFLICT OF INTEREST STATEMENT

No conflict of interest has been declared by the authors.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

ETHICS STATEMENT

The ethics committee of the hospital where the project was conducted approved the study (2020-705). All participants gave consent to participate in the research project.

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