CACCN

The Canadian Journal of Critical Care Nursing

Volume 36, Number 2, Summer 2025

ISSN (Print): 2368-8653, (Online): 2563-8998

IN THIS ISSUE:

The Canadian Journal *of* Critical Care Nursing

Volume 36, Number 2, Summer 2025

Canadian Association of Critical Care Nurses

CACCN National Office

Chief Operating Officer:
Christine R. Halfkenny-Zellas, P.Mgr., CIM
P.O. Box 25322, London, Ontario N6C 6B1
caccn.ca
email: caccn@caccn.ca
phone: 519-207-7007
toll-free: 1-866-477-9077

The *Canadian Journal of Critical Care Nursing* is the only peer-reviewed, open-access critical care journal in Canada, and is published by Pappin Communications, Cobden, Ontario. Printed in Canada. ISSN: 2368-8653 (Print), 2563-8998 (Online). The journal is offered electronically on our website at cjccn.ca. A small number of print copies are produced for paid subscribers.

Advertising information: For advertising enquiries, contact Heather Coughlin, Pappin Communications, 1012 Snake River Line, Cobden, ON K0J 1K0, telephone: 613-633-1938, email: heather@pappin.com, website: www.pappin.com

Author Enquiries: All manuscript submissions are to be sent to Chief Editor, Canadian Journal of Critical Care Nursing (CJCCN): cjccneditor@caccn.ca and CACCN National Office: caccn@caccn.ca. For Author Guidelines, refer to the Canadian Journal of Critical Care Nursing (CJCCN) website: https://cjccn.ca/

CANADIAN ASSOCIATION OF CRITICAL CARE NURSES

Canadian Association of Critical Care Nurses

Vision statement

All critical care nurses provide the highest standard of patient- and family-centred care through an engaging, vibrant, educated and research-driven specialized community.

Mission statement

We engage and inform Canadian critical care nurses through scholarship, education, and networking providing a strong unified national identity.

Values and beliefs statement

Our core values and beliefs:

- Excellence and Leadership
  - Collaboration and partnership
  - Pursuing excellence in education, research, and practice
- Dignity and Humanity
  - Respectful, healing, and humane critical care environments
  - Combining compassion and technology to advocate and promote excellence
- Integrity and Honesty
  - Accountability and the courage to speak up for our beliefs
  - Promoting open and honest relationships

Pathways to success

1. **Leadership:**
   - Lead collaborative teams in critical care interprofessional initiatives
   - Develop, revise, and evaluate CACCN Standards of Care and Position Statements
   - Develop a political advocacy plan

2. **Education:**
   - Provision of excellence in education
   - Advocate for critical care certification
3. **Communication and Partnership:**
   - Networking with our critical care colleagues
   - Enhancement and expansion of communication with our members
4. **Research:**
   - Encouraging, supporting, facilitating to advance the field of critical care
5. **Membership:**
   - Strive for a steady and continued increase in CACCN membership

From the Chief Editor

In preparation for this letter from the chief editor, I found myself reflecting on my nursing career, the role of the intensive care unit (ICU) environment, and the people I had the privilege of working with throughout my career in the ICU. Two large celebrations took place in the last six weeks: the first was the grand opening of a new ICU that had been more than 20 years in the making, bringing together present and past ICU staff, and a celebration of life for an intensivist who lost his battle with myelodysplastic syndrome. Both events took me right back to my days at the bedside, allowing me the space to reflect on how those years have shaped me and my career.

I started in the ICU during a time when there were few new graduates even allowed through the unit door. The ICU was a place of prestige and honour, and I still feel a sense of pride from working in that environment. The manager, Pam Holberton, took a chance on me without any critical care experience and placed me under the guidance of a nurse clinician named Carol Logan and a senior nursing team. These two phenomenal leaders and nurses nurtured my self-esteem, entrusted me to develop my skills and knowledge gradually and safely, challenged me to be better each shift, and led a community of other nurses who took us *young ones* under their wings for protection and guidance. For the first time in 25 years, I was able to express my gratitude to these two phenomenal women for the profound impact they have had on my life and career.

The critical care environment has challenged all of us at some point, and if we were open to it, it changed our perspective on how we live our lives. Whether you are those who currently work in the ICU, those who have left the environment for other areas of healthcare, academia, policy, or another nursing role, I hope you take a moment to thank the people who have supported you on your path.

Belonging to the ICU community is a gift, despite the changes and difficult times over the past few years. You are a part of something bigger than your role, and the impact you have on the people you care for and work with can last for years to come. I was reminded of how fortunate I was to work with the people I did and the community that still comes together, even during a celebration of new opportunities and remembering a life well-lived.

Take a moment to thank the people who impacted you. You are standing on the shoulders of giants. For me, I have had some amazing shoulders lifting me over the years, and I hope that I am providing the same support to others.

All my best,

Kara Sealock, EdD, MEd, RN, CNCC(C), CCNE
Chief Editor

Nurses' perceived feasibility and the clinical utility of the Nociception Level (NOL™) Index for pain assessment in critically ill adults

By Shiva Shahiri T., MScA, RN, Patrick Lavoie, PhD, RN, Marc O. Martel, PhD, Philippe Richebé, MD, PhD, DESAR, and Céline Gélinas, PhD, RN, FCAN

Abstract

Introduction: *The Nociception Level (NOL™) Index monitors nociception and related pain using multiple physiologic parameters through a non-invasive finger probe and is currently undergoing validation for pain assessment in the Intensive Care Unit (ICU). This study aimed to describe its feasibility and clinical utility from nurses' perspectives, which is crucial for its potential adoption in clinical practice.*

Methods: *This descriptive study involved ICU nurses who received a brief training (5-minute video and handout) as part of the validation process of the NOL Index in a medical-surgical ICU. Trained nurses who used the NOL Index at the ICU bedside completed a self-administered questionnaire on its feasibility and clinical utility on a 4-point scale. Scores of 3 and 4 supported its feasibility and clinical utility.*

Results: *Of the 21 trained nurses, nine (43%) used the NOL on enrolled patients, but eight (38%) completed the questionnaire. Their average age was 34 years, and 63% were female. Feasibility indicators were endorsed by 95% of nurses supporting the NOL's easy application, installation, and calibration, with clear usage instructions. Training strategies (i.e., video and handout) were rated positively with scores ≥ 3/4 by 95% of nurses. Nurses recommended adding more hands-on practice for the bedside use of the NOL. Clinical utility indicators were endorsed by 87.5 % of nurses suggesting it should remain an assistive, not a diagnostic tool. Indeed, several factors including patient's hemodynamic instability and movements limit the NOL Index's use in the ICU.*

Conclusion: *Nurses perceived the NOL Index as a potential alternative measure for pain assessment in mechanically ventilated and sedated ICU patients unable to self-report.*

Keywords: feasibility, clinical utility, nociception, pain assessment, intensive care unit

Shahiri, S., Lavoie, P., Martel, M. O., Richebé, P., & Gélinas, C. (2025). Nurses' perceived feasibility and the clinical utility of the Nociception Level (NOL™) Index for pain assessment in critically ill adults. *The Canadian Journal of Critical Care Nursing, 36*(2), 6–17. DOI: 10.5737/23688653-3626

Implications for Nursing

- The Nociception Level (NOL) Index, a multiparametric technology initially developed for use during anesthesia, is being validated for ICU pain assessment.
- During the validation process, it is critical to evaluate the new tool's usage feasibility and clinical utility from nurses' perspectives.
- Nurses considered the NOL Index a potential alternative measure for pain assessment in mechanically ventilated and sedated ICU patients, contingent upon addressing clinical factors (e.g., hemodynamic instability, and movements) that limit its use.

Introduction

Nurses in the intensive care unit (ICU) provide complex care to critically ill adults who suffer from severe illnesses, trauma, and surgery. These conditions expose them to pain caused by nociception from tissue damage, invasive interventions, and noxious stimuli from standard care procedures (Devlin et al., 2018). While patient self-report is the reference standard measure of pain, the use of sedative medications, mechanical ventilation, or clinical conditions affecting brain functioning may hinder self-reporting (Devlin et al., 2018). In such cases, nurses use behavioural assessment tools as alternative standard pain measures, such as the Behavioral Pain Scale (BPS; Payen et al., 2001) and the Critical-Care Pain Observation Tool (CPOT; Gélinas et al., 2006). However, these tools cannot be used in patients on high doses of sedatives or neuromuscular blockers as they become unresponsive to stimulation (Chanques et al., 2020; Devlin et al., 2018; Herr et al., 2024). Thus, exploring alternative pain assessment methods is necessary.

Continuous bedside monitoring provides immediate access to vital signs. ICU nurses use vital signs for various purposes including pain assessment (Damico et al., 2016; Gnass, 2015; Rose et al., 2012). However, evidence has demonstrated that individual vital signs lack validity for ICU pain assessment purposes (Devlin et al., 2018; Herr et al., 2024; Shahiri & Gélinas, 2023). Studies in the field of anesthesia have shown that the combination of multiple physiologic parameters (e.g., heart rate, blood pressure) may be superior to their individual use for nociception monitoring (Ben-Israel et al., 2013; Edry et al., 2016; Martini et al., 2015; Renaud-Roy et al., 2019; Stockle et al., 2018). The developed Nociception Level (NOL™) Index (Medasense Biometrics Ltd., 2025) simultaneously incorporates multiple physiologic parameters captured from a non-invasive finger probe to monitor nociception and pain in anesthetized

patients (Ben-Israel et al., 2013). The finger probe incorporates a disposable sensor that extracts several physiologic parameters, including heart rate, heart rate variability, photoplethysmography pulse wave amplitude (an indicator of arterial blood pressure), and skin conductance and temperature (Ben-Israel et al., 2013; supplementary file A). Values exceeding 20–25 were found to be indicative of nociception and pain (Coulombe et al., 2021; Gélinas et al., 2021; Ledowski et al., 2021; Meijer et al., 2020; Renaud-Roy et al., 2019). Since a tool can only be valid for a specific population and in a given context (Streiner et al., 2024), the validation of the NOL Index for pain assessment in critically ill adults in the ICU setting was necessary. We conducted two initial pilot studies in 54 conscious postoperative ICU cardiac patients and 15 conscious mechanically ventilated ICU patients able to self-report (Gélinas et al., 2021; Shahiri et al., 2020). Our findings supported the NOL Index's ability to detect pain using standard pain measures including self-reporting (reference standard) and CPOT (alternative standard). Our findings also supported the NOL Index's ability to discriminate between non-nociceptive (e.g., taking blood pressure using cuff inflation) and nociceptive procedures part of ICU standard care (e.g., chest tube removal, endotracheal/tracheal suctioning; Gélinas et al., 2021; Shahiri et al., 2020).

Evaluating feasibility and clinical utility in the early stage of the validation process is crucial to ensuring comprehensive consideration for future development and implementation (Eysenbach et al., 2018). Feasibility refers to the ease of technology's clinical application, while clinical utility pertains to the relevance of technology's use for clinical practice purposes (Duhn & Medves, 2004; Smart, 2006; Weiner et al., 2017). Evidence supports that frontline clinicians such as nurses, should play a role in designing, developing/validating, purchasing, implementing, and evaluating healthcare technologies (Lambert et al., 2023; Schoville & Titler, 2015; Weiner et al., 2017), as neglecting their involvement may hinder future adoption in clinical practice (Schoville & Titler, 2015). Therefore, the evaluation of the NOL Index's feasibility and clinical utility during the validation process could guide technology adoption decisions and evidence-based clinical recommendations (Weiner et al., 2017). This study aimed to describe the feasibility and clinical utility of the NOL for ICU pain assessment from nurses' perspectives.

Methods and materials

Study design and setting

A descriptive design was used to achieve the study purpose. This study was conducted as a complementary objective of a larger research project focused on validating the NOL for ICU pain assessment across three medical-surgical ICUs of university-affiliated hospitals in Montreal, Canada. The present study was conducted in one of these ICUs, which has a 30-bed capacity. However, due to nursing shortage caused by the COVID-19 pandemic, the number of available beds was reduced to 20, with 15 nurses per shift during the study period. On average, the ICU admits between 1,000 and 1,500 patients annually. The *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)* checklist was used for the description of the study and the reporting of the results (von Elm et al., 2007).

Participants

Two populations were recruited for the larger research project: nurse and patient participants. The present study focuses exclusively on nurse participants. The eligibility criteria for patient participants are provided because they were under the care of the nurse participants who tested the NOL Index on them.

Convenience sampling was used to recruit nurse participants, which was well aligned with our aim to obtain an overview of the perspectives and insights from ICU nurses involved in the NOL Index validation study. Nurses with part-time and full-time positions and a minimum experience of 6 months were eligible, as this period is required to complete orientation and probation.

Enrolled ICU patients under the care of the nurse participants were: ≥18 years old, English, or French speaking, and mechanically ventilated. They were excluded if they had conditions that could affect the NOL Index signal, such as hemodynamic instability (e.g., cardiac arrhythmias, severe peripheral vascular disease, state of hypoperfusion, or receiving high doses of vasopressors) or movements or agitation.

Recruitment procedures

Ethical approval was submitted in February 2022 and approved in June 2022 (project # MP-05-2022-2988). The research trainee (SS) presented the study to ICU nurses during staff meetings. The study description and invitation were also emailed to all ICU nurses by the nurse clinical consultant. Nurses who expressed interest during the staff meeting, on the unit during the data collection, or via email were contacted by the research trainee for additional study details. The research trainee confirmed eligibility, addressed questions, and provided explanations about the study and consent form. A screening log was maintained, documenting the number of nurses who agreed to participate, and reasons for refusal or withdrawal.

Data collection procedures

Training of nurse participant for NOL study procedure

The research trainee provided the training to nurse participants before the NOL study procedure at the ICU bedside. Nurse participants watched a 5-minute training video in mp4 format prepared by the research trainee and reviewed by the principal investigators (CG and PR), which was accompanied by a handout detailing the NOL Index's description, function, and measurement method. These materials were sent to the nurses via email. The training video encompassed all information covered in the handout, along with a demonstration of NOL Index device setup, including finger probe placement and calibration. The research trainee addressed any questions, provided a concise review of the steps, and offered additional clarification as needed until the nurse participant felt prepared to proceed. A checklist was provided to assist in the NOL procedure, and the research trainee completed it during the process. Throughout the data collection of the NOL study procedure, the research trainee was present and available to address any questions from the nurse participants.

NOL Index procedure by nurse participants

The data collection of the NOL study procedure took place from July 2022 to March 2023. Once an ICU patient was enrolled and under the care of a nurse participant, the research trainee informed the nurse about the start of the data collection procedure. First, the NOL's training content and the procedure steps were reviewed with the nurse participant. Then, the nurse installed the disposable sensor in the finger probe and placed it on the patient's index finger or any available finger. Subsequently, the nurse performed bedside calibration of the NOL device and observed NOL values before and during mouth/endotracheal/tracheal suctioning. This intervention was selected as the nociceptive procedure because it is known to induce moderate to severe pain (Dale et al., 2020; Dale et al., 2018; Kurt & Zaybak, 2022; Özsaban et al., 2023; Puntillo et al., 2014) and is part of standard care for mechanically ventilated ICU patients. The suctioning procedures were performed by respiratory therapists based on patients' care needs. Considering that the NOL is still in the validation process, it was emphasized that NOL values should not influence nurses' decision-making regarding the administration of analgesia during this study. The research trainee was present to verify proper probe placement and device calibration, ensuring accurate device application by the nurse participants (Bialocerkowski et al., 2010). The nurse participants had the opportunity to address questions to the research trainee during the procedures, if required.

Upon completion of training and all steps of the NOL study procedure for an enrolled patient, the nurse participants were asked to fill out demographic, and feasibility and clinical utility questionnaires and returned them in a sealed envelope to the research staff within a 72-hour period. A small compensation of 40 CAD was offered to nurses for their participation upon returning their completed questionnaire. It is noteworthy that prior to being part of the present study, nurse participants also had exposure to observing other instances in which the research staff performed data collection during the validation study, including any challenges encountered during the NOL study procedure.

Instruments

Socio-demographic information from nurse participants

The socio-demographic questionnaire included information on participants' age, sex, gender, and educational level. The following data on professional experience were also collected: ICU position, current employment status, years in the current ICU position, and total years of experience in nursing.

Feasibility and clinical utility questionnaire

The self-administered Feasibility and Clinical Utility questionnaire comprised 13 closed-ended questions presented on a descriptive scale ranging from 1 to 4, where 1 indicates "Not at all", 2, indicates "A little", 3 indicates "Sufficiently" and 4 indicates "Very". Therefore, we considered scores of 3 and 4 as endorsements of feasibility and clinical utility. The questionnaire was adapted from prior versions assessing CPOT feasibility and clinical utility (Gélinas, 2010; Gélinas et al., 2011; Richard-Lalonde et al., 2019) which was initially developed by Puntillo et al. (2002) for their pain assessment tool (Pain Assessment and Intervention Notation [P.A.I.N.]). Feasibility indicators (n = 5) included duration of training, quickness of use, clarity in NOL application, comprehensibility, and simplicity of completion. Clinical utility indicators (n = 3) addressed the recommendation of the NOL's use, its helpfulness, and its potential influence on clinical practice. Additional questions (n = 5) were created to assess specific aspects of the training, such as the effectiveness of the training handout and video, as well as the support provided by the research team. Each question allowed for short comments to provide additional context to ratings. Furthermore, open-ended questions were included to gather insights for potential future implementation of the NOL into practice. The questionnaire was available in both English and French to accommodate participants' language preferences.

NOL Index procedure checklist

A checklist was designed to guide the NOL study procedure. It included six steps for the nurse participants to follow: 1) installation of disposable sensor on the finger probe; 2) placement of the non-invasive finger probe on any available finger of the patient; 3) turning on the NOL Index device; 4) calibrating the NOL Index by pressing the calibration button; 5) obtaining the NOL Index signal; 6) reading the NOL Index value.

Data analysis

Descriptive statistics, including frequencies and medians (interquartile intervals), were reported using SPSS 27 to characterize the study sample and nurses' responses to the questionnaires. The frequency and percentage of nurses who provided a score of 3 or 4 for each aspect of the NOL's use (i.e., feasibility, training, and clinical utility) were also calculated. Written responses were categorized by topics and arranged in the order of occurrence frequency.

Results

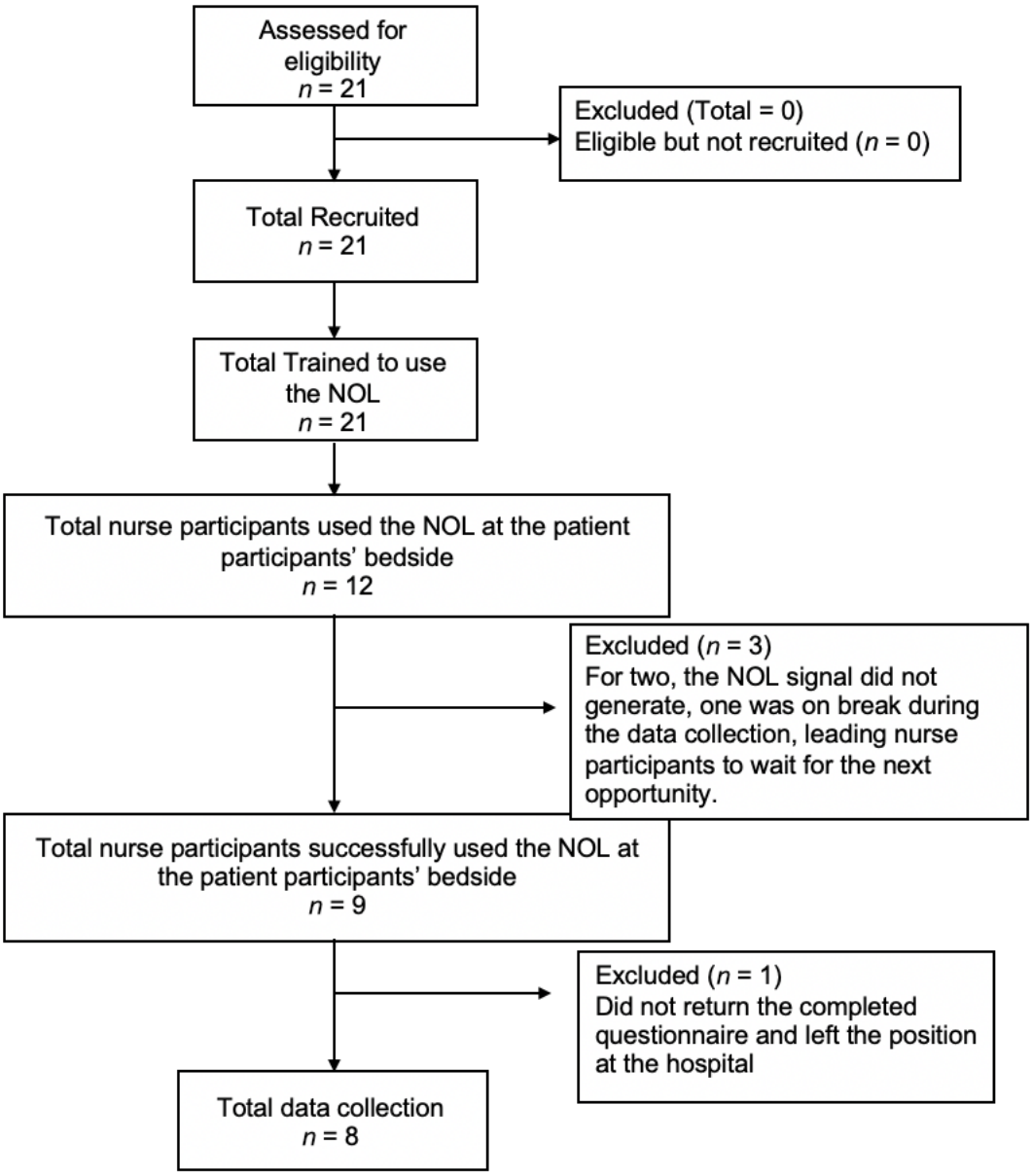
All 21 ICU nurses who were interested and approached agreed to participate and were trained to use the NOL. The participant flow diagram is provided in Figure 1.

Out of the 21 nurses trained to perform the NOL study procedure, 12 (57%) did not complete the bedside data collection procedure during validation testing. Among them, nine never had the opportunity to perform the NOL study procedure at the ICU bedside since no patient under their care was enrolled in the validation study. For the remaining three nurses, the NOL Index signal failed to generate in two cases, potentially due to factors such as sudden changes in cardiac rhythms during the procedure or cold fingers. In the third case, the nurse was on a break during the suctioning procedure, but the replacement nurse, also a nurse participant, completed the procedure. Consequently, those three were unable to complete the NOL study procedure at the bedside and, therefore, were not asked to fill out the feasibility and clinical utility questionnaire. None of these nurses had the opportunity to retry with another patient participant.

Nine nurses (43%) successfully completed the NOL study procedure at the bedside. Among them, two achieved successful data collection on a second attempt with another patient participant due to initial signal loss on their first patient participant. For one of the nurse participants, the patient participant experienced

Figure 1

Nurse Participants Flow Diagram



Note. NOL = Nociception Level Index

sudden onset of irregular cardiac rhythm at the time of procedure, leading to the NOL signal not generating. This condition was also an exclusion criterion due to its impact on heart rate variability, a parameter crucial to the NOL algorithm. Therefore, the patient participant was excluded. For the other nurse participant, signal loss may have been due to the patient's cold finger. One nurse participant left the hospital prior to returning the completed questionnaire and was unreachable. Thus, eight nurses returned their completed questionnaire.

Socio-demographics of nurse participants

The sociodemographic information of the nurse participants is presented in Table 1. The nurses' median age was 39 years (range = 25–60). As a complementary analysis, we performed the Mann-Whitney U test to examine if age, number of years in the current ICU position, and total years of experience in nursing were different between nurses who completed the NOL Index procedure at the bedside and those who did not. The age of nurses who completed the NOL study procedure (n = 8) versus those who did not (n = 9) was not significantly different (U = 48.00, p = .277). Educational level was similar for nurses who used the NOL and those who did not. However, they were significantly different in their number of years in the current ICU position (U = 45.00, p = .036) and total years of nursing experience (U = 59.50, p = .021), indicating that nurses who completed the NOL study procedure were less experienced.

Table 1

Sociodemographic Information of Nurse Participants (n = 21)

Variable	Used the NOL (*n* = 9)*	Did not use the NOL (*n* = 12)#	Total (*n* = 21)
Age	34 (24–44)	40 (34–47)	39 (28–46)
Sex			
Female	5 (55.5%)	7 (58.3%)	12 (57.1%)
Male	3 (33.3%)	2 (16.7%)	5 (23.8%)
Gender			
Woman	5 (55.5%)	7 (58.3%)	12 (57.1%)
Man	3 (33.3%)	2 (16.7%)	5 (23.8%)
Ethnicity			
North American Indigenous origin	0	1 (8.3%)	1 (4.8%)
Other North American origin	3 (33.3%)	0	3 (14.3%)
European origin	3 (33.3%)	3 (25%)	6 (28.6%)
Caribbean origin	0	1 (8.3%)	1 (4.8%)
Asian origin	0	2 (16.7%)	2 (9.3%)
Middle eastern origin	2 (22.2%)	2 (16.7%)	4 (19.1%)
Highest level of education			
Bachelor's degree in nursing	6 (66.6%)	8 (66.7%)	14 (66.6%)
Master's degree	2 (22.2%)	1 (8.3%)	3 (14.3%)
Employee status			
Permanent full-time	7 (77.7%)	7 (58.3%)	14 (66.6%)
Temporary full-time	1 (11.1%)	2 (16.7%)	3 (14.3%)
Work shift			
Evening	1 (11.1%)	0	1 (4.8%)
Night	0	1 (8.3%)	1 (4.8%)
Rotation	7 (77.7%)	8 (66.7%)	15 (71.3%)
Work hours			
8-hour shift	2 (22.2%)	3 (25%)	5 (23.8%)
8 or 12-hour shift	6 (66.6%)	6 (50%)	12 (57.1%)
Years of experience as an ICU nurse	2.8 (1.8–12)	14 (8–16.5)	11 (2.8–16)
Years of experience as a nurse	7 (2.5–14.3)	17 (10.5–22)	13 (5–19)
Missing	1 (11.1%)	3 (25%)	4 (19.1%)

Note. Values are median (IQR) or *n* (%).

*One nurse left the hospital and did not complete the questionnaire.

#Three nurses left the hospital without completing the NOL procedure, having only filled out the socio-demographic questionnaire.

NOL = Nociception Level Index; ICU = intensive care unit.

Socio-demographics of patient participants under the care of nurse participants

Thirteen patients were cared for by nurse participants over the course of the study. Among these, a NOL signal was successfully generated in nine patients, but not in four. For the nine patients for whom the NOL signal was generated, the median age was 71 years (range = 46–79, IQR = 61–74). The majority were male (n = 7) and mechanically ventilated (n = 8). One patient participant was extubated at the time of the nurse participant's data collection; however, mouth suctioning was performed, and the nurse participant was able to complete the NOL procedure. Patient participants were admitted to the ICU with a medical (n = 2) or a surgical (n = 7) diagnosis. Six patients had no alteration of consciousness (Glasgow Coma Scale [GCS] = 13–15; Teasdale & Jennett, 1974), while three had an altered level of consciousness (GCS = 6–11). For the four patient participants for whom the NOL Index signal did not generate, the median age was 72 (range = 59–75, IQR = 65–74). Two were female. All four were conscious (GCS = 13–15), mechanically ventilated, and admitted to the ICU with a surgical diagnosis.

NOL Index feasibility and clinical utility

All the steps of the NOL study procedure checklist were successfully achieved per nurse participants (n = 8). On three occasions, the nurse participants asked the research trainee to turn on the NOL device or press the calibration button, because they were on the other side of the bed and away from the device. Results from the evaluation of feasibility and clinical utility of the NOL are presented in Table 2 and written comments provided by the nurse participants are presented in Table 3. All nurse participants completed the English version of the questionnaire.

Feasibility indicators and training strategies were endorsed by 95% of nurses, indicating easy application of the finger probe, installation, and calibration of the NOL. Nurses indicated that the support from the research staff during training and their presence during the NOL study procedure were the most helpful training strategies. Moreover, they stated the real-time demonstration was a better training strategy than the recorded video. More exposure and practice with the NOL were also requested.

Table 2

Nurse Participants' Responses to the Questionnaire Regarding Feasibility, Training Evaluation, and Clinical Utility of the NOL (n = 8)

	Questions	Not at all	A little	Sufficiently	Very	Median	IQR
Feasibility	Was the length of time sufficient to train you to use the NOL accurately?	0	1	3	4	3.5	3–4
	Is the NOL quick to use?	0	0	3	5	4	3–4
	Were the directives about the use of the NOL clear?	0	0	3	5	4	3–4
	Is the NOL simple to understand?	0	1	3	4	3.5	3–4
	Is the NOL easy to apply?	0	0	3	5	4	3–4
Training Evaluation	Did the training help you understand how the NOL can help you better care for your patients?	0	0	5	3	3	3–4
	Did the training facilitate the understanding of the NOL's use?	0	0	3	5	4	3–4
	Was the training handout useful?	0	1	3	4	3.5	3–4
	Was the training video useful?	0	1	4	3	3	3–4
	Was the support from the research team helpful when setting up the NOL device at the bedside?	0	0	0	8	4	4–4
Clinical Utility	I would recommend using the NOL routinely	0	2	2	4	3.5	2.5–4
	The NOL would be helpful for practice.	0	0	4	4	3.5	3–4
	Using the NOL could influence my practice	0	1	3	4	3.5	3–4

Note. NOL = Nociception Level Index.

Table 3

Nurse Participants' Comments on Feasibility and Clinical Utility of the NOL for ICU Pain Assessment

Comments	Frequency
The NOL Index is quick and easy to use	
Easy and quick installation, application, and calibration	4
Directive about the use of the NOL	
Very clear directive	2
Most helpful training strategies	
Actual practice on a real patient/Hands on learning	2
Observing the monitoring process at the bedside	1
The presence of research staff during the procedure	3
The training is convenient; however, a real time demonstration is more beneficial	1
Reasons for recommending the use of the NOL	
Provides an alternative pain measure for non-communicative ICU patients who are non-agitated and sedated	8
Reasons for not recommending the use of the NOL	
Inaccurate readings on restless ICU patients or during movement	1
The NOL Index is not suitable during acute phase of a shock (e.g., sepsis) or on patients with edema on their fingers	1
There is a concern whether the NOL detects only pain or other emotions such as fear and anxiety	1
The NOL is helpful for practice	
The NOL provides another quantitative measure of pain other than vital signs	1
The NOL seems to be a helpful alternative measure of pain in non-communicative, sedated, and mechanically ventilated patients	5
The NOL is helpful to evaluate the effectiveness of treatment in sedated and mechanically ventilated patients	1
The NOL is not helpful for practice	
Anxiety seems to influence the NOI's reading; the NOL Index values increased on an awake patient who self-reported being anxious but not being in pain	1
The NOL signal does not generate on ICU patients with complex clinical conditions (e.g., state of shock, cardiac arrhythmias, edema).	1
Using the NOL in the study has influenced my practice in assessing the patient's pain	
The NOL would enable clinicians to optimize pain management and to avoid over-/under treatment	4
The NOL would help decreasing the length of mechanical ventilation and ICU stay and subsequently lower the incidence of delirium	1
Using the NOL in the study has not influenced my practice in assessing the patient's pain	
The NOL would remain a tool and not to diagnose pain	1
How to improve the use of the NOL	
Integrate the NOL into the ICU beside VS monitoring device	1
Provide different types/sizes for the finger probe	1
Unsure at this point	1

Note. NOL = Nociception Level Index; ICU = intensive care unit.

Clinical utility indicators were endorsed by 87.5 % of nurses. Nurses indicated that the NOL, if found valid, could provide an alternative measure for pain assessment and guide analgesic effectiveness evaluation in mechanically ventilated and sedated ICU patients. They further mentioned that by optimizing analgesia, the NOL may help to decrease the length of ICU stay and improve patient outcomes. However, they also pointed out that impeding factors, such as agitation, cardiac arrhythmias, edema, state of shock, and movements may hinder its utility in the ICU context. Another concern was raised regarding whether the NOL Index detects only pain or related emotions, such as fear and anxiety. Lastly, they suggested that the NOL should remain as an assistive technology and not a diagnostic tool.

To improve the clinical utility of the NOL in the ICU setting, nurses recommended integrating the NOL into the ICU bedside monitoring device. In some instances, nurses had difficulty placing the finger probe. Thus, they also recommended providing different sizes and shapes of the NOL's finger probe as it exists for oxygen saturation finger probes. Finally, the strategies for potential future NOL's implementation into ICU clinical practice were described in Table 4.

Discussion

Nurses' perceived feasibility and clinical utility of the NOL was evaluated for the first time within the context of its validation process. Almost half of the nurse participants who were trained had the opportunity to perform the NOL procedure at least once at the ICU bedside. They also observed the research staff performing NOL data collection during the validation study, which could have influenced their evaluations. The majority of nurses who completed the NOL procedure in this study are considered as expert in their professional development (Benner, 1982). Research has shown that greater clinical experience is associated with a higher likelihood of utilizing technology at the bedside (Brown et al, 2020). Thus, nurses with greater clinical experience may be more likely to incorporate bedside technology effectively into patient care.

Table 4

Nurse Participants' Recommended Implementation Strategies of the NOL Index for ICU Pain Assessment

Comments	Frequency
Provide an information session to describe the NOL Index, its utility, and benefits for the patient	1
Include a training and hands on practice, as was conducted by the research staff	2
Include the training as one of the ICU's mandatory trainings	1
Include a nurse champion or a resource nurse for the implementation	1
Include a trouble-shooting mechanism, as with more practice, issues may arise	1
Involve the engaged partners, such as ICU leadership teams, to ensure their buy-in	1

Note. NOL = nociception level; ICU = intensive care unit.

Most ICU nurse participants agreed with all feasibility indicators assessed. The NOL was perceived as easy and quick to use and understand, and simple and quick to apply with clear directives for application. While support from the research staff was considered the most helpful training strategy, nurses recommended incorporating real-time demonstrations and multiple opportunities for practice with the NOL into training sessions.

Nurses pointed out several factors that may limit the clinical utility of the NOL for ICU pain assessment, including patient movement, agitation, cardiac arrhythmias, and edema. Our previous findings also highlighted the potential impact of patient movements on NOL signal quality, which was mitigated by instructing participants to limit finger movement during data collection, as they were all awake and conscious during these pilot studies (Gélinas et al., 2021; Shahiri et al., 2020). Yet, in agitated ICU patients who are not sedated, the NOL's clinical utility is likely to be compromised. Given that most patient participants in this study were conscious, nurses likely found it easier to identify issues primarily related to patient movement. Cardiac arrhythmias, although an exclusion criterion from the validation study, are common in critically ill patients and can affect heart rate variability (one of the parameters of the NOL algorithm), potentially leading to signal loss and limiting its use in the ICU. Similarly, edema can affect photoplethysmography outputs, posing challenges for patients with swollen fingers. Similar findings regarding NOL signal issues compromising its clinical utility in the ICU were also reported in our pilot studies. These issues included variability in the shapes and sizes of patients' fingers, as well as patient movements (Gélinas et al., 2021; Shahiri et al., 2020). According to the nurses' suggestions, some of these challenges could be addressed by enhancing the finger probe design to accommodate a wider range of finger sizes and shapes.

To address nurses' concerns about whether the NOL detects only pain or other distressful feelings, our pilot study with postoperative ICU cardiac patients found associations between NOL values and pain intensity, but not anxiety (Gélinas et al., 2021). Mechanically ventilated ICU patients often experience distressing symptoms, such as anxiety and fear (Guttormson et al., 2023). Certainly, the coexistence of pain, fear, and anxiety highlights the necessity for using assessment tools that exhibit greater sensitivity and specificity to pain (Gélinas et al., 2014). Further validation results may elucidate this concern.

Implementation strategies suggested by nurses could assist in determining suitable implementation frameworks in ICU clinical practice for the NOL (Moullin et al., 2020). The suggested strategies in this study align with the refined *Expert Recommendations for Implementing Change in the ICU* framework, which include conducting ongoing and dynamic training sessions, educational meetings, identifying and preparing champions, offering interactive assistance, and involving executive boards (Mosch et al., 2022).

Limitations

This study had some limitations. Firstly, the participation rate was lower than anticipated compared to the total number of ICU nurses who received training. This was primarily due to trained nurses not being assigned to enrolled patients and one being on break during data collection. Secondly, the group of nurse participants who did not have the opportunity to perform the NOL study procedure at the bedside had more clinical experience than those who did, potentially affecting additional comments or insights. However, this assignment occurred randomly as the nurse and patient assignments were not controlled in this study but were determined by the assistant nurse manager. Thirdly, nurses could only complete the questionnaire after all steps of the NOL study procedure, so no data is available for instances where the NOL signal did not generate, and these nurses did not have a second opportunity. Fourthly, missing data occurred due to nurses leaving their positions in the ICU post-pandemic crisis. Finally, the questionnaire relied on quantitative evaluation of specific feasibility and clinical utility indicators, with the option to provide additional written comments. Further research with qualitative methods, such as semi-structured interviews could allow nurses to expand on their perspectives on the use of the NOL in the ICU.

Conclusions

During the validation process of the NOL Index, nurse participants positively evaluated the feasibility of using the NOL Index in the ICU setting. However, the clinical utility of the NOL Index was hindered by factors such as cardiac arrhythmias, edema, and the state of shock as experienced by ICU nurse participants in enrolled ICU patients. As the NOL Index validation process for ICU pain assessment is still ongoing, feedback from bedside clinicians, such as ICU nurses, can inform improvements to the NOL Index device to address these challenges. If NOL Index is found to be valid for ICU pain assessment, further implementation studies are warranted to evaluate the feasibility and clinical utility of this technology in routine clinical practice, its effects on pain management protocols, and patient outcomes.

Author notes

Shiva Shahiri T., MScA, RN, Ingram School of Nursing, McGill University. Centre for Nursing Research and Lady Davis Institute, Jewish General Hospital, Montreal, Quebec, Canada

Patrick Lavoie, PhD, RN, Faculty of Nursing, Université de Montréal, Montreal, Quebec, Canada and Montreal Heart Institute Research Centre, Montreal, Quebec, Canada.

Marc O. Martel, PhD, Faculty of Dental Medicine and Department of Anesthesiology, McGill University, Montreal, Quebec, Canada.

Alan Edwards, Pain Management Unit, McGill University Health Centre, Montreal, Quebec, Canada.

Philippe Richebe, MD, PhD, DESAR, Département d'anesthésie et réanimation, Polyclinique Bordeaux Nord Aquitaine, Bordeaux, France Department of Anesthesiology and Pain Medicine, Université de Montréal, Montreal, Quebec, Canada.

Céline Gélinas, PhD, RN, FCAN, Ingram School of Nursing, McGill University. Centre for Nursing Research, and Lady Davis Institute, Jewish General Hospital, Montreal, Quebec, Canada.

***Corresponding Author:** Shiva Shahiri T., MScA, RN, Ingram School of Nursing, McGill University. Centre for Nursing Research and Lady Davis Institute, Jewish General Hospital, Montreal, Quebec, Canada. Email: shiva.shahiri@mail.mcgill.ca*

Funding and conflict of interest

The authors acknowledge that Shiva Shahiri T. has been supported by doctoral awards from the Fonds de Recherche du Québec-Santé (FRQS), the Quebec Network on Nursing Intervention Research (RRISIQ), and Ministère de l'Enseignement Supérieur de la Recherche et de la Science (MES). The validation study of the NOL Index is primarily funded by the Canadian Institutes of Health Research (CIHR Project Grant #168983) led by Céline Gélinas (principal investigator) and Philippe Richebé (co-principal investigator). Shiva Shahiri T. is a graduate research trainee on this major grant and obtained research stipend. The funding agencies were not involved in the preparation of the research protocol or in the writing of this paper.

Medasense Biometrics Ltd. has not been involved in any part of the NOL Index validation study or the present study. The NOL Index device was purchased using CIHR funds to ensure complete independence.

The authors declare no known conflicts of interest.

REFERENCES

Ben-Israel, N., Kliger, M., Zuckerman, G., Katz, Y., & Edry, R. (2013). Monitoring the nociception level: A multi-parameter approach. *Journal of Clinical Monitoring & Computing: Including a Specialty Section on Surgical Neuromonitoring, 27*(6), 659–668. https://doi.org/10.1007/s10877-013-9487-9

Benner, P. (1982). From novice to expert. *AJN, American Journal of Nursing, 82(3),* 402–407.

Bialocerkowski, A., Klupp, N., & Bragge, P. (2010). How to read and critically appraise a reliability article. *International Journal of Therapy and Rehabilitation*, *17*(3), 114–120. https://doi.org/10.12968/ijtr.2010.17.3.46743

Brown, J., Pope, N., Bosco, A. M., Mason, J., & Morgan, A. (2020). Issues affecting nurses' capability to use digital technology at work: An integrative review. *Journal of Clinical Nursing, 29(15–16)*, 2801–2819. https://doi.org/10.1111/jocn.15321

Chanques, G., Constantin, J.-M., Devlin, J. W., Ely, E. W., Fraser, G. L., Gélinas, C., Girard, T. D., Guérin, C., Jabaudon, M., Jaber, S., Mehta, S., Langer, T., Murray, M. J., Pandharipande, P., Patel, B., Payen, J.-F., Puntillo, K., Rochwerg, B., Shehabi, Y., … Kress, J. P. (2020). Analgesia and sedation in patients with ARDS. *Intensive care medicine*, *46*(12), 2342–2356. https://doi.org/10.1007/s00134-020-06307-9

Coulombe, M. A., Décary, E., Maximos, S., Brulotte, V., Drolet, P., Tanoubi, I., Issa, R., Zaphiratos, V., Verdonck, O., Fortier, L. P., Godin, N., Idrissi, M., Raft, J., & Richebé, P. (2021). Assessing the antinociceptive effect of nitrous oxide to tetanic stimulation in anaesthetised patients with new intra-operative nociception monitors: An observational study. *European Journal of Anaesthesiology*, *38(5),* 512–523..https://doi.org/10.1097/EJA.0000000000001431

Dale, C. M., Carbone, S., Gonzalez, A. L., Nguyen, K., Moore, J., & Rose, L. (2020). Recall of pain and discomfort during oral procedures experienced by intubated critically ill patients in the intensive care unit: A qualitative elicitation study. *Canadian Journal of Pain*, *4*(3), 19–28. https://doi.org/10.1080/24740527.2020.1732809

Dale, C. M. R. N. P., Prendergast, V. R. N. P., Gélinas, C. R. N. P., & Rose, L. R. N. P. (2018). Validation of the Critical-care Pain Observation Tool (CPOT) for the detection of oral-pharyngeal pain in critically ill adults. *Journal of Critical Care*, *48*, 334–338. https://doi.org/10.1016/j.jcrc.2018.09.024

Damico, V., Tonella, S., Murano, L., & Coppadoro, A. (2016). Strumenti e metodi di accertamento del dolore in Terapia Intensiva : Indagine in 173 unità Italiane. *Pain Nursing Magazine – Italian Online Journal*, *5*, 29–34. https://doi.org/10.19190/PNM2016.1ao29

Devlin, J. W., Skrobik, Y., Gélinas, C., Needham, D. M., Slooter, A. J. C., Pandharipande, P. P., Watson, P. L., Weinhouse, G. L., Nunnally, M. E., Rochwerg, B., Balas, M. C., van den Boogaard, M., Bosma, K. J., Brummel, N. E., Chanques, G., Denehy, L., Drouot, X., Fraser, G. L., Harris, J. E., … Alhazzani, W. (2018). Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Critical Care Medicine*, *46*(9), e825–e873. https://doi.org/10.1097/CCM.0000000000003299

Duhn, L. J., & Medves, J. M. (2004). A systematic integrative review of infant pain assessment tools. *Advances in Neonatal Care, 4*(3), 126–140. https://doi.org/10.1016/j.adnc.2004.04.005

Edry, R., Recea, V., Dikust, Y., & Sessler, D. I. (2016). Preliminary intraoperative validation of the Nociception Level Index: A noninvasive nociception monitor. *Anesthesiology*, *125*(1), 193–203. https://doi.org/10.1097/ALN.0000000000001130

Eysenbach, G., Mircheva, I., Granja, C. A. O., Janssen, W., & Johansen, M. A. (2018). Factors determining the success and failure of eHealth interventions: Systematic review of the literature. *Journal of Medical Internet Research*, *20*(5). https://doi.org/10.2196/10235

Gélinas, C. (2010). Nurses' evaluations of the feasibility and the clinical utility of the Critical-Care Pain Observation Tool. *Pain Management Nursing*, *11*(2), 115–125. https://doi.org/10.1016/j.pmn.2009.05.002

Gélinas, C., Arbour, C., Michaud, C., Vaillant, F., & Desjardins, S. (2011). Implementation of the critical-care pain observation tool on pain assessment/management nursing practices in an intensive care unit with nonverbal critically ill adults: A before and after study. *International Journal of Nursing Studies*, *48*(12), 1495–1504. https://doi.org/10.1016/j.ijnurstu.2011.03.012

Gélinas, C., Chanques, G., & Puntillo, K. (2014). In pursuit of pain: Recent advances and future directions in pain assessment in the ICU. *Intensive Care Medicine*, *40*(7), 1009–1014. https://doi.org/10.1007/s00134-014-3299-3

Gélinas, C., Fillion, L., Puntillo, K. A., Viens, C., & Fortier, M. (2006). Validation of the critical-care pain observation tool in adult patients. *American Journal of Critical Care*, *15*(4), 420–427. https://www.ncbi.nlm.nih.gov/pubmed/16823021

Gélinas, C., Shahiri, T. S., Richard-Lalonde, M., Laporta, D., Morin, J. F., Boitor, M., Ferland, C. E., Bourgault, P., & Richebé, P. (2021). Exploration of a multi-parameter technology for pain assessment in postoperative patients after cardiac surgery in the intensive care unit: The Nociception Level Index (NOL)™. *Journal of Pain Research*, *14*, 3723–3731. https://doi.org/10.2147/jpr.S332845

Gnass, I. (2015). Die Schmerzeinschätzung – beobachtet im Intensivbereich. *Pflege & Gesellschaft 4/2015*. https://doi.org/10.3262/P&G1504348

Guttormson, J. L., Khan, B., Brodsky, M. B., Chlan, L. L., Curley, M. A. Q., Gélinas, C., Happ, M. B., Herridge, M., Hess, D., Hetland, B., Hopkins, R. O., Hosey, M. M., Hosie, A., Lodolo, A. C., McAndrew, N. S., Mehta, S., Misak, C., Pisani, M. A., van den Boogaard, M., & Wang, S. (2023). Symptom assessment for mechanically ventilated patients: Principles and priorities: An official American Thoracic Society workshop report. *Annals of the American Thoracic Society*, *20*(4), 491–498. https://doi.org/10.1513/AnnalsATS.202301-023ST

Herr, K., Anderson, A. R., Arbour, C., Coyne, P., Ely, E. Gélinas, C., & Manworren, R. C. B. (2024). Pain assessment in the patient unable to self- report: Clinical practice recommendations in support of the ASPMN 2024 position statement. *Pain Management Nursing, 25*, 551–568. https://doi.org/10.1016/j.pmn.2024.09.010

Kurt, E., & Zaybak, A. (2022). Pain behavior experienced during nursing interventions by patients on mechanical ventilation: A cross-sectional study. *Florence Nightingale Journal of Nursing*, *30*(2), 126–132. https://doi.org/10.54614/FNJN.2022.21178

Lambert, S. I., Madi, M., Sopka, S., Lenes, A., Stange, H., Buszello, C.-P., & Stephan, A. (2023). An integrative review on the acceptance of artificial intelligence among healthcare professionals in hospitals. *NPJ Digital Medicine*, *6*(1), 111. https://doi.org/10.1038/s41746-023-00852-5

Ledowski, T., Schlueter, P., & Hall, N. (2021). Nociception level index: Do intra-operative values allow the prediction of acute postoperative pain? *Journal of Clinical Monitoring & Computing*, *36*(2), 349–354. https://doi.org/10.1007/s10877-021-00654-8

Martini, C. H., Boon, M., Broens, S. J., Hekkelman, E. F., Oudhoff, L. A., Buddeke, A. W., & Dahan, A. (2015). Ability of the nociception level, a multiparameter composite of autonomic signals, to detect noxious stimuli during propofol-remifentanil anesthesia. *Anesthesiology*, *123*(3), 524–534. https://doi.org/10.1097/ALN.0000000000000757

Medasense Biometrics Ltd. (2015). *Introducing the NOL™ Index*. Israel: Ramat Gan.

Meijer, F., Honing, M., Roor, T., Toet, S., Calis, P., Olofsen, E., Martini, C., van Velzen, M., Aarts, L., Niesters, M., Boon, M., & Dahan, A. (2020). Reduced postoperative pain using Nociception Level-guided fentanyl dosing during sevoflurane anaesthesia: A randomised controlled trial. *British Journal of Anaesthesia*, *125*(6), 1070–1078. https://doi.org/10.1016/j.bja.2020.07.057

Mosch, L. K., Poncette, A. S., Spies, C., Weber-Carstens, S., Schieler, M., Krampe, H., & Balzer, F. (2022). Creation of an evidence-based implementation framework for digital health technology in the intensive care unit: Qualitative study. *JMIR Formative Research*, *6*(4), e22866. https://doi.org/10.2196/22866

Moullin, J. C., Dickson, K. S., Stadnick, N. A., Albers, B., Nilsen, P., Broder-Fingert, S., Mukasa, B., & Aarons, G. A. (2020). Ten recommendations for using implementation frameworks in research and practice. *Implementation Science Communications*, *1*(1), 42. https://doi.org/10.1186/s43058-020-00023-7

Özsaban, A. P. B. S. N., Üzen Cura, Ş. P. B. S. N., Yılmaz Coşkun, E. P. B. S. N., & Kibar, D. M. B. S. N. (2023). Investigation of pain associated with endotracheal aspiration and affecting factors in an intensive care setting: A prospective observational study. *Australian Critical Care*, *36*(5), 687–694. https://doi.org/10.1016/j.aucc.2022.11.010

Payen, J. F., Bru, O., Bosson, J. L., Lagrasta, A., Novel, E., Deschaux, I., Lavagne, P., & Jacquot, C. (2001). Assessing pain in critically ill sedated patients by using a behavioral pain scale. *Critical Care Medicine*, *29*(12), 2258–2263.

Puntillo, K. A., Max, A., Timsit, J. F., Vignoud, L., Chanques, G., Robleda, G., Roche-Campo, F., Mancebo, J., Divatia, J. V., Soares, M., Ionescu, D. C., Grintescu, I. M., Vasiliu, I. L., Maggiore, S. M., Rusinova, K., Owczuk, R., Egerod, I., Papathanassoglou, E. D., Kyranou, M., … Azoulay, E. (2014). Determinants of procedural pain intensity in the intensive care unit. The Europain(R) study. *American Journal of Respiratory and Critical Care Medicine*, *189*(1), 39–47. https://doi.org/10.1164/rccm.201306-1174OC

Puntillo, K. A., Stannard, D., Miaskowski, C., Kehrle, K., & Gleeson, S. (2002). Use of a pain assessment and intervention notation (P.A.I.N.) tool in critical care nursing practice: Nurses' evaluations. *Heart & Lung : The Journal of Critical Care*, *31*(4), 303–314.https://doi.org/10.1067/mhl.2002.125652

Renaud-Roy, E., Stockle, P. A., Maximos, S., Brulotte, V., Sideris, L., Dube, P., Drolet, P., Tanoubi, I., Issa, R., Verdonck, O., Fortier, L. P., & Richebe, P. (2019). Correlation between incremental remifentanil doses and the Nociception Level (NOL) Index response after intraoperative noxious stimuli. *Canadian Journal of Anaesthesia*, *66*(9), 1049–1061. https://doi.org/10.1007/s12630-019-01372-1

Richard-Lalonde, M., Bérubé, M., Williams, V., Bernard, F., Tsoller, D., & Gélinas, C. (2019). Nurses' evaluations of the feasibility and clinical utility of the use of the Critical-Care Pain Observation Tool-Neuro in critically ill brain-injured patients. *Science of Nursing and Health Practices – Science infirmière et pratiques en santé*, *2*. https://doi.org/10.31770/2561-7516.1045

Rose, L., Smith, O., Gélinas, C., Haslam, L., Dale, C., Luk, E., Burry, L., McGillion, M., Mehta, S., & Watt-Watson, J. (2012). Critical care nurses' pain assessment and management practices: A survey in Canada. *American Journal of Critical Care*, *21*(4), 251–259. https://doi.org/10.4037/ajcc2012611

Schoville, R. R., & Titler, M. G. (2015). Guiding healthcare technology implementation: A new integrated technology implementation model. *Computers, Informatics, Nursing*, *33*(3), 99–107; quiz E101. https://doi.org/10.1097/CIN.0000000000000130

Shahiri, T. S., & Gélinas, C. (2023). The validity of vital signs for pain assessment in critically ill adults: A narrative review. *Pain Management Nursing, 24*(3), 318–328. https://doi.org/10.1016/j.pmn.2023.01.004

Shahiri, T. S., Richard-Lalonde, M., Richebé, P., & Gélinas, C. (2020). Exploration of the nociception level (NOL) index for pain assessment during endotracheal suctioning in mechanically ventilated patients in the intensive care unit: An observational and feasibility study. *Pain Management Nursing*, *21*(5), 428–434. https://doi.org/10.1016/j.pmn.2020.02.067

Smart, A. (2006). A multi-dimensional model of clinical utility. *International Journal for Quality in Health Care*, *18*(5), 377–382. https://doi.org/10.1093/intqhc/mzl034

Stockle, P. A., Julien, M., Issa, R., Decary, E., Brulotte, V., Drolet, P., Henri, M., Poirier, M., Latulippe, J. F., Dorais, M., Verdonck, O., Fortier, L. P., & Richebe, P. (2018). Validation of the PMD100 and its NOL Index to detect nociception at different infusion regimen of remifentanil in patients under general anesthesia. *Minerva Anestesiologica*, *84*(10), 1160–1168. https://doi.org/10.23736/S0375-9393.18.12720-9

Streiner, D. L., Norman, G. R., & Cairney, J. (2024). *Health measurement scales: A practical guide to their development and use* (6th ed.). Oxford University Press. https://doi.org/10.1093/med/9780192869487.001.0001

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. A practical scale. *Lancet*, *2*(7872), 81–84. https://doi.org/10.1016/s0140-6736(74)91639-0

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *Epidemiology*, *18*(6), 800–804.

Weiner, B. J., Lewis, C., Stanick, C., Powell, B., Dorsey, C., Clary, A., Boynton, M., & Halko, H. (2017). Psychometric assessment of three newly developed implementation outcome measures. *Implementation Science*, *12*(1), 1–12. https://doi.org/10.1186/s13012-017-0635-3

Supplementary File A

Nociception Level (NOL)™ Index (Medasense Biometrics Ltd., Ramat Gan, Israel)

Exploring long-term impacts on ICU survivors: A concept analysis of post-intensive care syndrome

By Brookelyn Hussey, MN, RN, and Connie Schumacher, PhD, RN

Abstract

Post-intensive care syndrome (PICS) has emerged as a concern for intensive care unit (ICU) survivors, particularly in the context of the increasing survival rates of patients with severe illness. This syndrome encompasses a range of physical, cognitive, and psychological impairments that can continue long after ICU discharge. PICS impacts survivors' quality of life, with common manifestations including muscle weakness, memory deficits, and depression. Despite growing awareness, PICS remains underexplored in clinical practice, with ongoing research focused on identifying its risk factors and effective management strategies. Risk factors such as prolonged mechanical ventilation, extended ICU stays, and delirium contribute to its development, particularly among older adults who face heightened vulnerability to long-term complications. This concept analysis, using the Walker and Avant (2011) method, aims to clarify the defining attributes, antecedents, and consequences of PICS, offering a framework to improve understanding, clinical management, and intervention. Through an extensive review of literature from 2012 to 2024, key elements of PICS are identified, and their implications for both healthcare providers and patients are discussed. The analysis highlights the need for standardized care pathways, including psychological support, physical rehabilitation, and follow-up care, and highlights the importance of early detection and intervention in the ICU and post-ICU settings. This paper contributes to the growing body of knowledge on PICS, offering a solid foundation for further research, clinical guidelines, and care protocols that will improve the long-term recovery, quality of life, and overall well-being of ICU survivors, ultimately improving patient outcomes and enhancing recovery strategies for all.

Keywords: post-intensive care syndrome, ICU survivors, long-term recovery, critical care, concept analysis

Hussey, B., & Schumacher, C. (2025). Exploring long-term impacts on ICU survivors: A concept analysis of post-intensive care syndrome. *The Canadian Journal of Critical Care Nursing, 36*(2), 18–23. DOI: 10.5737/23688653-36218

Nursing implications

- Early identification and assessment: Nurses should remain alert in identifying early signs of post-intensive care syndrome (PICS) in intensive care unit (ICU) survivors. Implementing screening tools and regular assessments in the post-ICU follow-up phase can facilitate early intervention.
- Multidisciplinary collaboration: Addressing PICS requires a collaborative approach among healthcare teams. Nurses have an important role in coordinating care and advocating for adequate treatment plans.
- Patient and caregiver education: Nurses should educate ICU survivors and their caregivers about the potential-long term effects of critical illness, including PICS.
- Advocacy for policy development: Nurses should advocate for healthcare policies that prioritize long-term follow-up care for ICU survivors, including regular screening for PICS and access to rehabilitation services.

Background

In recent years, rising survival rates for intensive care unit (ICU) patients have highlighted the long-term consequences of critical illness. Post-intensive care syndrome (PICS), characterized by impairments in cognition, psychology, and physical health, is among the most concerning outcomes (Smith & Rahman, 2023). PICS significantly impacts survivors' quality of life, necessitating multidisciplinary care beyond ICU discharge (Voiriot et al., 2022). Despite its recognition as a distinct condition, PICS remains underexplored (Smith & Rahman, 2023).

PICS encompasses symptoms that extend beyond the acute care phase, often lasting weeks to years post-ICU. Symptoms include muscle weakness, memory and concentration deficits, anxiety, depression, and post-traumatic stress disorder (PTSD; Hiser et al., 2023). Cognitive impairments similar to moderate traumatic brain injury and Alzheimer's dementia have been seen in patients up to one-year post-ICU stay (Pandharipande et al., 2013). Studies estimate 50%–70% of ICU survivors experience some form of PICS (He et al., 2024; Schwitzer et al., 2023; Wang et al., 2018). Care challenges are exacerbated by limited screening tools and insufficient follow-up care (Pant et al., 2023; Wang et al., 2022). PICS demands standardized approaches to prevention, early detection, and management.

Risk factors for PICS include prolonged mechanical ventilation, extended ICU stays, delirium, and sedative exposure (Needham et al., 2012). A Canadian study identified a lack of care availability, which would typically be provided in post-ICU follow-up clinics (Stapleton et al., 2020). Addressing ICU survivors' long-term challenges is increasingly relevant. This concept analysis explores the complex nature of PICS, focusing on its implications for survivors and care needs, particularly in older adults. By clarifying the defining attributes, antecedents, and consequences of PICS, this analysis aims to inform clinical practice and future research.

Design/methodology

This concept analysis followed Walker and Avant's (2011) framework. First, the concept was selected, and relevant literature was reviewed to define its purpose. Key elements, including defining attributes, antecedents, and consequences were identified. Model, borderline, and contrary cases were developed to illustrate the concept. Empirical referents were identified, and research gaps highlighted.

Data collection

Relevant literature was sourced from CINAHL, PubMed, and Google Scholar. Search terms included "post-intensive care syndrome," "PICS," and "ICU survivors." Articles from 2012 to 2024 were prioritized. Only peer-reviewed studies in English focusing on PICS' long-term effects were included. Studies on pediatric populations or unrelated interventions were excluded. A total of 43 articles were analyzed.

Results

Examining the applications of the concept

Examining the applications of the concept of PICS reveals its role in enhancing the care of ICU survivors. PICS, as a concept, informs healthcare providers about the diverse challenges ICU survivors face, guiding interventions (Hiser et al., 2023). For instance, PICS is applied in creating care pathways that facilitate psychological support and rehabilitation, addressing the cognitive and emotional needs of survivors (Renner et al., 2023). In clinical settings, the concept is often used to develop educational programs aimed at equipping healthcare professionals with the knowledge to recognize and manage PICS (Zhang et al., 2023). Furthermore, PICS informs policy decisions regarding follow-up care, advocating for integrated healthcare models that promote long-term recovery (Schwitzer et al., 2023).

Defining attributes

In conducting a concept analysis of PICS using the Walker and Avant (2011) framework, the defining attributes represent the characteristics that distinguish this concept. A literature review revealed three key attributes consistently associated with PICS: neurocognitive impairment, physical debilitation, and emotional disturbances.

Neurocognitive impairment, a defining attribute of PICS, includes memory loss, attention difficulties, and executive functioning challenges. These deficits can significantly impact ICU survivors' daily lives, as studies have shown declines in concentration, information recall, and decision-making abilities post-ICU (Alro et al., 2022; Kohler et al., 2019; Pereira et al., 2024). Mart et al. (2022) noted that cognitive difficulties often persist long after discharge, sometimes resembling early dementia.

Physical debilitation encompasses fatigue, muscle weakness, weight loss, pain, and functional impairment (Boelens et al., 2022; Makinen et al., 2020; Wischmeyer & San-Millan, 2015). Prolonged immobility, combined with sedation and mechanical ventilation, often leads to muscle atrophy and diminished physical endurance (Boelens et al., 2022; Lad et al., 2020). Goddard et al. (2024) documented challenges with activities like walking or climbing stairs months or years post-discharge. Recovery through physical rehabilitation is critical, though outcomes vary based on illness severity and length of ICU stay (Boelens et al., 2022).

Emotional disturbances including anxiety, depression, and PTSD are a third key attribute (Abdelbaky & Eldelpshany, 2024; Hatch et al., 2018). Survivors often experience distress from life-threatening situations, invasive procedures, and isolation during their ICU stay (Vrettou et al., 2022). Abdelbaky & Eldelpshany (2024) identified PTSD-like symptoms prevalent in patients who underwent prolonged sedation or mechanical ventilation, exacerbating their emotional challenges. These psychological aspects of PICS significantly affect survivors' quality of life and engagement in rehabilitation (He et al., 2024).

Antecedents

Several factors contribute to the development of PICS in ICU survivors. Prolonged mechanical ventilation is a key antecedent, linked to physical and cognitive declines post-ICU (Bulic et al., 2020; Huang et al., 2022; Jubran et al., 2018). Extended sedation, often required for ventilated patients, frequently leads to delirium, another contributor to PICS (Ceric et al., 2024). Patients with ICU delirium are at increased risk for long-term cognitive impairment, highlighting the importance of sedation management (Goldberg et al., 2020; Schwitzer et al., 2023).

The length of ICU stay is another critical factor, with long stays correlating to greater risks of physical, psychological, and cognitive impairments (Fiani et al., 2022). Prolonged exposure to invasive procedures, immobility, and stress in the ICU environment exacerbates these risks (Inoue et al., 2019). Additionally, pre-existing comorbidities in older adults increase their susceptibility to PICS due to underlying frailty and functional declines (Green et al., 2021; Inoue et al., 2019). Understanding these antecedents is essential to reducing PICS incidence and improving outcomes for ICU survivors.

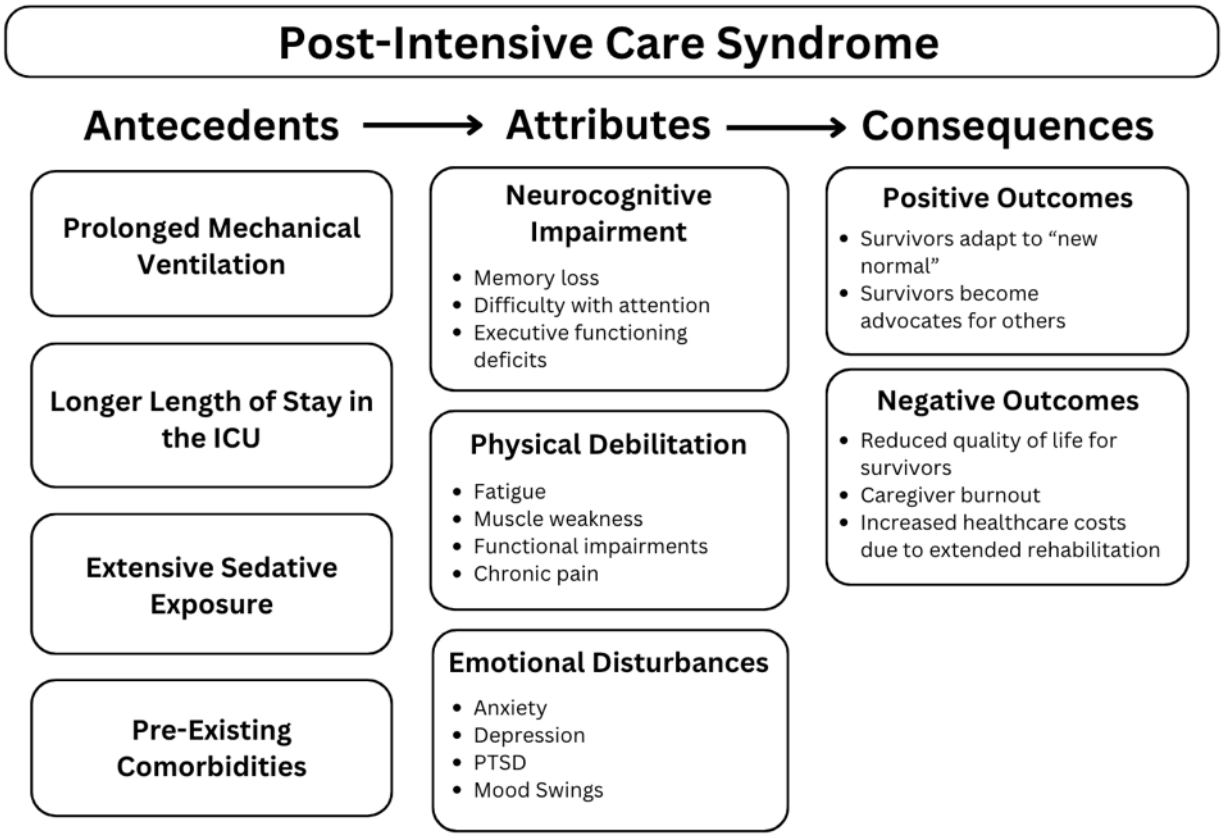
Consequences

Consequences are the outcomes resulting from the concept of PICS (Walker & Avant, 2011). While primarily adverse, some positive outcomes have been observed. A notable positive consequence is that some ICU survivors adapt to a "new normal" and become advocates for others transitioning out of the ICU (Hirshberg et al., 2020).

Adverse consequences are more common, including diminished quality of life due to physical, cognitive, and psychological impairments (Geense et al., 2021; Hofhuis et al., 2021). PICS often leads to long-term issues, such as muscle weakness, memory loss, anxiety, and depression, impacting survivors' health-related quality of life (Smith & Rahman, 2023). These challenges also extend to caregivers, many of whom face significant emotional and physical burdens. Nearly 50% of caregivers report feeling overburdened when caring for PICS survivors (Van Beusekom et al., 2016; Van Sleeuwen et al., 2020). These outcomes emphasize the widespread impact of PICS on individuals, their support networks, and healthcare systems.

Figure 1

Antecedents, Attributes, and Consequences of PICS



Note. ICU = intensive care unit; PTSD = post-traumatic stress disorder.

Model case

This model case illustrates the concept of PICS and serves as an example for understanding and explaining it.

John, a 70-year-old man, is discharged from the ICU after being treated for severe pneumonia. After his discharge, he experiences physical weakness, memory loss, and depression. His wife, overwhelmed by his needs and behavioural changes, struggles as his primary caregiver. Despite follow-up care, John's recovery is slow, and his quality of life declines. Eventually, John and his wife join a support group for ICU survivors, where they gain tools for managing symptoms and supporting others. Over time, John adapts to his "post-normal" life. This case demonstrates the key attributes of PICS and its impact on patients and caregivers.

Additional cases

Examining borderline, related, and contrary cases clarifies PICS attributes. Borderline cases exhibit most, but not all attributes, related cases share some similarities, but lack critical features, and contrary cases lack PICS entirely (Walker & Avant, 2011).

Borderline case

A 68-year-old man, recently discharged from the ICU following a cardiac event, experiences fatigue and occasional confusion, but retains physical function and manages daily activities independently. His memory issues cause minor frustrations but do not require formal rehabilitation. While his symptoms align partially with PICS, they are mild and manageable, missing the severity and functional impact characteristic of the condition.

Related case

A 74-year-old woman is discharged from the hospital after a lengthy stay for pneumonia, but was never admitted to the ICU. She experiences fatigue and a reduced quality of life. Although she finds daily tasks more tiring, she has no cognitive impairments and can still perform her routine activities with minimal physical assistance. Her symptoms stem from post-hospital syndrome rather than PICS, lacking ICU-specific factors and the significant impairments of the syndrome.

Contrary case

A 55-year-old man is admitted to the ICU for several days after a traumatic accident, but makes a full recovery upon discharge, with no cognitive, physical, or psychological complications. He returns to his pre-ICU routine without assistance or lasting symptoms. This case contrasts with PICS, as it involves a complete recovery without residual challenges.

Empirical referents of PICS

Empirical referents are measurable indicators that confirm a concept's real-world presence (Walker & Avant, 2011). For PICS, they translate the concept into observable terms, aiding in developing valid assessment tools.

Existing assessments often measure isolated aspects of PICS, such as physical limitations or psychological distress, but lack

the breadth required for a holistic evaluation (Pant et al., 2023). Tools like the Medical Research Council Scale for Muscle Strength and Activities of Daily Living (ADL) measure physical dysfunction (Edemekong et al., 2023), while the Hospital Anxiety and Depression Scale (HADS) and Posttraumatic Stress Symptoms-14 (PTSS-14) assess psychological symptoms (Milton et al., 2018). However, these tools rarely address the interplay between PICS domains, limiting their ability to capture the full scope of its impact.

The Post-Intensive Care Syndrome Questionnaire (PICSQ) uses an 18-item, four-point Likert scale to evaluate cognition, physical function, and psychological status (Jeong & Kang, 2019). While it addresses core cognitive concerns, it insufficiently accounts for the social and community impacts critical to understanding PICS. This highlights a gap in current tools, which restricts providers' ability to assess the syndrome's complete effects on survivors' lives.

Discussion

This concept analysis highlights PICS as a multidimensional phenomenon profoundly impacting ICU survivors' quality of life. Defined by neurocognitive impairment, physical debilitation, and emotional disturbances, PICS presents diverse challenges that persist after ICU discharge (Boelens et al., 2022; Mart et al., 2022). Older adults are particularly vulnerable, as age-related factors exacerbate recovery challenges, underscoring the need for specialized interventions (Fiani et al., 2022). Antecedents such as prolonged mechanical ventilation, extended ICU stays, and sedation exposure increase the risk of PICS, emphasizing opportunities for preventative strategies (Green et al., 2021; Huang et al., 2022; Schwitzer et al., 2023).

PICS consequences extend beyond patients, significantly impacting caregivers and healthcare systems. Caregivers often face emotional and physical strain, while healthcare systems bear costs related to extended rehabilitation (Van Sleeuwen et al., 2020). Interdisciplinary follow-up care and referrals to post-ICU clinics are essential for supporting survivors and their caregivers, ensuring adequate treatment and rehabilitation (Stapleton et al., 2020). This concept analysis underscores the importance of standardized care models and protocols to address PICS effectively. Future research should prioritize refining nursing interventions, particularly for high-risk groups, such as older adults, to enhance post-ICU quality of care.

Conclusion

This analysis of PICS offers foundational insights to enhance its understanding and management in critical care settings. By clarifying essential attributes, antecedents, and consequences, this concept analysis supports a framework that can guide education, patient care, and future research across healthcare disciplines. The findings contribute to a growing body of knowledge on PICS and provide practical groundwork for healthcare providers and educators to develop targeted interventions, assessment tools, and policies.

Author notes

Brookelyn Hussey, MN, RN, Department of Nursing, Faculty of Applied Health Sciences, Brock University, St. Catharines, Ontario, Canada

Connie Schumacher, PhD, RN, Department of Nursing, Faculty of Applied Health Sciences, Brock University, St. Catharines, Ontario, Canada

Corresponding Author: *Brookelyn Hussey, MN, RN, Department of Nursing, Faculty of Applied Health Sciences, Brock University, St. Catharines, Ontario, Canada. Email: bh22ks@brocku.ca*

Funding and conflict of interest

No funding was provided for this research from the public, commercial, and/or not-for-profit sectors. The authors declare no conflicts of interest.

Acknowledgements

The authors express our gratitude to Dr. Joanne Crawford of Brock University for her guidance and advice on research methodologies. Her feedback throughout provided a solid foundation for the topic of this concept analysis.

REFERENCES

Abdelbaky, A. M., & Eldelpshany, M. S. (2024). Intensive care unit (ICU)- related post-traumatic stress disorder: A literature review. *Cureus, 16*(3), e57049. https://doi.org/10.7759/cureus.57049

Alro, A. B., Nedergaard, H. K., Scenningsen, H., Jensen, H. I., & Dreyer, P. (2022). Patients' experiences of cognitive impairment following critical illness treated in an intensive care unit: A scoping review. *Journal of Critical Care Nursing, 32*(15–16), 4374–4390. https://doi.org/10.1111/jocn.16490

Boelens, Y. F. N., Melchers, M., & van Zanten, A. R. H. (2022). Poor physical recovery after critical illness: Incidence, features, risk factors, pathophysiology, and evidence-based therapies. *Current Opinions in Critical Care, 28*(4), 409–416. https://doi.org/10.1097/MCC.0000000000000955

Bulic, D., Bennett, M., Georgousopoulou, E. N., Shehabi, Y., Pham, T., Looi, J. C. L., & van Haren, F. M. P. (2020). Cognitive and psychosocial outcomes of mechanically ventilated intensive care patients with and without delirium. *Annals of Intensive Care, 10*(104). https://doi.org/10.1186/s13613-020-00723-2

Ceric, A., Holgersson, J., May, T. L., Skrifvars, M. B., Hastbacka, J., & Saxena, M. (2024). Effect of level of sedation on outcomes in critically ill adult patients: A systematic review of clinical trials with meta-analysis and trial sequential analysis. *Eclinicalmedicine, 28*(21), 102569. https://doi.org/10.1016/j.eclinm.2024.102569

Edemekong, P. F., Bomgaars, D. L., Sukumaran, S., & Schoo, C. (2023). Activities of daily living. In *StatPearls.* StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK470404/

Fiani, B., Figueras, R. A., Samones, P., Lee, C., Castillo, A., Sangalang, B., & Perez, F. G. (2022). Long-term intensive care unit (ICU) stays can lead to long-term cognitive impairment (LTCI): Neurosurgery nursing strategies to minimize risk. *Cureus, 14*(9). https://doi.org/10.7759/cureus.28967

Geense, W. W., de Graaf, M., Vermeulen, H., van der Hoeven, J., Zegers, M., & van den Boogaard, M. (2021). Reduced quality of life in ICU survivors – The story behind the numbers: A mixed methods study. *Journal of Critical Care, 65*, 36–41. https://doi.org/10.1016/j.jcrc.2021.05.008

Goddard, S., Gunn, H., Kent, B., & Dennett, R. (2024). The experience of physical recovery and physical rehabilitation following hospital discharge for intensive care survivors – A qualitative systematic review. *Nursing Reports, 14*(1), 148–163. https://doi.org/10.3390/nursrep14010013

Goldberg, T. E., Chen, C., Wang, Y., Jung, E., Swanson, A., Ing, C., Garcia, P. S., Whittington, R. A., & Moitra, V. (2020). Association of delirium with long-term cognitive decline: A meta-analysis. *JAMA Neurology, 77*(11), 1373–1381. https://doi.org/10.1001/jamaneurol.2020.2273

Green, O., Rochwerg, B., & Wang, X. M. (2021). Optimizing care for critically ill older adults. *Canadian Medical Association Journal, 193*(39), 1525–1533. https://doi.org/10.1503/cmaj.210652

Hatch, R., Young, D., Barber, V., Griffiths, J., Harrison, D. A., & Watkinson, P. (2018). Anxiety, depression and post traumatic stress disorder after critical illness: A UK-wide prospective cohort study. *Critical Care, 22*(310). https://doi.org/10.1186/s13054-018-2223-6

He, X., Song, Y., Cao, Y., Miao, L., & Zhu, B. (2024). Post intensive care syndrome: A review of clinical symptoms, evaluation, intervention. *Heliyon, 10*(10, e31278. https://doi.org/10.1016/j.heliyon.2024.e31278

Hirshberg, E. L., Butler, J., Francis, M., Davis, F. A., Lee, D., Tavake-Pasi, F., Napia, E., Villalta, J., Mukundente, V., Coulter, H., Stark, L., Beesley, S., Orme, J. F., Brown, S. M., & Hopkins, R.O. (2020). Persistence of patient and family experiences of critical illness. *BMJ Open, 10*(4), e035213. 10.1136/bmjopen-2019-035213

Hiser, S. L., Fatima, A., Ali, M., & Needham, D. M. (2023). Post-intensive care syndrome (PICS): Recent updates. *Journal of Intensive Care, 11*(23). https://doi.org/10.1186/s40560-023-00670-7

Hofhuis, J. G. M., Schrijvers, A .J. P., Schermer, T., & Spronk, P. E. (2021). Health-related quality of life in ICU survivors – 10 years later. *Scientific Reports, 11*, 15189. https://doi.org/10.1038/s41598-021-94637-z

Huang, H., Huang, C., & Li, L. (2022). Prolonged mechanical ventilation: Outcomes and management. *Journal of Clinical Medicine, 11*(9), 2451. https://doi.org/10.3390/jcm11092451

Inoue, S., Hatakeyama, J., Kondo, Y., Hifumi, T., Sakuramoto, H., Kawasaki, T., Taito, S., Nakamura, K., Unoki, T., Kawai, Y., Kenmotsu, Y., Saito, M., Yamakawa, K., & Nishida, O. (2019). Post-intensive care syndrome: Its pathophysiology, prevention, and future directions. *Acute Medicine & Surgery, 25*(6), 233–246. https://doi.org/10.1002/ams2.415

Jeong, Y., & Kang, J. (2019). Development and validation of a questionnaire to measure post-intensive care syndrome. *Intensive Critical Care Nursing, 55*, 102756. https://doi.org/10.1016/j.iccn.2019.102756.

Jubran, A., Grant, B. J. B., Duffner, L. A., Collins, E. G., Lanuza, D. M., Hoffman, L. A., & Tobin, M. J. (2018). Long-term outcome after prolonged mechanical ventilation. A long-term acute-care hospital study. *American Journal of Respiratory and Critical Care Medicine, 199*(12). https://doi.org/10.1164/rccm.201806-1131OC

Kohler, J., Borchers, F., Endres, M., Weiss, B., Spies, C., & Emmrich, J. V. (2019). Cognitive deficits following intensive care. *Deutsches Arztelblatt International, 116*(38), 627–634. https://doi.org/10.3238/arztebl.2019.0627

Lad, H., Saumur, T. M., Herridge, M. S., dos Santos, C. C., Mathur, S., Batt, J., & Gilbert, P. M. (2020). Intensive care unit-acquired weakness: Not just another muscle atrophying condition. *International Journal of Molecular Sciences, 21*(21), 7840. https://doi.org/10.3390/ijms21217840

Makinen, O. J., Backlund, M. E., Liisanantti, J., Peltomaa, M., Karlsson, S., & Kalliomaki, M. (2020). Persistent pain in intensive care survivors: A systematic review. *British journal of Anaesthesia, 125*(2), 149–158. https://doi.org/10.1016/j.bja.2020.04.084

Mart, M. F., Pun, B. T., Pandharipande, P., Jackson, J. C., & Ely, E. W. (2022). ICU survivorship – The relationship of delirium, sedation, dementia, and acquired weakness. *Critical Care Medicine, 49*(8), 1227–1240. https://doi.org/10.1097/CCM.0000000000005125

Milton, A., Schandl, A., Soliman, I. W., Meijers, K., Van Den Boogard, M., Larssen, I. M., Brorsson, C., Ostberg, U., Oxenboll-Collet, M., Savilampi, J., Paskins, S., Bottai, M., & Sackey, P. V. (2018). Development of ICU discharge instrument preducing psychological morbidity: A multinational study. *Intensive Care Medicine, 44*, 2038–2047. https://doi.org/10.1007/s00134-018-5467-3

Needham, D. M., Davidson, J., Cohen, H., Hopkins, R. O., Weinert, C., Wunsch, H., Zawistowski, C., Bemis-Dougherty, A., Berney, S. C., Bienvenu, O. J., Brady, S. L., Brodsky, M. B., Denehy, L., Elliott, D., Flatley, C., Harabin, A. L., Jones, C., Louis, D., Meltzer, W., Muldoon, S. R., … Harvey, M. A. (2012). Improving long-term outcomes after discharge from intensive care unit: Report from a stakeholders' conference. *Critical Care Medicine*, *40*(2), 502–509. https://doi.org/10.1097/CCM.0b013e318232da75

Pandharipande, P. P., Girard, T. D., Jackson, J. C., Morandi, A., Thompson, J. L., Pun, B. T., Brummel, N. E., Hughes, C. G., Vasilevskis, E. E., Shintani, A. K., Moons, K. G., Geevarghese, S. K., Canonico, A., Hopkins, R. O., Bernard, G. R., Dittus, R. S., Ely, E. W., & BRAIN-ICU Study Investigators. (2013). Long-term cognitive impairment after critical illness. *New England Journal of Medicine, 369*(14), 1306–1316. https://doi.org/10.1056/NEJMoa1301372

Pant, U., Vyas, K., Meghani, S., Park, T., Norris, C. M., & Papathanassoglou, E. (2023). Screening tools for post–intensive care syndrome and post-traumatic symptoms in intensive care unit survivors: A scoping review. *Australian Critical Care*, *36*(5), 863–871. https://doi.org/10.1016/j.aucc.2022.09.007

Pereira, I. J., Santos, M., Sganzerla, D., Robinson, C. C., de Souza, D., Kochhann, R., Falavigna, M., Azevedo, L., Bozza, F., Sharshar, T., Rosa, R. G., Granja, C., & Teixeira, C. (2024). Long term cognitive dysfunction among critical care survivors: Associated factors and quality of life – a multicenter cohort study. *Annals of Intensive Care, 14*(116). https://doi.org/10.1186/s13613-024-01335-w

Renner, C., Jeitziner, M., Albert, M., Brinkmann, S., Diserens, K., Dzialowski, I., Heidler, M. D., Luck, M., Busch, R., Sandor, P. S., Schafer, A., Scheffler, B., Wallesch, C., Zimmermann, G., & Nydahl, P. (2023). Guideline on multimodal rehabilitation for patients with post-intensive care syndrome. *Critical Care, 27*(301). https://doi.org/10.1186/s13054-023-04569-5

Schwitzer, E., Jensen, K. S., Brinkman, L., DeFrancia, L., VanVleet, J., Baqi, E., & Aysola, R., Qadir, N. (2023). Survival ≠ recovery: A narrative review of post-intensive care syndrome. *CHEST Critical Care, 1*(1). https://doi.org/10.1016/j.chstcc.2023.100003

Stapleton, K., Jefkins, M., Grant, C., & Boyd, J. G. (2020). Post-intensive care unit clinics in Canada: A national

survey. *Canadian Journal of Anesthesia/Journal Canadien d'anesthésie*, *67*, 1658–1659. https://doi.org/10.1007/s12630-020-01741-1

Smith, S., & Rahman, O. (2023). Post intensive care syndrome. *StatPearls [Internet]*. StatPearls publishing. https://pubmed.ncbi.nlm.nih.gov/32644390/

Van Beusekom, I., Bakhshi-Raiez, F., de Keizer, N. F., Dongelmans, D. A., & der Schaaf, M. (2016). Reported burden on informal caregivers of ICU survivors: A literature review. *Critical Care, 21*(16). https://doi.org/10.1186/s13054-016-1185-9

Van Sleeuwen, D., van de Laar, F., Geense, W., van den Boogaard, M., & Zegers, M. (2020). Health problems among family caregivers of former intensive care unit (ICU) patients: An interview study. *BJGP Open, 26*(4). https://doi.org/10.3399/bjgpopen20X101061

Voiriot, G., Oualha, M., Pierre, A., Salmon-Gandonniere, C., Gaudet, A., Jouan, Y., Kallel, H., Radermacher, P., Vodovar, D., Sarton, B., Stiel, L., Brechot, N., Preau, S., & Joffre, J. (2022). Chronic critical illness and post-intensive care syndrome: From pathophysiology to clinical challenges. *Annals of Intensive Care, 12*, 58. https://doi.org/10.1186/s13613-022-01038-0

Vrettou, C. S., Mantziou, V., Vassiliou, A. G., Orfanos, S. E., Kotanidou, A., & Dimopoulou, I. (2022). Post-intensive care syndrome in survivors from critical illness including COVID-19 patients: A narrative review. *Life (Basal), 12*(1), 107. https://doi.org/10.3390/life12010107

Walker, L. O., & Avant, K. C. (2011). *Strategies for theory construction in nursing* (5th ed.). Prentice Hall.

Wang, S., Jawed, Y., Perkins, A., Gao, S., Seyffert, S., Khan, S., Boustani, M. & Khan, B. (2022). Healthy aging brain care monitor, caregiver version: Screening for post–intensive care syndrome. *American Journal of Critical Care*, *31*(2), 137–144. https://doi.org/10.4037/ajcc2022451

Wang, S., Allen, D., Kheir, Y. N., Campbell, N., & Khan, B. (2018). Aging and post-intensive care syndrome (PICS): A critical need for geriatric psychiatry. *American Journal of Geriatric Psychiatry, 26*(2), 212–221. https://doi.org/10.1016/j.jagp.2017.05.016

Wischmeyer, P. E., & San-Millan, I. (2015). Winning the war against ICU-acquired weakness: New innovations in nutrition and exercise physiology. *Critical Care, 19*(6). https://doi.org/10.1186/cc14724

Zhang, F., Chen, Z., Xue, D., Zhang, R., & Cheng, Y. (2023). Barriers and facilitators to offering post-intensive care follow-up services from the perspective of critical care professionals: A qualitative study. *Nursing in Critical Care, 29*(4), 682–694. https://doi.org/10.1111/nicc.13002

Caregiver needs in and after the ICU: A call to action for critical care nurses

By Angie K. Grewal, MN, RN, and Carmel L. Montgomery, PhD, RN

Grewal, A. K., & Montgomery, C. L. (2025). Caregiver needs in and after the ICU: A call to action for critical care nurses. *The Canadian Journal of Critical Care Nursing, 36*(1), 24–25. DOI: 10.5737/23688653-36224

Despite increasing illness severity and patient complexity, intensive care unit (ICU) and hospital mortality continue to decline (Prescott et al., 2024). At the same time, the long-term physical, cognitive, and mental health challenges experienced by ICU survivors are becoming better understood and more frequently recognized as post-intensive care syndrome (PICS; Needham et al., 2012; Schwitzer et al., 2023). In contrast, the experiences and needs of family members, who often transition into unpaid caregiving roles after discharge, remain underrecognized in the ICU setting. These family caregivers frequently experience post-intensive care syndrome–family (PICS-F), a cluster of emotional, psychological, physical, and social symptoms that can impair their health and caregiving capacity (Davidson et al., 2012).

Family members of ICU patients report anxiety, depression, sleep disturbances, fatigue, and even post-traumatic stress disorder (PTSD) during and after the ICU stay (Davidson et al., 2012; Choi et al., 2018). Many take on caregiving roles with little preparation, encountering complex discharge planning and fragmented outpatient care (Law et al., 2021). Although nearly 50% of ICU survivors rely on family caregivers at home after discharge (Avgeri et al., 2023), few ICU settings offer formal assessment or support for these caregivers.

Currently, family-centred care in the ICU emphasizes family involvement in patient care and decision-making, but does not systematically assess or support caregiver well-being (Grieshop, 2023). In contrast, Caregiver-Centred Care recognizes caregivers as individuals with their own distinct health and informational needs (Parmar et al., 2021). This model advocates for identifying, engaging, and supporting caregivers as an integral part of the critical care recovery process.

ICU clinicians, especially nurses, are well-positioned to intervene early to support family caregivers. Proactive communication, early involvement of social work and spiritual care providers, and routine screening for caregiver distress can help reduce the impact of PICS-F. Post-ICU recovery clinics and community organizations (e.g., Caregivers Nova Scotia, Caregivers Alberta, and the Ontario Caregiver Organization) offer valuable support to family caregivers. However, consistent referral practices are needed to ensure access to these resources. Simple tools, such as family needs checklists or caregiver strain indices can be incorporated into clinical workflows to support caregiver assessment and enhance discharge planning (Watland et al., 2023; Mistraletti et al., 2017).

Future clinical quality improvement and research efforts should prioritize interdisciplinary education, the integration of caregiver needs into ICU recovery pathways, and policy-level recognition of caregivers as essential to improving long-term patient outcomes. It is time to extend our critical care thinking beyond the bedside—to care truly for those who care.

Author notes

Angie K. Grewal, MN, RN, Faculty of Nursing, College of Health Sciences, University of Alberta, Edmonton, Alberta, Canada.

Carmel L. Montgomery, PhD, RN, Faculty of Nursing, College of Health Sciences, University of Alberta, Edmonton, Alberta, Canada.

Angie Grewal and Carmel L Montgomery are invited authors. This article has not been peer-reviewed.

Corresponding Author: *Angie K. Grewal, MN, RN, Faculty of Nursing, College of Health Sciences, University of Alberta, Level 3 ECHA, 11405 87 Avenue NW, Edmonton, AB, Canada, T6G 1C9. Email: asangha@ualberta.ca*

Funding and conflict of interest

The authors declare no funding and/or conflicts of interest.

REFERENCES

Avgeri, K., Zakynthinos, E., Tsolaki, V., Sgantzos, M., Fotakopoulos, G., & Makris, D. (2023). Quality of life and family support in critically ill patients following ICU discharge. *Healthcare (Basel), 11*(8). https://doi.org/10.3390/healthcare11081106

Choi, J., Lingler, J. H., Donahoe, M. P., Happ, M. B., Hoffman, L. A., & Tate, J. A. (2018). Home discharge following critical illness: A qualitative analysis of family caregiver experience. *Heart & Lung, 47*(4), 401–407. https://doi.org/10.1016/j.hrtlng.2018.04.003

Davidson, J. E., Jones, C., & Bienvenu, O. J. (2012). Family response to critical illness: Postintensive care syndrome-family. *Critical Care Medicine, 40*(2), 618–624. https://doi.org/10.1097/CCM.0b013e318236ebf9

Grieshop, S. (2023). ABCDEF Bundle. *American Journal of Critical Care, 32*(2), 100. https://doi.org/10.4037/ajcc2023998

Law, S., Ormel, I., Babinski, S., Kuluski, K., & Quesnel-Vallee, A. (2021). "Caregiving is like on the job training but nobody has the manual": Canadian caregivers' perceptions of their roles within the healthcare system. *BMC Geriatrics, 21*(1), 404. https://doi.org/10.1186/s12877-021-02354-z

Mistraletti, G., Umbrello, M., Mantovani, E. S., Moroni, B., Formenti, P., Spanu, P., Anania, S., Andrighi, E., Di Carlo, A., Martinetti, F., Vecchi, I., Palo, A., Pinna, C., Russo, R., Francesconi, S., Valdambrini, F., Ferretti, E., Radeschi, G., Bosco, E., Malacarne, P., … http://www.intensiva.it Investigators. (2017). A family information brochure and dedicated website to improve the ICU experience for patients' relatives: an Italian multicenter before-and-after study. *Intensive Care Medicine, 43*(1), 69–79. https://doi.org/10.1007/s00134-016-4592-0

Needham, D. M., Davidson, J., Cohen, H., Hopkins, R. O., Weinert, C., Wunsch, H., Zawistowski, C., Bemis-Dougherty, A., Berney, S. C., Bienvenu, O. J., Brady, S. L., Brodsky, M. B., Denehy, L., Elliott, D., Flatley, C., Harabin, A. L., Jones, C., Louis, D., Meltzer, W., …Harvey, M. A. (2012). Improving long-term outcomes after discharge from intensive care unit: Report from a stakeholders' conference. *Critical Care Medicine, 40*(2), 502–509. https://doi.org/10.1097/CCM.0b013e318232da75

Parmar, J., Anderson, S., Duggleby, W., Holroyd-Leduc, J., Pollard, C., & Bremault-Phillips, S. (2021). Developing person-centred care competencies for the healthcare workforce to support family caregivers: Caregiver centred care. *Health & Social Care in the Community, 29*(5), 1327–1338. https://doi.org/10.1111/hsc.13173

Prescott, H. C., Harrison, D. A., Rowan, K. M., Shankar-Hari, M., & Wunsch, H. (2024). Temporal trends in mortality of critically ill patients with sepsis in the United Kingdom, 1988-2019. *American Journal of Respiratory and Critical Care Medicine, 209*(5), 507–516. https://doi.org/10.1164/rccm.202309-1636OC

Schwitzer, E., Jensen, K. S., Brinkman, L., DeFrancia, L., VanVleet, J., Baqi, E., Aysola, R., & Qadir, N. (2023). Survival ≠ Recovery: A narrative review of post-intensive care syndrome. *CHEST Critical Care, 1*(1). https://doi.org/10.1016/j.chstcc.2023.100003

Watland, S., Solberg Nes, L., Hanson, E., Ekstedt, M., Stenberg, U., & Borosund, E. (2023). The caregiver pathway, a model for the systematic and individualized follow-up of family caregivers at intensive care units: Development study. *JMIR Formative Research, 7,* e46299. https://doi.org/10.2196/46299

No drug selected: Nurses report safety risks when programming smart pumps

By Lynn Riley, RN, and Dorothy Tscheng, RPh

Riley, L., & Tscheng, D. (2025). Medication safety practice corner: No drug selected: Nurses report safety risks when programming smart pumps. *The Canadian Journal of Critical Care Nursing, 36*(2), 26–27. DOI: 10.5737/23688653-36226

ISMP CANADA Report a med error

In this regular column, ISMP Canada will feature a critical care-related medication story and share practical learning for critical care nurses.

Implementation of dose error reduction software (DERS) alongside a tailored library of medications with dosing guidelines can support organizations to detect dosing and programming errors that may harm patients (ISMP Canada, 2023; Joint Commission, 2021).

Incident examples

An infusion for a diuretic was ordered. The pump library had no entry for the specified medication, so the "no drug selected" mode was chosen. The concentration was entered as 1 mg/mL, even though the actual concentration was 10 mg/mL. As a result, the patient received 10 times the prescribed dose during the infusion period.

A medication was ordered for infusion at a rate that exceeded the hard upper limit permitted by the pump. The prescriber confirmed that the dose and rate were correct as ordered. A suggestion was made to set up two pumps, with the dose split between them, such that neither pump exceeded the upper limit. An alternative workaround using the "no drug selected" option was later proposed to allow the medication to be infused with a single pump.

Methodology and analysis

Over the 5-year period between December 2019 and November 2024, 210 reports of safety incidents were submitted to the Canadian Medication Incident Reporting and Prevention System (CMIRPS) that involved bypassing the DERS in smart pumps. Of these incidents, about two-thirds occurred in critical care areas. Although errors reached the patients in some incidents, the overwhelming majority of reports described concerns about having to use the "no drug selected," "basic mode," or "IV fluids" option to infuse drugs at a rate outside the limits set by the drug library. Numerous medications or medication classes were reported (Table 1), including many high-alert medications.

Discussion

Reasons for bypassing the DERS (e.g., through use of the "no drug selected" option) included:

- Medication was not found in the drug library or not found in the drug library for the specific clinical care area.
- Medication profile in the drug library was not specific to the population served.
- Concentration of medication to be infused did not match the concentration in the drug library.
- Medications were ordered according to units or rates not present in the drug library.
- Preprinted order sets, IV medication monographs, and the medication profile in the drug library were misaligned, a situation that was reported to occur after a change to an order set.
- Care provider was unable to enter patient weight accurately due to limits in the weight parameter of the medication profile.

From the reports analyzed, it was clear that the nurses intended to use the DERS within the pump library but encountered one or more of the barriers described above, which made it impossible to run the infusion safely. Dealing with the barriers led to deviation from policies and protocols and subsequent use of workarounds to administer the medication. When nurses choose a workaround, they may unintentionally compromise safety (McCord et al., 2022).

Table 1

Medications/Classes Reported to Require Bypass of the Drug Error Reduction Software, in Descending Order of Frequency

Vasopressors
Anticoagulants (e.g., heparin)
Sodium bicarbonate
Chemotherapeutic agents
IV solution containing concentrated electrolytes (e.g., potassium phosphate)
Anti-infective agents
Monoclonal antibodies
Opioids
Neuromuscular blocking agents (e.g., cisatracurium)
Sedatives (e.g., dexmedetomidine)

The narratives in the safety reports also demonstrated that nurses were uncomfortable with using workarounds. In particular, choosing the "no drug selected" option necessitates manual programming of the infusion dosing parameters, outside the DERS. When the DERS is bypassed, the smart pump cannot identify pump programming errors (Giuliano & Ruppel, 2017; ISMP Canada, 2023).

Reporters described communicating their concerns to prescribers, charge nurses, or pharmacists. They also described performing double and triple checks with nursing colleagues and alerting other team members to the situation. Most striking was the time spent submitting safety reports even when an error did not occur; such reports were intended to flag a gap in the DERS or library with the goal of a timely resolution.

Key practice tips for critical care nurses

- Continue to report missing, incorrect, or misaligned drug entries in the DERS or drug library to clinical leaders and/or pharmacy; share examples at safety huddles.
- Ask colleagues to provide an independent double check if programming pumps with "no drug selected" is required, particularly for high-alert medications.

Recommendations for nursing leadership

- Develop an organizational process to provide just-in-time support (e.g., formalized line of priority communication with the smart pump informatics team) to nurses when they identify missing, incorrect, or misaligned drug entries.
- Frequently solicit feedback from nurses about the use of the "no drug selected" option.
- Collaborate with the multidisciplinary team responsible for the oversight of smart infusion pumps to
  - ensure that drug libraries reflect current evidence, as well as local prescribing practices for each specialty area
  - standardize drug concentrations, dosing, and infusion rates (e.g., units/min, units/h, mcg/min, mcg/kg/min), where applicable, across the medication-use system
  - ensure that the indication for the entry is discernible in the library, where a drug has different dosing parameters for different indications (e.g., oxytocin, *N*-acetylcysteine)
  - update drug libraries in a timely manner to ensure alignment across medication resources
  - analyze data from pumps to identify and address situations when users are choosing "no drug selected".

Conclusion

Critical care nurses need robust DERS and libraries that align with prescribing practices and organizational protocols and resources to ensure that medications are safely administered to patients. Use of the "no drug selected" option in the DERS is a workaround that affects medication safety. Nurses are flagging this risk through safety incident reports. Organizations can support nursing teams by addressing gaps identified, by providing timely clinical support when barriers are encountered, and by proactively analyzing data to ensure that the DERS and library content are continuously evaluated and updated.

Acknowledgements

The authors thank the following individuals for their review of the article: Michael Hamilton, MD, Carolyn Hoffman, RN, Mary Harber, RN, Peggy Robinson, ELS, and Alice Watt, RPh.

REFERENCES

Giuliano, K. K. & Ruppel, H. (2017). Are smart pumps smart enough? *Nursing,47*(3), 64–66. https://doi.org/10.1097/01.NURSE.0000512888.75246.88

ISMP. (2020). *Guidelines for optimizing safe implementation and use of smart infusion pumps*. https://ecri.ca/blogs/ismp-resources/guidelines-for-optimizing-safe-implementation-and-use-of-smart-infusion-pumps

ISMP Canada. (2023). "No drug selected" = Taking the smart out of smart pumps. *ISMP Canada Safety Bulletin, 23*(1), 1–4. https://ismpcanada.ca/wp-content/uploads/ISMPCSB2023-i1-Smart-Pumps.pdf

Joint Commission. (2021). Optimizing smart infusion pump safety with DERS. *Sentinel Event Alert, 63,* 1–5. http://jointcommission.org/-/media/tjc/documents/resources/patient-safety-topics/sentinel-event/sea-63-smart-infusion-pumps-w-ders-final.pdf

McCord, J. L., Lippincott, C. R., Abreu, E., & Schmer, C. (2022). A systematic review of nursing practice workarounds. *Dimensions of Critical Care Nursing, 41*(6), 347–356. https://doi.org/10.1097/DCC.0000000000000549