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RESEARCH ARTICLE

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Exploring intensive care unit nurses' acceptance of clinical decision support systems and use of volumetric pump data: A qualitative description study

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Abstract

Background: Intensive care units are well positioned for the rapid development of data-driven clinical decision support systems. However, clinical decision support systems using volumetric pump data are uncommon. This may be explained by the complexity of this data source as well as our limited understanding of the acceptability of clinical decision support systems and volumetric pump data use from nurses' perspectives.

Aim: To describe intensive care unit nurses' perceptions regarding (1) the acceptability of developing and implementing novel intensive care technologies (i.e. clinical decision support systems) and (2) the acceptability of using infusion pump data to inquire about intensive care practices and improve the quality of care.

Study Design: A qualitative description study was performed. Semi-structured interviews were conducted between January and March 2024 and involved 10 intensive care nurses from the province of Quebec (Canada).

Results: Nurses generally perceived the development and implementation of novel technologies, and the use of pump data, as acceptable. However, the discrepancy between the delays in care computerization and the rapid development of novel technologies with advanced algorithmic capabilities, coupled with nurses' doubts and limited comprehension of data-driven clinical decision support systems, influenced their perspectives. Nurses' appraisal that infusion logs can enhance clinical practices and that logs should align with their documentation motivated their perception that it is acceptable to use this data source.

Conclusions: Overall, novel technologies as well as volumetric pump data use were perceived as acceptable. Leveraging novel data processing and computation techniques could lead to the development of more dynamic clinical decision support systems that utilize infusion logs, further improving care delivery.

Relevance to Clinical Practice: For clinical decision support systems to be useful for intensive care nurses, alarms must be seamlessly integrated into their workflows. Involving nurses in the technological development process may help ensure the usability of these technologies.

KEYWORDS
decision support systems, infusion pumps, intensive care, nursing informatics

1 | INTRODUCTION

The intensive care unit (ICU) is an environment with rapidly evolving technologies (e.g. monitoring, invasive life support) that can assist specialized staff in optimizing patient care delivery and potentially improving the outcomes of critically ill patients.[1] Among these technologies, data-driven clinical decision support systems (CDSS) have frequently surfaced in recent years.[1,2] Whether they are derived from electronic health records (EHR), genomics, imaging or monitoring data, CDSS are gaining recognition for their potential in reshaping ICU organization and care delivery.[1–3]

What is known about the topic

- Intensive care units are well positioned for the development of novel data-driven clinical decision support systems (CDSS).
- Dynamic CDSS using data derived from volumetric pumps are uncommon despite medication use being a central component of ICU clinical practice.
- Our understanding of the acceptability of CDSS and volumetric pump data use from the perspective of ICU nurses is limited.

What this paper adds

- CDSS development and deployment were generally perceived as acceptable, as well as using volumetric pump data.
- The discrepancy between the introduction of novel technologies with advanced algorithmic capabilities and the delays in care computerization influences nurses' perspectives regarding CDSS potential.
- Nurses' appraisal that infusion logs can enhance clinical practices and that logs should align with their documentation motivated their acceptance of using this data source.

2 | BACKGROUND

The fast-paced development of CDSS presents opportunities and significant challenges.[4] Experimental testing of CDDS use as compared to usual care has shown limited improvements in patients receiving the desired care (pooled improvement of 5.8% [95% CI 4%–8%]).[5] Multiple barriers to implementation and acceptance have been described. Regulatory and legal concerns (e.g. certification, data access), limited quality data, the opacity of CDSS algorithms and trust of clinicians towards CDSS outputs may have an influence.[4,6] These challenges could explain the 'implementation gap', whereas very few data-driven CDSS showing promising performance (e.g. predictive algorithms) are really implemented and used in clinical practice.[4,7]

Volumetric pump infusion logs hold crucial information regarding medication use in the ICU (e.g. drugs, dosages, titrations, boluses, timestamps). Dynamic CDSS using data derived from infusion logs are uncommon despite medication use being a central component of ICU practice that is mostly managed using these pumps. For CDSS to be useful for ICU nurses, they should be informed by high-quality data, especially for medication. However, some evidence suggests that EHR entries are inaccurate for commonly used intravenous medication (e.g. propofol),[8] limiting the potential usefulness of EHR entries. Using volumetric pump data logs or data feeds may be a convenient way to circumvent the limitations associated with using manually recorded data from EHR.

Thus far, nurses' acceptance of CDSS has been investigated in various contexts such as delirium prediction, wound treatment suggestions, clostridium difficile bundle and neonatal ICU sepsis prediction.[6,9–11] However, our understanding of the acceptability of CDSS from the perspective of ICU nurses is limited. Also, the limited use of infusion logs in current CDSS may be influenced by the complexity of this data source, as well as the absence of data regarding whether ICU nurses perceive that using infusion logs is acceptable.

3 | AIMS AND OBJECTIVES OF THE STUDY

The objectives of this study were to describe the perceptions of ICU nurses regarding the acceptability of developing and implementing novel technologies in the ICU, and more specifically CDSS (i.e. decision support, automated alert systems, algorithms/artificial intelligence [AI]), and to describe the perceptions of ICU nurses related to the acceptability of using infusion logs to inquire about ICU practices and to improve the quality of care.

4 | DESIGN AND METHODS

We undertook a qualitative description study as part of a larger mixed methods study on the use of sedation boluses in the ICU. Qualitative description allows to describe a phenomenon utilizing an insider's perspective while staying closer to the data as compared to other qualitative methods.[12,13] Our research was anchored in a postpositivist paradigm.

4.1 | Setting and sample

We used a purposive sampling strategy and targeted ICU nurses working with adult patient populations in the province of Quebec (Canada).[12,14] ICU nurses caring for mechanically ventilated adults were deemed eligible. We aimed to recruit between 7 and 10 ICU nurses based on the sample sizes of previous qualitative studies on sedation use in the ICU.[15] This sample size was also chosen to provide a comprehensive description of the participant perspectives, while ensuring that it would be large enough to meet our research objectives, as supported by four similar qualitative studies.[15] Nurses were recruited using two strategies. First, we recruited ICU nurses working at a large university-affiliated hospital in the province of Quebec (Canada) through electronic invitations shared by the nurse managers of the unit. Second, we recruited nurses working in other ICUs in the province of Quebec through an electronic invitation shared with the members (~500 ICU nurses) of the *Regroupement des Infirmières et Infirmiers en Soins Intensifs du Québec* (RIISIQ) by the organization's manager. This nonprofit organization offers continuing education opportunities to ICU nurses. Snowball sampling strategies were utilized to increase the number of participants.[14] We recruited ICU nurses until no significant novel information was generated during interviews and aimed to obtain a balanced sample between both recruitment strategies.

4.2 | Data collection

We used semi-structured individual interviews as part of a larger convergent mixed methods study.[14] An interview guide was developed by the first author and revised by two members of our research team (i.e. FMC, MC), mostly covering domains related to sedation bolus use in the ICU as part of our larger study. There were two iterations to the interview outline, and we did not pilot the interview guide. The interview guide ended by open-ended questions about the acceptability of novel technologies and using volumetric pump data. For the current study, we focused on these concluding open-ended questions designed so that participants could freely express their perspectives without prior preparation.[12] Interviews were facilitated by one investigator (CV) trained in research and qualitative methods, as well as having experience in ICU nursing care. Interviews were conducted on Zoom® (Zoom Video Communications, United States) electronic platform between January and March 2024. The interviews were conducted in French and lasted approximately 30 min. Interviews were audio recorded and transcribed verbatim. One investigator (CV) reviewed the audio recordings and verbatims concomitantly to improve the quality of verbatims.[16] To promote reflexivity, the facilitators' thoughts about the interviews were collected after each interview in an electronic text file.[17]

4.3 | Data analysis

We performed inductive qualitative content analysis following the recommendations of Elo and Kyngas.[18] Based on these recommendations, we used an inductive analytical approach because, at the study's inception, there was not enough ICU-related knowledge to support using a specific theoretical framework. Our analysis was minimally interpretative and therefore guided by ICU nurses' perspectives and marginally influenced by prior conceptualizations or knowledge.[18] We began by preparing the data and familiarizing them with their contents. We reviewed files with facilitators' thoughts during the initial analysis.[19] Afterwards, we used an iterative open-coding process, whereas all the qualitative materials were freely coded. Codes were then regrouped into subcategories and main categories, and we used abstraction to provide a general description of the underlying meaning of the main categories. Analyses were performed by one investigator (CV) using NVivo Qualitative Data Analysis (Lumivero, USA) software. To enhance rigour and trustworthiness, we utilized a formative qualitative audit trail review by an independent expert with both extensive experience in ICU nursing as well as qualitative data analysis.[20] This expert reviewed the deidentified verbatims, analytical nodes and the categorization and examined the veracity of the conclusions of the analysis. The auditor also examined whether the documented a priori of the analyst could have had an impact on the findings.

We reported the main categories and subcategories for each objective with supporting illustrative quotes. Illustrative quotes were liberally translated into English. Findings for each objective are presented separately in the findings section.

4.4 | Ethics statement

This research was approved by our institutional research ethics board (REB project number: 23.050), on 18 July 2023. Nurses provided

informed consent prior to participating and had the opportunity to withdraw their consent at any time. No compensation was offered. Verbatims were coded, and participant numbers were assigned to nurses, mentions of location and volumetric pump brands were removed. The study was conducted according to the Guidelines for Good Clinical Practice and the Declaration of Helsinki.

5 | FINDINGS

We performed a total of 10 interviews between January and March 2024. The average duration of electronic meetings was 36 min. There was one transient interruption at the beginning of one of the interviews. On average, one-quarter of the verbatim corpus consisted of discussions related to novel technologies and pump-related questions which herein are used for this study. Most participants identified as the female gender (80%, $n = 8$), had a bachelor's degree (80%, $n = 8$) and worked at the bedside as registered nurses (80%, $n = 8$). The median age and number of years of ICU experience of the participants were respectively 36 years (Q1–Q3: 31–47) and 7 years (Q1–Q3: 6–16). All nurses in our sample cared for mixed medical-surgical patient populations, and all but one ($n = 9$, 90%) worked in tertiary hospitals and ICUs corresponding to the highest level of care acuity.

5.1 | Nurses' acceptance of novel technologies (Objective 1)

For our first research objective, we found that all ICU nurses in our sample believed that the development and implementation of novel technologies in the ICU were acceptable. For the first objective, we have identified two categories and five subcategories (Table 1).

5.1.1 | Advanced algorithmic capabilities versus clinical reality

ICU nurses expressed that they were increasingly hearing about algorithms/AI. However, nurses perceived a mismatch between their day-

TABLE 1 Summary of the findings.

Objectives	Categories	Subcategories	Selected illustrative quotes
Objective 1	Advanced algorithmic capabilities vs. clinical reality	1. Obsolete information technologies	'Going more towards modernity, I am not at all against it, because having 10 sheets of paper, still, it is really not ideal. […] We are far from monitoring patients with artificial intelligence' (P9).
		2. Grey areas and large volumes of multimodal data	'I think that the human value of care that you give, because it is not just an assemblage of data […] especially in the sector of intensive care, it's more complex than that and it's finer, it's not white or black' (P8).
		3. Support human clinical decision-making	'It could probably be useful in many cases. But obviously, it's always thinking and not forgetting that the clinical judgement must always remain […] because it's still humans that we treat with it' (P9).
		4. AI uncertainty	'Artificial intelligence, I don't really know how. I mean that I'm not really equipped in life to understand what is going on with that at the moment' (P3).
	Conditions for successful implementation	1. Navigating challenges	'Now, is everyone open to new technologies, I would say I don't know. […] There always are those who resist or *well we don't need that*' (P7).
Objective 2	Quality and validity of pump data	1. Pump data completeness	'It could give an even more precise portrait of what is really administered. Because are there boluses that are forgotten at times? That we forget to document in the charts? Most likely. Not only boluses, but the perfusions also there are a lot of changes in rates' (P9).
		2. Documentation should match pump data	'Anyways, what I administer should be transcribed, as is, in my medication administration sheet. There shouldn't be any secrecy. As prescribed' (P6).
	Understanding and improving clinical practices	1. Pump data usability	'I think it's certain that there are […] differences between professionals in the use of protocols. So, it would be interesting to highlight it and try to assess the impact and to standardize practices to improve the quality of care' (P1).
		2. Partial picture of medication use	'It's like when families ask you […] what is this number [vital sign] […] unfortunately they will fixate on this number, but that does not take into account the overall patient situation. Here, it's the same idea, we will take the dose of medication but who is this patient?' (P8).
	Ethical considerations and dilemmas	1. Pump data confidentiality	'Anyhow, it's not nominal [pump data]. You would not have access to the patient file.' (P6).
		2. Surveillance and control	'Is there a risk that nurses find that, in the end, we have a type of *Big Brother* who monitors everything we do with medication, what we give and all. I think there will be a certain reluctance […]' (P7).

Abbreviations: AI, artificial intelligence; vs., versus.

to-day clinical practice as compared to the advanced capabilities of algorithms/AI.

Obsolete information technologies

Among the reasons for this mismatch, the health information technologies they use influenced their perspectives. ICU nurses notably discussed the systematic use of paper-based documentation and manual recording of data that is otherwise recorded by devices (e.g. vital signs) in their clinical practice.

> Going more towards modernity, I am not at all against it, because having ten sheets of paper, still, it is really not ideal. [...] We are far from monitoring patients with artificial intelligence.
>
> (P9)

Grey areas and large volumes of multimodal data

Nurses felt that the ICU is a peculiar work environment where grey areas in decisions are frequent. For these nurses, clinical decision-making therefore does not revolve around binary decisions, especially in the context of nursing care that is anchored in humanism. They expressed having difficulty imagining a scenario in which CDSS could match their capacity to handle the large volume of data from multiple sources (i.e. multimodal) that they cognitively process utilizing their knowledge and experience to shape decisions.

> I think that the human value of care that you give, because it is not just an assemblage of data [...] especially in the sector of intensive care, it's more complex than that and it's finer, it's not white or black.
>
> (P8)

Support human clinical decision-making

Nurses have the perception that CDSS can help them in their day-to-day practice. However, for a technology to be acceptable, the ultimate decision regarding care must always remain in the hands of clinicians.

> It could probably be useful in many cases. But obviously, it's always thinking and not forgetting that the clinical judgement must always remain [...] because it's still humans that we treat with it.
>
> (P9)

AI uncertainty

Overall nurses expressed more difficulty taking position for AI-related technologies. They felt that AI, unlike the monitoring systems and alarms that they use continuously, is novel and not something that they understand well. They also expressed uncertainty about whether a given technology was actually AI.

> Artificial intelligence, I don't really know how. I mean that I'm not really equipped in life to understand what is going on with that at the moment.
>
> (P3)

> Artificial intelligence it has just started to be implemented, so my opinion is certainly not very clear on the matter because it is still very, very new and it remains to develop.
>
> (P9)

5.1.2 | Conditions for successful implementation

The implementation of new technologies can be met with important challenges, and to ensure a fruitful implementation, clinical staff has to be mobilized.

Navigating challenges

Two main challenges to technology implementation emanated from our analysis, the first is adapting the implementation process to account for those 'refractory to change', and the second is to minimize the impact of the technology on the cognitive load of clinicians. Nurses exposed that technologies must adapt to their work processes.

> Now, is everyone open to new technologies, I would say I don't know. [...] There always are those who resist or well we don't need that.
>
> (P7)

> So the balance between helping, because technology can help, like understand lots of things that we are unable to see, but without overloading us so that we still have time to use our clinical judgement.
>
> (P9)

5.2 | Nurses' acceptance of using volumetric pump logs (Objective 2)

For our second research objective, all ICU nurses in our sample believed that it was acceptable to use volumetric pump infusion logs to inquire about ICU clinical practices and improve clinical practices. For this objective, we have identified three categories and six subcategories (Table 1).

5.2.1 | Quality and validity of pump data

Using infusion logs could help gain a better understanding of medication use because this source of data may provide a valid representation of the clinical reality.

Pump data completeness

For nurses, pump data may be more complete, not only for sedation boluses but also for all drugs which are frequently titrated for targets and for which data entries in EHR may not represent the clinical reality.

> It could give an even more precise portrait of what is really administered. Because are there boluses that are forgotten at times? That we forget to document in the charts? Most likely. Not only boluses, but the perfusions also there are a lot of changes in rates.
>
> (P9)

Documentation should match pump data

While some nurses noted the potential for discrepancies between EHR entries and volumetric pump logs, most reported that using infusion logs is acceptable because they believed that manual entries should match infusion logs.

> Anyways, what I administer should be transcribed, as is, in my medication administration sheet. There shouldn't be any secrecy. As prescribed.
>
> (P6)

5.2.2 | Understanding and improving clinical practices

The acceptability of using infusion logs is further influenced by ICU nurse's perceptions that these data can be used to improve clinical practices.

Pump data usability

Nurses felt that infusion logs could help understand the dynamics of care at the bedside on 24-hour periods and help assert between-clinician variability.

> I think it's certain that there are [...] differences between professionals in the use of protocols. So, it would be interesting to highlight it and try to assess the impact and to standardize practices to improve the quality of care.
>
> (P1)

Partial picture of medication use

However, nurses expressed that using infusion logs alone would only present a partial picture of medication use.

> It's like when families ask you [...] what is this number [vital sign] [...] unfortunately they will fixate on this number, but that does not take into account the overall patient situation. Here, it's the same idea, we will take the dose of medication but who is this patient?
>
> (P8)

5.2.3 | Ethical considerations and dilemmas

Using infusion logs raises concerns about the level of privacy of this data source, and its potential use to 'control' ICU nursing practice.

Pump data confidentiality

Nurses highlight that infusion logs without patient identifiers are not nominal data which increases the acceptability of their use. However, when they are linked to patient records, it raises questions about whether patients should consent to their use.

> Anyhow, it's not nominal [pump data]. You would not have access to the patient file.
>
> (P6)

Surveillance and control

For a participant, gaining access to infusion logs could create a scenario in which there is greater surveillance and control for ICU nursing clinical practices revolving around medication use.

> Is there a risk that nurses find that, in the end, we have a type of *Big Brother* who monitors everything we do with medication, what we give and all. I think there will be a certain reluctance [...].
>
> (P7)

6 | DISCUSSION

Our study aimed to describe ICU nurses' perceptions regarding the acceptability of developing and implementing novel technologies, notably tools that support clinical decision-making in the ICU. Overall, ICU nurses perceived these technologies as acceptable. Yet, the discrepancy between the emergence of algorithm-driven technologies and the delays nurses' witness in care computerization, as well as nurses limited exposure to data-driven CDSS, and their doubts about the capacity of such technologies to handle large volumes of multimodal data, influenced their perceptions. Also, we sought to describe the acceptability of using volumetric pump infusion logs to inquire about and improve clinical practices. All ICU nurses expressed that using infusion logs was acceptable. This was mostly influenced by nurses' perception that this data source is valid and that logs could improve clinical practices. However, concerns about patient confidentiality and potential normative surveillance of clinical practices affected how acceptable some participants found the use of infusion logs.

Our study highlights that ICU nurses perceive CDSS as acceptable but consider that there is an important discrepancy between the rapid development of algorithm-based technologies and the limited computerization of clinical care. Paper-based clinical documentation and manual recording of data (e.g. ventilator parameters, infusion rates) was the clinical reality of most participants who also reported wishing for more computerization of care and more efficient health information systems. There is currently witnessable momentum across Canada and Europe to modernize health information systems.[21] In the meantime, the between-country variability in care computerization and health information systems may impact the transportability of data-driven technologies.[22] Hence, despite developments in natural language processing, notably utilizing nursing notes,[23,24] it still

remains unfeasible to extract crucial ICU variables (e.g. urine output, level of consciousness) from handwritten documentation, potentially limiting the implementation of some tools in poorly computerized systems.

Our results suggest that ICU nurses believe that CDSS can be useful in improving patient care delivery, which contributes to the perceived acceptability. However, nurses expressed doubts about the capacity of data-driven technologies to process the large volumes of multimodal data that they use to shape their complex decisions. This was previously observed in interviews involving expert nursing scientists.[25] Similarly, the authors of a recent review highlighted that seasoned health care workers typically prefer relying on their own perspective, shaped by their knowledge and experience, rather than using data-driven technologies.[6] Lack of trust regarding CDSS or AI outputs is a recurrent finding in the health care literature.[26] Also, our results support that the unfamiliarity of nurses with novel technologies, especially AI, and their limited exposure to potential clinical use cases may further influence their acceptance. In prior studies, most nurses had favourable attitudes towards the potential impacts of AI,[26] but lack of knowledge and unfamiliarity regarding CDSS or AI was prevalent.[27] Recent systematic reviews related to health care data-driven technologies highlight that nurses, despite often being the end-user, are rarely involved in their development.[22,28] This may contribute to nurse's unfamiliarity with novel technological advances.

Alarm fatigue resulting from the combination of 'classic' ICU alarms (e.g. monitoring devices, life support technologies) and those generated by CDSS is a known factor that influences the acceptability and may affect CDSS adoption.[29] Hence, inappropriate or repeated alarms are recognized as one of the main pitfalls to successful CDSS implementation.[30–32] Some nurses in our sample believed that data-driven technologies must adapt to their work processes, to minimize the impact on their cognitive load, and so that they have enough time remaining to perform their professional activities. Alarm integration in critical care settings must be considered in future CDSS development.

Acceptability related to using volumetric pump data was mostly influenced by nurses' perception that this data source could help improve practices through standardization and a better understanding of clinical practices. The main concerns were related to data confidentiality and one participant discussed the potential for increased normative surveillance of nursing practices. It is well-known that nursing documentation is often suboptimal.[8,22] However, the main category that emanated was that this data source was perceived as valid. Nurses felt that infusion logs and EHR entries both measured the same thing through different processes. This finding contrasts with the reports of some of our participants that infusion logs were more accurate than EHR entries for commonly used drugs, namely drugs that are frequently titrated (e.g. pressors) and sedation boluses.

Considering delays in care computerization, and to compensate for incomplete data, one might be tempted to compensate by having clinicians collect additional data outside of their usual work processes. This has been shown to have negative impacts on both their work and cognitive load.[30] Relying on poor-quality data alters the performance of CDSS, and ultimately, their clinical relevance and usability.[30] Thus far, CDSS utilizing infusion logs have had three main targets — data linkage with EHR, reducing medication errors, and automating dosage calculations.[32] In a United States' hospital, linking ICU infusion logs with EHR resulted in a 75% increase in the number of recorded changes in norepinephrine and epinephrine rates.[33] Also, implementing 'connected' volumetric pumps has been shown to reduce the number of medication errors through enforcing medication libraries.[32,34] Moving forward, harnessing novel algorithmic techniques may allow to develop more dynamic CDSS utilizing raw infusion data such as the drugs and dosages, to emit predictions in real time and further improve ICU care delivery. For example, developing a CDSS linking raw infusion logs and high frequency or waveform data from patient multiparametric monitors (i.e. blood pressure) could allow to titrate vasodilators or pressors more precisely than trial and error by forecasting the variation in blood pressure that could result from a change in infusion rate.[35] However, such CDSS may inadvertently increase the workload of ICU nurses. To address this, early device feasibility and acceptability studies should be performed to measure and minimize the impact of a given CDSS on current nursing care processes. Also, to facilitate the integration of such CDSS into broader electronic health systems, CDSS outputs should be generated in an interoperable format.

6.1 | Limitations

This study has multiple limitations. First, participants were recruited from a single Canadian province, and the current technological state of the province's health care system must have impacted our findings. Second, a single investigator performed the qualitative analysis. However, the minimally interpretative nature of the analysis and the formative qualitative audit trail may minimize the impact of this limitation on the confirmability of the results.[20] Third, this study was embedded in a larger mixed methods study on sedation bolus use in the ICU. The embedded nature of the study may have influenced and narrowed the reports of ICU nurses by preemptively triggering responses related to the clinical context of sedation use. Fourth, we conducted electronic interviews to promote the feasibility of our study. Yet, this may have impacted our ability to assess contextual elements, such as non-verbal language, and influenced the discussions. Also, the similarities observed with prior literature increase the credibility of our findings. Last, most of our participants worked in tertiary hospitals and mixed ICUs. Nurses who agreed to participate may have different perspectives compared with non-participants. These limitations affect the transferability of our findings.

6.2 | Implications and recommendations for practice

Novel data-driven CDSS represent a significant opportunity to improve patient care delivery in the ICU. However, for a CDSS to be

useful for ICU nurses, alarms must be seamlessly integrated into their complex workflows. Also, gaining nurses' insight during every step of the development and implementation of CDSS may increase the acceptability and thereafter influence the impact of CDSS deployment on ICU clinical practice. Using volumetric pump data is generally perceived as acceptable. Therefore, developing dynamic data-driven CDSS utilizing volumetric data logs could be a promising strategy to improve the quality of care for critically ill patients receiving high-risk medications.

7 | CONCLUSION

The rapid development of CDSS presents significant opportunities. Our results indicate that both CDSS development and deployment were perceived as acceptable, as well as using volumetric pump data. The discrepancy between the introduction of novel technologies with advanced algorithmic capabilities and the delays in care computerization, coupled with nurses' doubts and limited comprehension of data-driven CDSS, influenced their perspectives. Nurses' appraisal that infusion logs can enhance clinical practices and that logs should align with their documentation motivated their acceptance of using such logs. Leveraging novel data processing and computation techniques could lead to the development of more dynamic CDSS that utilize infusion logs, further improving ICU nursing care.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

PATIENT CONSENT STATEMENT

Participating nurses have provided consent for publication.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

We did not reproduce material from other sources.

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REFERENCES

1. Kerlin MP, Costa DK, Kahn JM. The Society of Critical Care Medicine at 50 years: ICU organization and management. *Crit Care Med [Internet]*. 2021;49(3):391-405. doi:10.1097/CCM.0000000000004830
2. Meissen H, Gong MN, Wong AKI, et al. The future of critical care: optimizing technologies and a learning healthcare system to potentiate a more humanistic approach to critical care. *Crit Care Explor*. 2022;4(3):e0659. doi:10.1097/CCE.0000000000000659
3. Maslove DM, Lamontagne F, Marshall JC, Heyland DK. A path to precision in the ICU. *Crit Care (Lond Engl)*. 2017;21(1):79. doi:10.1186/s13054-017-1653-x
4. Pinsky MR, Bedoya A, Bihorac A, et al. Use of artificial intelligence in critical care: opportunities and obstacles. *Crit Care*. 2024;28(1):113. doi:10.1186/s13054-024-04860-z
5. Kwan JL, Lo L, Ferguson J, et al. Computerised clinical decision support systems and absolute improvements in care: meta-analysis of controlled clinical trials. *BMJ*. 2020;370:m3216. doi:10.1136/bmj.m3216
6. Lambert SI, Madi M, Sopka S, et al. An integrative review on the acceptance of artificial intelligence among healthcare professionals in hospitals. *NPJ Digit Med*. 2023;6(1):111. doi:10.1038/s41746-023-00852-5
7. Seneviratne MG, Shah NH, Chu L. Bridging the implementation gap of machine learning in healthcare. *BMJ Innov*. 2020;6(2):45-47. doi:10.1136/bmjinnov-2019-000359
8. McGain F, Lam K, Bates S, Towns M, French C. An audit of propofol administration in the intensive care unit: infusion pump-recorded versus electronically documented amounts. *Aust Crit Care Off J Confed Aust Crit Care Nurses*. 2020;33(1):25-29. doi:10.1016/j.aucc.2018.12.005
9. Khong PCB, Hoi SY, Holroyd E, Wang W. Nurses' clinical decision making on adopting a wound clinical decision support system. *Comput Inform Nurs*. 2015;33(7):295-305. doi:10.1097/CIN.0000000000000164
10. Kitzmiller RR, Vaughan A, Skeeles-Worley A, et al. Diffusing an innovation: clinician perceptions of continuous predictive analytics monitoring in intensive care. *Appl Clin Inform*. 2019;10(2):295-306. doi:10.1055/s-0039-1688478
11. Blanco N, O'Hara LM, Robinson GL, et al. Health care worker perceptions toward computerized clinical decision support tools for Clostridium difficile infection reduction: a qualitative study at 2 hospitals. *Am J Infect Control*. 2018;46(10):1160-1166. doi:10.1016/j.ajic.2018.04.204
12. Bradshaw C, Atkinson S, Doody O. Employing a qualitative description approach in health care research. *Glob Qual Nurs Res*. 2017;4:2333393617742282. doi:10.1177/2333393617742282
13. Kim H, Sefcik JS, Bradway C. Characteristics of qualitative descriptive studies: a systematic review. *Res Nurs Health*. 2017;40(1):23-42. doi:10.1002/nur.21768
14. Guest G, Namey EE, Mitchell ML. *Collecting Qualitative Data: A Field Manual for Applied Research*. Sage Publications, Ltd; 2013. doi:10.4135/9781506374680
15. Varga S, Ryan T, Moore T, Seymour J. What are the perceptions of intensive care staff about their sedation practices when caring for a mechanically ventilated patient?: a systematic mixed-methods review. *Int J Nurs Stud Adv*. 2022;4:100060. doi:10.1016/j.ijnsa.2021.100060
16. MacLean LM, Meyer M, Estable A. Improving accuracy of transcripts in qualitative research. *Qual Health Res*. 2004;14(1):113-123. doi:10.1177/1049732303259804
17. Olmos-Vega FM, Stalmeijer RE, Varpio L, Kahlke R. A practical guide to reflexivity in qualitative research: AMEE guide No. 149. *Med Teach*. 2023;45(3):241-251. doi:10.1080/0142159X.2022.2057287
18. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs*. 2008;62(1):107-115. doi:10.1111/j.1365-2648.2007.04569.x

19. Phillippi J, Lauderdale J. A guide to field notes for qualitative research: context and conversation. *Qual Health Res*. 2018;28(3):381-388. doi:10.1177/1049732317697102
20. De Kleijn R, Van Leeuwen A. Reflections and review on the audit procedure: guidelines for more transparency. *Int J Qual Methods*. 2018;17(1):1609406918763214. doi:10.1177/1609406918763214
21. Hertzum M, Ellingsen G. The implementation of an electronic health record: comparing preparations for epic in Norway with experiences from the UK and Denmark. *Int J Med Inform*. 2019;129:312-317. doi:10.1016/j.ijmedinf.2019.06.026
22. von Gerich H, Moen H, Block LJ, et al. Artificial intelligence -based technologies in nursing: a scoping literature review of the evidence. *Int J Nurs Stud*. 2022;127:104153.
23. Khurana D, Koli A, Khatter K, Singh S. Natural language processing: state of the art, current trends and challenges. *Multimed Tools Appl*. 2023;82(3):3713-3744. doi:10.1007/s11042-022-13428-4
24. Mitha S, Schwartz J, Hobensack M, et al. Natural language processing of nursing notes: an integrative review. *Comput Inform Nurs*. 2023;41(6):377-384. doi:10.1097/CIN.0000000000000967
25. Seibert K, Domhoff D, Fürstenau D, Biessmann F, Schulte-Althoff M, Wolf-Ostermann K. Exploring needs and challenges for AI in nursing care – results of an explorative sequential mixed methods study. *BMC Digit Health*. 2023;1(1):13. doi:10.1186/s44247-023-00015-2
26. Rony MKK, Parvin MR, Wahiduzzaman M, Debnath M, Bala SD, Kayesh I. "I wonder if my years of training and expertise will be devalued by machines": concerns about the replacement of medical professionals by artificial intelligence. *SAGE Open Nurs*. 2024;10:23779608241245220. doi:10.1177/23779608241245220
27. Sommer D, Schmidbauer L, Wahl F. Nurses' perceptions, experience and knowledge regarding artificial intelligence: results from a cross-sectional online survey in Germany. *BMC Nurs*. 2024;23(1):205. doi:10.1186/s12912-024-01884-2
28. Zhou Y, Li Z, Li Y. Interdisciplinary collaboration between nursing and engineering in health care: a scoping review. *Int J Nurs Stud*. 2021;117:103900. doi:10.1016/j.ijnurstu.2021.103900
29. Wong A, Berenbrok LA, Snader L, et al. Facilitators and barriers to interacting with clinical decision support in the ICU: a mixed-methods approach. *Crit Care Explor*. 2023;5(9):e0967. doi:10.1097/CCE.0000000000000967
30. Sutton RT, Pincock D, Baumgart DC, Sadowski DC, Fedorak RN, Kroeker KI. An overview of clinical decision support systems: benefits, risks, and strategies for success. *NPJ Digit Med*. 2020;3(1):17. doi:10.1038/s41746-020-0221-y
31. Olakotan OO, Mohd YM. The appropriateness of clinical decision support systems alerts in supporting clinical workflows: a systematic review. *Health Informatics J*. 2021;27(2):14604582211007536. doi:10.1177/14604582211007536
32. Withall JB, Schwartz JM, Usseglio J, Cato KD. A scoping review of integrated medical devices and clinical decision support in the acute care setting. *Appl Clin Inform*. 2022;13(5):1223-1236. doi:10.1055/s-0042-1759513
33. Joseph R, Lee SW, Anderson SV, Morrisette MJ. Impact of interoperability of smart infusion pumps and an electronic medical record in critical care. *Am J Health-Syst Pharm AJHP Off J Am Soc Health-Syst Pharm*. 2020;77(15):1231-1236. doi:10.1093/ajhp/zxaa164
34. Melton KR, Timmons K, Walsh KE, Meinzen-Derr JK, Korkandall Smart pumps improve medication safety but increase alert burden in neonatal care. *BMC Med Inform Decis Mak*. 2019;19(1):213. doi:10.1186/s12911-019-0945-2
35. Kamboj N, Metcalfe K, Chu CH, Conway A. Predicting blood pressure after nitroglycerin infusion dose titration in critical care units: a multicenter retrospective study. *Comput Inform Nurs*. 2024;42(4):259-266. doi:10.1097/CIN.0000000000001086

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