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QUALITY IMPROVEMENT REPORT

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Extending the interval for changing flushing solutions for central venous and arterial line systems in the intensive care unit: An evidence-based quality improvement project

Junel Padigos[1,2] | Lauren Murray[2] | Olivia Bredhauer[2] | Jenny Jaspers[2] | Sue Bethune[3]

[1]School of Public Health, The University of Queensland, Herston, Queensland, Australia

[2]Intensive Care Unit, Sunshine Coast Hospital and Health Service, Birtinya, Queensland, Australia

[3]SCHI Library, Sunshine Coast Hospital and Health Service, Birtinya, Queensland, Australia

Correspondence
Junel Padigos, School of Public Health, The University of Queensland, 266 Herston Road, Herston, Qld 4006, Australia.
Email: j.padigos@uq.edu.au

Abstract

Background: Central venous lines (CVLs) and arterial lines (ALs) are commonly used for patients in the intensive care units (ICUs) to facilitate the administration of medications and haemodynamic monitoring. In an ICU in Queensland, Australia (AU), saline (sodium chloride 0.9%) flush bags used for these lines were routinely changed every 24 h following organizational policy that all intravenous fluid bags are to be changed within a 24-h period.

Aim: This quality improvement (QI) project aimed to evaluate current practice guided by the Plan-Do-Study-Act (PDSA) model of QI and implementation science. Benchmarking practices with other ICUs was conducted.

Study Design: A narrative literature review focused on evaluating the safe interval for changing flush solutions every 24 h was performed using EBSCO Medline, CINAHL, Cochrane Library, Embase and Google Scholar databases for citations up to November 2022. Bloodstream infection rates attributed to CVLs and/or ALs were monitored. Economic analysis was performed. End-user feedback was sought. A change of practice was implemented for a 1-year study period (March 2023 – March 2024) to extend dwell times of flushing solutions for CVLs and ALs from every 24 h to every 96 h.

Results: One-year post-implementation, no bloodstream infections were linked to CVLs or ALs. A simplified economic analysis was performed based on costs of 0.9% sodium chloride 500-mL fluid bags, which revealed that changing the fluid bags once every 96 h resulted in a per patient saving of AU$3.21 for any individual AL or CVL and up to AU$6.42 per patient where both an AL and CVL are in situ, based on fluid bag cost at AU$1.07 per bag. This saving excludes potential savings from reduced nursing time, infection-related costs and recycling costs.

Conclusion: A sustainable practice change based on evidence was implemented in the local ICU. The use of the PDSA model of the QI process and the principles of implementation science strengthened the buy-in and implementation of the project.

Relevance to Clinical Practice: This practice change was examined through lenses of evidence-based practice, environmental sustainability (minimizing environmental footprint by limiting plastic bag usage), patient safety, cost minimization, and reduced nursing workload.

KEYWORDS

arterial line, central venous line, evidence-based practice, fluid stewardship, flush bag change

1 | INTRODUCTION

1.1 | Problem description

Central venous lines (CVLs) and arterial lines (ALs) are essential sets commonly used in intensive care units (ICUs) for administering medications and haemodynamic monitoring.[1,2] With these lines, a catheter is inserted into a central vein for CVLs and into a peripheral artery for ALs.[1,2] These lines are connected to a transducer system and a pressure bag with a flushing solution to facilitate continuous and intermittent flushing of the system, zeroing or recalibrating the pressure.[1,2] Since its use, the practice has evolved from using heparinized 0.9% sodium chloride flushing solutions to 0.9% sodium chloride solution alone.[3] The practice in the local ICU where this QI activity was conducted was to change the 0.9% sodium chloride flush bags of the CVLs and ALs every 24 h, while the transducing administration sets are changed every 7 days.

This practice of changing the 0.9% sodium chloride flushing solutions every 24 h was in line with an organization-wide policy of changing intravenous fluid bags within a 24-h period from the time the fluid bag was spiked, as a precautionary measure to mitigate the risk of developing bloodstream or other nosocomial infections from fluid bag contamination.[4] Despite the acceptance of this practice across the organization, it was not clear that the currently recommended interval of changing the 0.9% sodium chloride flush bags for CVLs and ALs every 24 h was substantiated with evidence.

This project was conducted in a 12-bed tertiary regional ICU in Queensland, Australia (AU), with a mean of 1159 patients admitted per year (standard deviation = 95) from the year 2020 to 2024. During the one-year intervention period (March 2023 – March 2024), 1343 patients were admitted in the ICU.

1.2 | Available knowledge

Bloodstream infections (BSIs), frequently attributed to the use of indwelling catheters like CVLs and ALs, pose a significant challenge resulting in increased patient morbidity and mortality, extended antimicrobial treatment and hospitalization.[5,6] Managing CVLs and ALs varies globally, including dwell times of flushing solutions and administration sets for these lines.[7,8] Best practice recommendations also exist, particularly from the Centers for Disease Control and Prevention (CDC) and from the Infusion Nurses Society for infection prevention related to catheter care[9–11]; however, most studies that informed the guidelines have a primary focus on administration sets and their intervals of changing,[12,13] rather than specifically on the interval of the flushing solutions of the pressure-transducing administration sets. This identified gap in the literature raises questions on the necessity and efficacy of the currently routine practice and calls for the need for an evidence-based approach.

What is known about the topic

- The intervals of changing flushing solutions in pressure bags for central venous and arterial line systems vary across institutions.
- Despite recent strong evidence for extending dwell times of transducing administration sets of these lines to 7 days, data on extended dwell times for flushing solutions are limited and inconclusive.

What this paper adds

- Evidence synthesis performed in this project suggested a recommended interval of changing flush solutions of these line systems every 96 h based on primary evidence and practice recommendations.
- Project outcomes indicate that adhering to the available evidence may not only be safe (reduces contamination risk) but also cost-effective and time-saving.
- Primary studies using rigorous methodologies such as randomized controlled trials are needed to particularly explore the efficacy and safety of longer dwell times for flushing solutions of these lines.
- Embedding implementation science principles in quality improvement cycles enhanced the processes of buy-in and adaptation of this project.

1.2.1 | Literature review

A narrative literature review focused on evaluating the safety of changing flush solutions every 24 h was conducted, from the earliest available records in the selected databases until November 2022. A search strategy was established using the following keywords: Central N4 (line OR catheter* OR cannula), (Frequency OR timing) AND (replace* OR chang*), Saline OR solution OR "flush solution" OR tube* OR tubing OR "administration set*", Pressure OR "haemodynamic monitoring" OR "hemodynamic monitoring", Infect* OR contaminat*. EBSCO Medline, CINAHL, Cochrane Library, Embase and Google Scholar databases were used. Citation tracking was also performed. Included studies must: (i) be peer-reviewed, with focus on practices related to changing intervals of flush bags in CVLs and/or ALs, (ii) have retrievable full-text equivalent and (iii) be written in English language. There was no imposed restriction between adult and paediatric settings. Excluded were studies focused solely on changing intervals of transducing administration sets without pertaining to the interval of changing flush bags for CVLs and ALs, as well as letters to editors because of the lack of thorough peer review. Textual analysis was used for contextual analysis of the evidence selected. The narrative literature review identified peer-reviewed documents pertaining to the interval of changing flushing solutions on CVLs and ALs.

Using databases identified, only studies that highlighted the change of flush solutions were included for review and textual analysis ($N = 6$), which were published from 1988 to November 2022 (Table 1). Of the six documents, three were primary studies[14–16] and three were review/practice recommendations.[10,11,17] The primary studies were conducted from the years 1988–1998, and the review/practice recommendations, which were informed by the primary studies, were published between the years 2011–2021. There were very limited studies, with no recent primary study. In a pilot study conducted by Covey et al. (1988),[14] there was no difference in the incidence of catheter-related infection whether the intervals for changing flushing solutions and pressure monitoring tubings were 24 and 48 h. McLane et al. (1998)[16] evaluated the risk of contamination in flushing solutions for arterial and pulmonary artery catheters by comparing the changing of flushing solutions between 48-h and 72-h intervals and found no contamination in either group. In a study by O'Malley et al.[15] bacterial growth was isolated on four samples of two patients within 48 h following a violation of the line system attributed to flush bag changes. In the same study, no positive cultures were found among 451 intervals where the line systems remained unviolated (except for sampling) for ≥96 h.[15] The Centers for Disease Control and Prevention (CDC) (2011) and the Infusion Nurses Society (Gorski et al., 2021) strongly recommended changing flush solutions every 96 h.[10,11] Gorski et al. (2021)[11] based this recommendation on a systematic review performed by Daud et al. (2013).[17] Daud et al. (2013)[17] based their recommendations on CDC (2011)[10] as the study included in their review by Covey et al. (1988)[14] only tested up to 48 h. The studies informing the CDC guideline focused on the frequency/interval of changing administration/transducer sets[12,18,19] rather than specifically on flushing solutions, but CDC strongly recommended changing flush solutions every 96 h along with other components at the time of transducer change (Grade of recommendation IB) and minimizing manipulation of the system (Grade of recommendation II) to reduce inadvertent contamination risk.[10] The Infusion Nurses Society (Gorski et al., 2021) also recommended the 96-h interval, including changing flushing solutions, immediately when contamination is suspected or when there is a compromise on the system/product.[11]

1.2.2 | The value of evidence-based practice

Evidence-based practice (EBP) is the cornerstone in health care, which calls for the integration of best available research and clinical practice with the end goal of optimizing patient experience and health outcomes.[20,21] In health care organizations, EBP improves patient safety, quality of care and resource efficiency.[20,21] Examining the practice of changing 0.9% sodium chloride flush bags for CVLs and ALs every 24 h, although traditionally accepted, exemplifies a policy that can be re-examined using the lens of EBP. The 24-h practice of changing flush bags for CVLs and ALs was based on a precautionary principle rather than direct evidence. With EBP, clinical decisions are not solely based on traditions but are informed by reliable evidence with the aim to eliminate outdated practices that are not effective or necessary, which can reduce costs and minimize potential harm.[20,21] For example, the recommended practice guidelines from the Centers for Disease Control and Prevention and the 2024 recommendations from the Infusion Nurses Society are grounded in research and expert consensus.[9,10]

The use of EBP in ICU also highlights the need for collaboration between ICU and hospital stakeholders to ensure interdisciplinary consultation is performed, with the commitment to improve practice.[22] Performing interdisciplinary consultation ensures that change of practice interventions undergo rigorous evaluation and are updated regularly to accommodate new findings and recommendations to practice.

1.3 | Rationale

Recent advancements in infection prevention and control, the need to appropriate health care costs on interventions rooted in evidence and the evolving guidelines from organizations have led to a re-evaluation of routine procedures.[21,22] Aligning local practices to available evidence aims to enhance patient safety, optimize resource allocations in the ICU, contribute to a broader discourse in EBPs and uphold standards of care. In the context of this project, the need to reassess routine procedures is not only driven by infection prevention and control perspectives, but also by the management of costs and human resources, especially in the ICU where resource utilization is higher compared with other clinical areas. This is particularly relevant in the ICU where optimizing the use of supplies such as 0.9% sodium chloride solutions and nursing time can considerably impact both financial prioritization of care and work satisfaction outcomes.

TABLE 1 Study population, methods of analysis, key findings and recommended practice.

Author (year)	Population	Study type	Key findings	Recommendations for change of flush solutions
Covey et al. (1988)[14]	$N = 30$ critically ill patients who required invasive pressure monitoring	Descriptive, primary	• Group I: change of flush solution and pressure monitoring tubing every 24 h • Group II: change of flush solution every 24 h and change of pressure monitoring tubing every 48 h • Group III: change of flush solution and pressure monitoring tubing every 48 h. • All flush solution cultures were negative for growth. Incidence of catheter-related bacteraemia was zero. • The results of this pilot study suggest that there is no difference in the incidence of catheter-related infection whether the change interval for flush solution and pressure monitoring tubings is 24 or 48 h.	• Change every 48 h.
O'Malley et al. (1994)[15]	$N = 333$ monitoring kits/ lines cultured	Descriptive, primary	• Fluid samples were obtained from the proximal stopcock of the monitoring kits every 24 h, beginning with a sample at 72 h and continuing until either the plasticware or catheter was changed or discontinued. • Of 451 intervals in which the system remained unviolated for ≥96 h except for sampling, no positive cultures were found. • Of the 333 monitoring kits/ lines in the study, four cultures became positive within 48 h of a violation of the system (flush bag change). • Positive cultures were obtained from two different patients, one patient having positive fluid cultures from arterial, central venous and pulmonary arterial kits. This bacterial growth would not have been eliminated with routine system changes as it occurred within a 48-hr timeframe.	• Change every 96 h. • Invasive hemodynamic pressure monitoring systems including tubing and plasticware need not be changed routinely as these changes may cause a higher incidence of contamination because of increased violations of the systems.
McLane et al. (1998)[16]	$N = 76$ critically ill adult patients	Descriptive, primary	• Specimens were obtained for culture before each flush solution change per group assignment (48 or 72 h). All flush solutions for arterial line catheters and pulmonary artery catheters were negative for contamination for the 48-and 72-h group, respectively.	• Change every 72 h.
Centers for Disease Control and Prevention (2011)[10]	N/A	Practice recommendations	• Studies informing the guideline focused on frequency/ interval of changing administration/transducer sets[12,18,19] and source of basis of recommendation specific to intervals of changing flush solutions cannot be located. • Made recommendation to change pressure monitoring systems (including flush solutions) every 96 h.	• Change every 96 h. • Category IB – "Strongly recommended" for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; or an accepted practice (e.g., aseptic technique) supported by limited evidence.
Daud et al. (2013)[17]	N/A; reviewed the study by Covey et al. (1988)[14]	Systematic review	• See Covey et al. (1988)[14] and used CDC[10] recommendations in the discussion.	• This study reviewed the study of Covey et al. (1988)[14] which only tested up to 48 h. The other studies reviewed did not specify on flush solutions; however, the authors advised to follow CDC (2011)[10] recommendations.
Gorski et al. (2021)[11]	N/A; reviewed the study by Daud et al. (2013)[17]	Practice recommendations	• Used the systematic review performed by Daud et al. (2013).[17]	• Change every 96 h, including other components, immediately when contamination is suspected, or when there is a compromise on the system/product.[11]

1.4 | Specific aims

The specific aim of this quality improvement (QI) project was to implement a change of practice based on the available evidence by critically reviewing the available evidence on the safety and efficacy of changing flushing solutions of CVLs and ALs at different intervals.

2 | METHODS

2.1 | Context

The presentation of this QI report was in line with the Standards for Quality Improvement Reporting Excellence 2.0 guidelines.[23]

2.1.1 | The PDSA cycle

The Plan-Do-Study-Act (PDSA) cycle of QI process and the principles of implementation science were utilized in the implementation of this project.[24,25] PDSA is a QI model used for developing, testing and implementing changes that can lead to improvement.[24] The PDSA cycle is also known as a Deming wheel, named after William Edwards Deming, a statistician and a consultant in the field of quality management.[24] Over the years, the PDSA cycle has been used in QI initiatives in health care.[26] Principles of implementation science[25] such as evidence assessment, stakeholder engagement, economic evaluation and end-user feedback were embedded in the PDSA cycle (Figure 1).

Following the PDSA methodology, the *plan* phase (November 2022 – March 2023) involved narrative literature review and stakeholder consultation. The implementation of the change then followed with the *do* phase (March 2023 – March 2024) through bedside education, meetings and email communication. During the *study* phase (March 2023 – March 2024), monthly incidence rates of BSIs associated with the use of CVL and ALs were monitored. The *act* phase (March 2024 – present) focuses on identifying areas for improvement and initiating a unit-based protocol to reflect the change.

2.1.2 | Stakeholder consultation

Findings were presented to ICU nursing and medical leaders for review. Benchmarking of practice was performed with other hospitals through email groups of clinical nurse consultants in Queensland, Australia, and other overseas hospitals in Asia and North America. Follow-up consultations were undertaken with QI project officers, vascular access clinical nurse consultant, pharmacist, infection management team, a product representative and ICU staff nurses for feedback and insights. Observing these processes and procedures enables a guided approach to achieving the aims of the project.

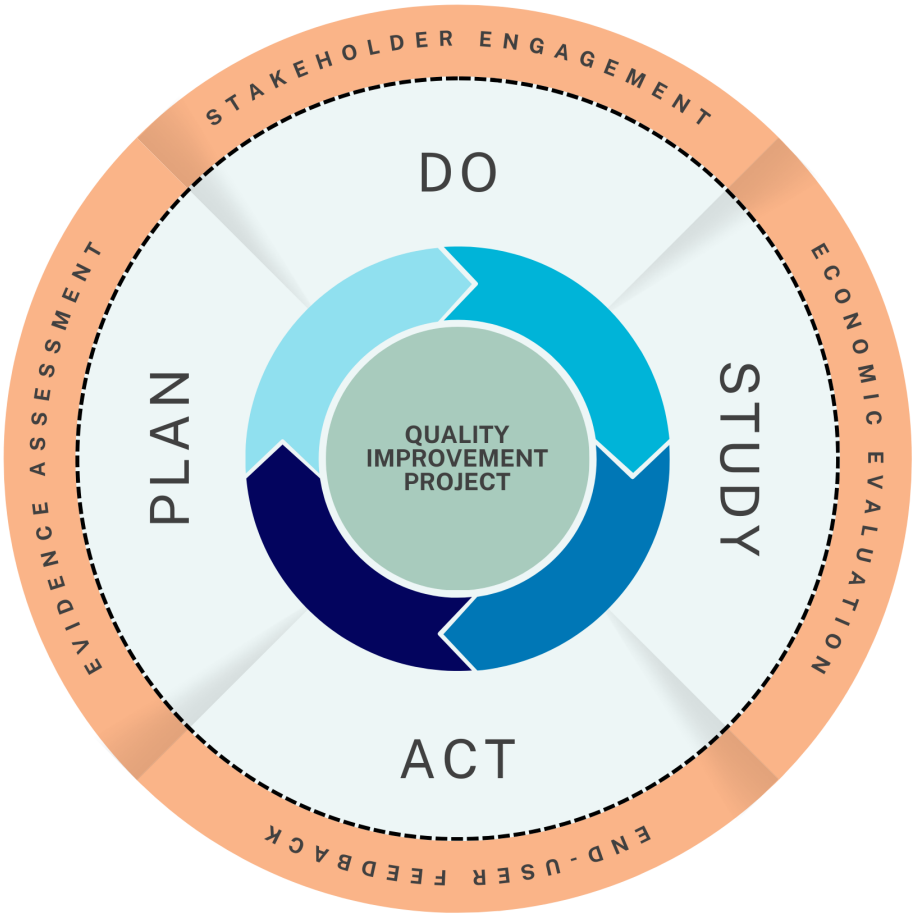

FIGURE 1 Deming wheel (Plan-Do-Study-Act cycle) of quality improvement embedded with implementation science principles.

2.2 | Intervention

Following approval in line with the results of the narrative literature review and the lack of evidence supporting the practice in our local ICU of changing flushing solutions every 24 h, a practice change of increasing the interval of changing saline flushing solutions to every 96 h was implemented on 15 March 2023.

2.3 | Study of the interventions

Following the PDSA cycle of the QI process, cases of BSIs associated with CVL and/or AL were monitored monthly within 1 year of the implementation period using the central monitoring system of the health service for BSIs. Verification of findings was conducted by the infection management service in the health service, which also monitors and investigates BSI cases for all patients. Cost implications of the practice change were reviewed.

2.4 | Measures

A two-item, open-ended post-implementation online survey was undertaken seeking end-user feedback, particularly perspectives surrounding the practice change (focusing on its impact on the delivery of care) and areas for improvement. A guideline document was initiated for publication internally to reflect the change of practice.

2.5 | Analysis

An economic analysis[27] limited to 0.9% sodium chloride flush bags only was performed to assess potential savings. Post-implementation online survey results were analysed using textual analysis.[28]

2.6 | Ethical considerations

This project received approval for ethical exemption from Metro North B Human Research Ethics Committees (EX/2024/MNHB/103416) on 9 February 2024 because of the intent to publish. Oversight of the project was managed by local QI project officers in the health service.

3 | RESULTS

3.1 | Results

Benchmarking of practices in ICUs in Queensland, Australia and overseas revealed variable practices, with intervals of changing CVL and AL flushing solutions between 24 h and 7 days. After the literature review, and consultation with and approval from stakeholders, a change of practice was implemented for a 1-year study period (March 2023 – March 2024). During this period, the ICU had 1343 patient admissions. The number of individual CVL and AL days was not captured as a priority. A simplified economic analysis was performed based on per patient saving on costs of 0.9% sodium chloride 500-mL fluid bags. The analysis revealed that changing the fluid bags once every 96 h resulted in a per patient saving of AU$3.21 for any individual AL or CVL, and up to AU$6.42 per patient where both an AL and CVL are in situ, based on fluid bag cost at AU$1.07 per bag (Appendix I: Table S1). This saving excludes potential savings from reduced nursing time, infection-related costs and recycling costs associated with the use of plastic saline flush bags.

Within the one-year intervention period, there were no recorded cases of BSIs associated with CVL and/or AL use (with two cases within 1 year prior to the intervention). Because of the nature of BSIs being multifactorial, and the relatively small sample size at a single site, any observed differences in BSI rates could not be attributed to the intervention; thus, the identification of statistical significance was precluded. Post-implementation survey indicated end-user satisfaction, saved nursing time, cost savings, lower risk for infections and suggestions for continuity and improvement. Compliance measures were also recommended, such as regular audits, adding dates and times when changing bags and utilizing 1-L 0.9% sodium chloride bag solution in a one-litre pressure bag for patients who required frequent blood sampling and flushes, for example, frequent monitoring of arterial blood gases.

4 | DISCUSSION

4.1 | Summary

The central focus of this QI project was on the interval of changing the 0.9% sodium chloride flushing solutions for CVLs and ALs, not the transducing administration sets of these lines, as the current practice in the local ICU was already in line with the latest evidence suggesting safety and efficacy for extended dwell times for transducing administration sets.[29] The primary recommendation of this QI project is to continue the EBP of changing the 0.9% sodium chloride flush bags for CVLs and ALs every 96 h beyond the *study* phase of the PDSA cycle. This recommendation is supported by the reviewed evidence and zero cases of BSIs associated with the use of CVLs and ALs during the intervention period. The recommendation from this QI supports the conservation strategies and the call for fluid stewardship, particularly in light of the recent concerns about the shortage of intravenous fluids in Australia.[30] Unless new robust evidence arises, continuing the new practice will ensure that, in the long term, it is cost-effective by reducing the use of resources, saving nursing time and minimizing contamination risk from unnecessary daily flush bag changes, which may break the sterility of CVL and AL systems.

In 2024, the Infusion Nurses Society[9] published new recommended standards of practice in changing sets and solutions, and highlighted the recent randomized controlled trial (RCT) by Rickard

et al. (2021).[29] While the study by Rickard et al. (2021)[29] demonstrated high-level evidence for the safety of longer dwell times of transducing administration sets up to 7 days, it did not directly focus on the safe intervals for changing flushing solutions of CVLs and ALs, which is the central focus of this QI project. Our ICU setting had already implemented the longer dwell times for transducing administration sets up to 7 days prior to the conduct of this QI, consistent with the findings by Rickard et al. (2021)[29] and practices in some hospitals in Australia, as reported in a recent point prevalence survey.[7] It is, however, strongly suggested to regularly review evidence and align clinical practice with current best practice recommendations emanating from research.

4.2 | Interpretation

The application of implementation science principles on this small project within the PDSA cycle has strengthened the implementation of this project. The conduct of evidence assessment was integral in the uptake of the idea to the stakeholders and end-users. This included consultations with nursing and medical ICU leaders, vascular access team, pharmacist, infection control practitioners and QI project officers to ensure that the project is feasible and well-supported by stakeholders involved. Employing these principles within the PDSA cycle ensures that changes can be dynamic and adaptable, especially when new evidence warrants another change, and effectively integrates new evidence in practice.[24] Another strength of this project is the conduct of economic evaluation, which is another implementation science principle.[25]

4.3 | Limitations

The performance of economic analysis was limited only to per patient savings associated with the use of 0.9% sodium chloride flushing solutions for the transducing administration sets of CVLs and ALs, with potential costs for saved nursing time, potential savings from BSIs and recycling costs not appropriated. Another limitation is the dearth of studies surrounding this topic of interest, with no recent primary studies available. This limitation underscores the need for rigorous methodologies employing robust research such as RCTs to examine evidence. The conduct of this project at a single site and the lack of a large cohort are also limitations.

4.4 | Recommendations for future research

With recent research and practices employing longer dwell times of CVL and/or AL infusion sets up to 7 days,[7,29] future research studies should prioritize using RCTs to produce higher quality evidence and to specifically include intervals of flush bags of these lines changes to ensure reliability, consistency and generalizability of evidence. As there are other potential cost savings not recognized in this project, such as time and experiences of registered nurses, and costs associated with line infections and recycling of plastic bags, future research in these areas is recommended.

5 | CONCLUSION

A practice change of increasing the interval of changing 0.9% sodium chloride flushing solutions for CVLs and ALs lines from every 24 h to every 96 h was implemented on 15 March 2023 in our ICU based on the review of evidence that supports this practice. One year post-implementation, the evaluation suggests that extending the interval of changing 0.9% sodium chloride flushing solutions in these invasive lines may not only be safe, but also beneficial from resource utilization, patient safety, care prioritization and cost-effectiveness perspectives. Primary studies using rigorous methodologies like RCTs are strongly recommended to gather more evidence on the safety and efficacy of longer dwell times, particularly including intervals of flush bag changes.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this project are available from the corresponding author upon reasonable request.

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ORCID

Junel Padigos https://orcid.org/0000-0002-0937-838X
Lauren Murray https://orcid.org/0000-0002-7567-1525
Olivia Bredhauer https://orcid.org/0009-0002-3956-1940
Jenny Jaspers https://orcid.org/0009-0001-7933-7620
Sue Bethune https://orcid.org/0000-0002-9494-3709

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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