International Journal of Nursing Studies 148 (2023) 104604

Contents lists available at ScienceDirect

International Journal of Nursing Studies

journal homepage: www.elsevier.com/locate/ns

The impact of a structured assessment and decision tool (I-DECIDED®) on improving care of peripheral intravenous catheters: A multicenter, interrupted time-series study

Gillian Ray-Barruel [a,b,c,d,e,f,g,*], Vineet Chopra [d,h,i], Paul Fulbrook [j,k,l], Josephine Lovegrove [a,b,c,j,m], Gabor Mihala [n], Michael Wishart [o], Marie Cooke [d,e], Marion Mitchell [e], Claire M. Rickard [a,b,c,d,e,m]

[a] School of Nursing, Midwifery and Social Work, The University of Queensland, Brisbane, Queensland, Australia
[b] Herston Infectious Diseases Institute, Metro North Health, Brisbane, Queensland, Australia
[c] UQ Centre for Clinical Research, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia
[d] Alliance for Vascular Access Teaching and Research (AVATAR), Griffith University, Brisbane, Queensland, Australia
[e] School of Nursing and Midwifery, Griffith University, Brisbane, Queensland, Australia
[f] Menzies Health Institute Queensland, Griffith University, Brisbane, Queensland, Australia
[g] Queen Elizabeth II Jubilee Hospital, Brisbane, Queensland, Australia
[h] The Michigan Hospital Medicine Safety Consortium, Ann Arbor, MI, United States of America
[i] Department of Medicine, University of Colorado Anschutz Medical Campus, Aurora, CO, United States of America
[j] Nursing Research and Practice Development Centre, The Prince Charles Hospital, Chermside, Queensland, Australia
[k] School of Nursing, Midwifery & Paramedicine, Faculty of Health Sciences, Australian Catholic University, Banyo, Queensland, Australia
[l] Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa
[m] National Health & Medical Research Council Centre for Research Excellence in Wiser Wound Care, Menzies Health Institute Queensland, Griffith University, Australia
[n] Centre for Health Services Research, The University of Queensland, Translational Research Institute, Woolloongabba, Queensland, Australia
[o] Infection Prevention and Control, St Vincent's Private Hospital Northside, Brisbane, Queensland, Australia

ARTICLE INFO

Article history:
Received 24 February 2023
Received in revised form 1 September 2023
Accepted 4 September 2023

Keywords:
Assessment, intravenous
Decision making
Documentation
Intravenous catheter, peripheral
Idle catheters

ABSTRACT

Background: Peripheral intravenous catheters are the most widely used invasive device in hospitals but have serious risks.
Objective: To determine if a structured assessment and decision tool (I-DECIDED®) improves daily peripheral intravenous catheter assessment and care decisions.
Design: Prospective, interrupted time-series study.
Settings: Seven adult inpatient wards in three Australian hospitals.
Participants: 825 adults with 867 peripheral intravenous catheters.
Methods: Between August 2017 and December 2018, peripheral intravenous catheter assessments and chart audits were undertaken with informed patient consent. Following a 4-month pre-intervention period (with 2-weekly measures), the I-DECIDED® tool was implemented over 3 months (no data collection) using multiple strategies (stakeholder meetings, vascular access device form, education sessions, ward champions, lanyard cards, and posters), followed by a 4-month post-intervention period (with 2-weekly measures). Primary outcomes were device utilization (number of peripheral intravenous catheters per total number of patients screened); idle/unused catheters; insertion site complications, substandard dressing quality; and primary bloodstream infections.
Results: Of 2055 patients screened, 1175 (57.2%) had a peripheral intravenous catheter, and 825 patients (867 catheters) consented and were included in the final analysis. Device utilization increased from 42.0% of catheters at baseline to 49.6% post-intervention (absolute risk difference [ARD] 7.5%, 95% confidence interval [CI] 4.8, 10.3; relative risk [RR] 1.18, 95% CI 1.11, 1.25; $p < 0.001$). The proportion of idle catheters reduced from 12.7% to 8.3% (ARD −4.4%, 95% CI −8.5, −0.3; RR 0.66, 95% CI 0.44, 0.97; $p = 0.035$). Peripheral intravenous catheter complications reduced from 16.1% to 10.9% (ARD −5.2%, 95% CI −9.7, −0.6; RR 0.68, 95% CI 0.48, 0.96; $p = 0.026$). Substandard dressings reduced from 24.6% to 19.5% (ARD −5.2%, 95% CI −10.7, 0.4; RR 0.79, 95% CI 0.61, 1.02; $p = 0.067$). Only one primary bloodstream infection occurred (post-intervention).
Conclusions: Implementation of a comprehensive device assessment and decision tool (I-DECIDED®) reduced idle catheters and catheter complications, despite higher device utilization. Dressing quality improved but was

* Corresponding author at: School of Nursing, Midwifery and Social Work, University of Queensland, Herston Infectious Diseases Institute, Metro North Hospital and Health Service, Level 3, Building 71/918, UQ Centre for Clinical Research, RBWH Campus, Herston, QLD 4029, Australia.
E-mail addresses: g.raybarruel@uq.edu.au (G. Ray-Barruel), vineet.chopra@cuanschutz.edu (V. Chopra), c.rickard@uq.edu.au (C.M. Rickard).

https://doi.org/10.1016/j.ijnurstu.2023.104604

not statistically significant. Further implementation of the tool could improve hospital safety for patients with an intravenous catheter.
ANZCTR trial registration: ACTRN12617000067370.
Date of registration 13 January 2017. Date of first data collection 3rd August 2017.
Tweetable abstract: #IDECIDEDassessment reduces prevalence of idle peripheral catheters and device complications.

What is already known

- Idle peripheral intravenous catheter rates have been reported as high as 50% in some studies and represent an avoidable source of patient harm.
- Over one-third of patients with a peripheral intravenous catheter experience site complications and device failure prior to treatment completion.
- Peripheral intravenous catheter documentation is reportedly missing in 20–25% of patient charts.

What this paper adds

- The I-DECIDED® tool distils the evidence-based guidelines for peripheral intravenous catheters into a simple mnemonic to guide point-of-care assessment and decision making.
- Implementation of the I-DECIDED® tool in three Australian hospitals resulted in a 4.4% reduction in idle peripheral intravenous catheters and a 5.2% decrease in catheter site complications.
- Nursing documentation of peripheral intravenous catheters improved by 44.5% from baseline, but compliance varied considerably between hospitals.

1. Background

Peripheral intravenous catheters are the most widely used invasive device worldwide, with an estimated one billion used each year (Alexandrou et al., 2018). Due in part to their ubiquity within hospital settings, peripheral intravenous catheters are often treated with benign neglect (Bourgault et al., 2021). Healthcare-associated infections acquired during hospitalization, including those attributable to peripheral intravenous catheters, are high-priority complications, given that the risk of occurrence may be reduced with the use of clinical mitigation strategies (Australian Commission on Safety and Quality in Health Care, 2021). Yet, errors of omission (or missed care), which have the potential to result in such complications, are common in hospitals and thus are a recognized threat to quality of care and patient safety (Jones et al., 2015; Kalisch and Xie, 2014). In relation to peripheral intravenous catheter care, a survey of over 4000 direct care registered nurses reported that insertion site care and site assessments were occasionally or frequently missed (28.2% and 6.8% respectively) (Kalisch et al., 2014), and multiple audits have shown that peripheral intravenous catheter documentation is incomplete or missing in 20–50% of patient records (Aghdassi et al., 2019; Alexandrou et al., 2018; Berger et al., 2022; Høvik et al., 2020).

The lack of documented assessment may contribute to the high prevalence of idle catheters, with reports that between 14 and 50% of peripheral intravenous catheters are left *in situ* 'just in case' they might be needed (Becerra et al., 2016; Bourgault et al., 2021; Evison et al., 2021; Gledstone-Brown and McHugh, 2018). This poses an unacceptable risk of bloodstream infection (Mermel, 2017)—believed to rival central line-associated bloodstream infection in the volume of patients affected (Tatsuno et al., 2019)—with serious implications for morbidity, mortality, and high hospital and personal costs (Sato et al., 2017). Fear of *S. aureus* bacteraemia, with its high mortality rates, has raised concerns about peripheral intravenous catheter length of time *in situ*, with many hospitals retaining routine replacement policies rather than adopting evidence-based clinically indicated removal (Webster et al., 2019). Both approaches have been recommended as peripheral intravenous catheter replacement options for Australian healthcare facilities, with national infection control guidelines recommending replacement every 72 h or as clinically indicated in facilities with regular monitoring for catheter-associated bloodstream infection, comprehensive peripheral intravenous catheter documentation with proven daily assessment documentation compliance, and compliance with insertion and management competencies (Australian Commission on Safety and Quality in Health Care, 2021). Nonetheless, reported rates of idle catheters (defined as not used in the previous 24 h and no plans for use in the next 24 h (Ray-Barruel et al., 2018)) remain unacceptably high, suggesting that clinicians are unclear about clinical criteria justifying peripheral intravenous catheter removal.

Traditionally, peripheral intravenous catheter assessment has concentrated on phlebitis detection, but this approach may be insufficient (Rickard and Ray-Barruel, 2017), as device failure may result from a range of additional causes, including dislodgement, infiltration, extravasation, occlusion, and infection (Marsh et al., 2021). Indeed, a recent secondary analysis of 12 prospective studies including 11,830 peripheral intravenous catheters identified that 36% of catheters failed before treatment completion and over one-third of patients with a peripheral catheter experienced painful complications (Marsh et al., 2021). Catheter dressing and securement remains a common problem leading to device failure; a global prevalence study identified 21% of peripheral intravenous catheter dressings as loose or lifting (Alexandrou et al., 2018). Device failure prior to treatment completion leads to delays in delivery of intravenous therapy, the need for insertion of more invasive devices, increased hospital costs and staff time, and a diminished patient experience (Marsh et al., 2021). These figures indicate room for improvement in nursing assessment and care of peripheral intravenous catheters, particularly earlier identification of risk factors for complications or infection, such as idle catheters, early signs of insertion site complications, and poor dressing integrity. Improved catheter assessment and decision-making could prompt removal of idle catheters, alert the caregiver to early signs of complications, and lead to improved patient outcomes, reduced risk of bloodstream infection, and decreased hospital costs (Ray-Barruel and Alexander, 2023; Ray-Barruel et al., 2018).

Evidence-based guidelines and clinical practice standards exist to guide local hospital policies and procedures for peripheral intravenous catheter management (Australian Commission on Safety and Quality in Health Care, 2021; Denton et al., 2016; Gorski et al., 2021; Loveday et al., 2016; O'Grady et al., 2011), but these are often lengthy and not always available at the point of care (Rickard and Ray-Barruel, 2017). To address the reported high prevalence of idle catheters and common shortfalls with assessment, care and documentation, the lead author developed I-DECIDED®, an evidence-based, point-of-care, mnemonic tool to prompt and guide catheter assessment and subsequent clinical decision-making around management and removal (Ray-Barruel et al., 2018).

The aim of this study was to implement and evaluate the effectiveness of the I-DECIDED® tool for peripheral intravenous catheter assessment and decision tool in three Australian hospitals. Specifically, this quality improvement initiative aimed to determine if using the tool could improve daily nursing assessment and decision-making, to improve peripheral intravenous catheter care and outcomes.

2. Methods

2.1. Study design and context

A quasi-experimental, interrupted time-series study was conducted between August 2017 and December 2018. The study protocol was published *a priori* (Ray-Barruel et al., 2018). Interrupted time-series studies with multiple time-points pre- and post-implementation are useful in the context of this study as they can identify trends over time (Hudson et al., 2019; Penfold and Zhang, 2013). Three adult metropolitan hospitals in southeast Queensland, Australia (two public teaching hospitals and one private hospital; 663, 175, and 227 beds, respectively) participated in the study. Data were collected over 16 two-weekly time-points at each hospital, to enable assessment of linear time trends independent of the intervention, and to assess as many peripheral intravenous catheters as possible. Participating wards included three medical, three surgical, and one infectious disease ward. Each hospital participated in the study for 11 months, although study commencement dates varied between sites due to local approval processes (see Supplementary Table 1).

Prior to the implementation of the tool, documentation of peripheral intravenous catheter insertion, assessment and removal differed somewhat at each facility (see Supplementary Table 2). In two hospitals, all peripheral catheters were inserted by general hospital medical staff or nurses (not vascular access teams), whereas in the third they were inserted by pathology service technicians. All hospitals used paper-based charts to record peripheral catheter information (insertion, removal, phlebitis score); one had a dedicated vascular access device form. All hospital policies mandated peripheral intravenous catheter replacement at 72–96 h, or as clinically indicated for patients with difficult intravenous access with the specific approval of a medical officer documented in the patient's chart.

2.2. Participants and sample size

Adult participants over 18 years with a peripheral intravenous catheter *in situ* on each day of data collection were eligible for inclusion. Exclusion criteria included patients unable to communicate in English, admitted for palliative treatment, or on a care of the dying pathway (see Supplementary Fig. 1). The original ethical approval required written patient consent, however, within the first month of the study, an amendment was approved for verbal consent after many patients stated that they were happy to participate but did not want to sign a consent form.

Sample size is not calculated for interrupted time-series analyses because power increases with more data time-points and number of observations (Wagner et al., 2002). Therefore, all eligible participants who consented during the data collection periods were included in the study.

2.3. Instrument

The tool comprises eight categories based on international best practice guidelines and recommendations (Australian Commission on Safety and Quality in Health Care, 2021; Denton et al., 2016; Gorski et al., 2021; Loveday et al., 2016; O'Grady et al., 2011), with a reminder to always consider local policy and consult with the multidisciplinary team and patient, as required.

- Identify if a device is *in situ*. If an intravenous catheter has been removed in past 48 h, observe site for post-infusion phlebitis
- Does the patient need the device? If not used in past 24 h, or unlikely to be used in next 24 h, consider removal. Consider change to oral medications.
- Effective function? Does the catheter infuse and/or flush well? Follow local policy for flushing and locking.
- Complications at insertion site? Assess for pain ≥ 2/10, redness > 1 cm, swelling > 1 cm, discharge, infiltration, extravasation, hardness, palpable cord or purulence.
- Infection prevention. Perform hand hygiene, scrub the hub & allow to dry before each intravenous access. Careful use of administration sets.
- Dressing and securement. Dressings should be clean, dry, and intact. Catheter and lines should be secure.
- Evaluate and educate. Evaluate any patient and family concerns with the catheter. Educate as needed. Discuss catheter plan with patient & family.
- Document your decision. Continue to monitor, troubleshoot as needed, change dressing/securement if needed, or remove the catheter. Replace if necessary.

The tool has previously demonstrated strong content validity and inter-rater reliability for peripheral intravenous catheter assessment, and assessment is relatively quick to complete (average 2 min, range 1–10 min); the measurement properties are reported in full elsewhere (Ray-Barruel et al., 2020).

2.4. Intervention

The I-DECIDED® tool was implemented in each participating ward following a 4-month pre-intervention time period (T1). Understanding and accommodating the unique context of each hospital (and ward) was essential; therefore, the Promoting Action on Research Implementation in Health Services (PARiHS) framework was used to prospectively plan and guide the implementation process (Harvey and Kitson, 2016; Kitson et al., 2008; Rycroft-Malone, 2004). Evidence, context, and facilitation elements used in the implementation are shown in Supplementary Fig. 2.

The implementation included the introduction of a dedicated vascular access device form for nurses to document their peripheral intravenous catheter assessment and subsequent decision to continue, troubleshoot or remove the catheter (see Supplementary Fig. 3). Prior to implementation, consultation was undertaken with key stakeholders, including 30 nurses from across the three hospitals who participated in discussions to provide feedback on the proposed form, with minor changes made accordingly (shading, location of comments section). The form was approved for the trial by the relevant governance committees at each hospital. Nurses in the trial wards documented peripheral intravenous catheters on the vascular access device form instead of the routine forms; however, peripheral catheters inserted by doctors, technicians, or nurses in non-trial areas (*e.g.*, emergency department, operating suite, or non-participating wards) were not documented on the vascular access device form, so nurses in the trial wards had to transcribe those catheter details to the vascular access device form.

In preparation for the rollout, an education program was conducted by the lead author at all sites during in-service sessions following the afternoon shift handover. Twenty-five scheduled 20-minute education sessions, with the lead author explaining the tool and vascular access device form, were attended by 180 staff (registered nurses, enrolled nurses, student nurses, medical officers, and administration staff) across the three hospitals. Pocket-sized lanyard cards displaying the tool were provided to all nurses and medical staff, and extra cards were placed in the nurses' stations and staff rooms alongside posters explaining the study and a sample template of the trial form, with dummy data entered

for instructional purposes. Laminated inserts of the tool were placed in each patient's bedside folder to remind staff to use the tool when performing peripheral intravenous catheter assessment. During the implementation phase, additional education was provided by local champions nominated by the local nurse unit managers for staff who had not attended a formal education session.

2.5. Data collection

Pre-intervention, baseline data were collected for the first 4 months of the study (T1), prior to a 3-month implementation period (T2) during which no data were collected, followed by a 4-month post-intervention period (T3) during which the same baseline data (repeated measures) were collected (see Supplementary Table 1). During T1 and T3, data were collected every two weeks to assess for simultaneous time trends in peripheral intravenous catheter processes and outcomes, and to better understand the effect and sustainability of the intervention. All patient data were de-identified.

A co-investigator (a professor of nursing and two infection prevention clinical nurse consultants) at each hospital nominated a research nurse to assist with local participant enrollment and data collection one day per fortnight. The research nurses were trained in the use of the tool and data collection forms and inter-rater reliability was confirmed, as described elsewhere (Ray-Barruel et al., 2020). During T1 and T3, a research nurse visited participating wards every two weeks to screen all admitted patients for eligibility and the presence of a peripheral intravenous catheter (if patients had multiple co-existing peripheral catheters, all were included). Each patient and catheter was only recruited once to the study. After explaining the purpose of the study and obtaining patient consent, the research nurse visually inspected the peripheral intravenous catheter using the I-DECIDED® tool as a checklist, then audited the patient's chart for the most recent peripheral catheter assessment documented by bedside nursing staff. The assessment and chart audit were recorded on the study data collection form (see Supplementary Fig. 4), replicated in a Research Electronic Data Capture (REDCap) database (Harris et al., 2009) and accessible *via* hand-held electronic devices at the bedside. A sticker was placed in each participating patient's chart, noting that the peripheral catheter had been assessed for the purposes of the study. During T1, as nurses were not yet using the I-DECIDED® tool, there were some minor differences in identification and documentation of *in situ* peripheral catheters (see Supplementary Table 3).

To provide time for familiarity and ensure workflows using the tool were in place, no data were collected during the implementation phase (T2). During the post-intervention phase (T3), data collection resumed, and nurse educators and project champions continued to promote the tool at ward meetings and staff huddles (brief team meetings), encouraging compliance with documentation. Throughout the study, the lead author visited each ward at least monthly and collected field notes to evaluate the implementation process. To understand the local context, bed occupancy data and staffing ratios were collected for each shift of data collection.

2.6. Variables

Primary outcomes included the *device utilization ratio* (number of peripheral intravenous catheters per total number of patients screened) and percentage of patients with an *idle catheter* (peripheral intravenous catheter *in situ* without a clear purpose: *i.e.*, not used in previous 24 h and no projected use in next 24 h); *substandard catheter dressing* (loose, soiled, or moist); *insertion site complications* (pain ≥2 out of the maximum of 10, redness >1 cm from insertion site, swelling >1 cm from insertion site, infiltration, discharge, hardness, palpable cord, or purulence); and *primary bloodstream infection* (National Healthcare Safety Network, 2022), collected from monthly routine infection control surveillance data at each hospital.

Secondary outcomes included: implementation compliance, analyzed using completion rates of peripheral intravenous catheter documentation by nursing staff; staff focus group feedback on the acceptability of the tool and the barriers/facilitators to peripheral catheter assessment (to be reported elsewhere); and proportion of patients verbally reporting that (a) staff had assessed their peripheral catheter that shift, (b) staff had informed them of the reason for their peripheral catheter or plans for intravenous therapy, and (c) the patient felt comfortable in speaking up if they had concerns. Bed occupancy data and staffing ratios were collected on each day of assessment to assess for equivalency of hospital level risk over the time periods of the study.

2.7. Data analysis

Descriptive statistics were used to describe the patient/device/clinical characteristics and outcome measures in the T1 and T3 phases. Differences of characteristics between T1 and T3 were assessed by calculating standardized differences, while changes in outcome measures were presented by using both absolute (risk difference) and relative (risk ratio) indicators and their 95% confidence intervals.

T1 and T3 phases were split into eight separate time-points (distinct group of observations; total 16). The observed outcome proportions were calculated at each time-point and graphed over time, including predicted values obtained by using linear regression. The piecewise logistic regression analyses included several terms required for the analysis of interrupted time series data: (a) a binary term indicating the T1 phase, (b) a binary term indicating the T3 phase, (c) a time variable for the T1 phase with values of −7, −6, −5, −4, −3, −2, −1, and −0.001, (d) a time variable for the T3 phase with values of 0.001, 1, 2, 3, 4, 5, 6, and 7, and a fixed-effect term for hospital. The constant terms were suppressed to allow for phase-specific intercepts to be calculated. We compared primary outcomes in T1 and T3 to assess for change both in their values and in the direction of any change in the values. We tested for differences in the intercepts (the last predicted values of T1 and the firsts of T3) and the slopes of the prediction lines using a linear combination of parameters. Data analysis was performed using Stata (StataCorp. 2021. Release 17. College Station, TX: StataCorp LLC.). A significance level of <0.05 was considered statistically significant. Missing values were not imputed.

2.8. Ethical approval

Human Research Ethics Committee approvals for the study were obtained from the relevant university (Ref. 2017/152) and hospitals (Refs. HREC/17/QPCH/47; 17/28). All participants provided informed consent prior to participation, and the study was conducted in accordance with the Australian Government National Statement on Ethical Conduct in Human Research. The study was registered prospectively: ANZCTR trial registration: ACTRN12617000067370 (Date of registration 13 January 2017. Date of first data collection 3rd August 2017). The results are reported in accordance with the Standards for Quality Improvement Reporting Excellence version 2.0 (SQUIRE 2.0) guidelines (Ogrinc et al., 2008).

3. Results

Between August 2017 and December 2018, out of 2055 screened patients, 1175 (57%) had a peripheral intravenous catheter, and 825 consenting patients with 867 peripheral catheters were included in the final analysis (T1 = 410; T3 = 457) (see Table 1 and Supplementary Fig. 4). More than half of peripheral intravenous catheters were in surgical patients (n = 477, 55%), with catheters placed in the antecubital fossa (n = 335, 41%), with bordered/window transparent dressings (n = 574, 66%), and additional securement with tubular net bandage (n = 295, 34%), non-sterile tape (n = 240, 28%), or none (n = 331, 38%). Clinical and demographic characteristics were similar in T1

Table 1
Patient and device characteristics.

	Pre-intervention	Post-intervention	Standardized difference[a]
Total PIVCs analyzed[b]	410 (47.3%)	457 (52.7%)	
Sites			0.091
Hospital 1	134 (32.7%)	156 (34.1%)	
Hospital 2	161 (39.3%)	191 (41.8%)	
Hospital 3	115 (28.0%)	110 (24.1%)	
Patient population			0.070
Surgical	218 (53.2%)	259 (56.7%)	
Medical	192 (46.8%)	198 (43.3%)	
Insertion site			**0.206**
Antecubital fossa	146 (39.7%)	189 (41.9%)	
Forearm	99 (26.9%)	143 (31.7%)	
Hand	115 (31.2%)	117 (25.9%)	
Other	8 (2.2%)	2 (0.4%)	
Not collected	42	6	
Dressing type			0.083
Bordered/window transparent	272 (66.3%)	302 (66.1%)	
Simple transparent	127 (31.0%)	148 (32.4%)	
Tape only	11 (2.7%)	7 (1.5%)	
Securements			
Securement: tubular net/bandage	123 (30.0%)	172 (37.6%)	**0.162**
Securement: non-sterile tape	109 (26.6%)	131 (28.7%)	0.047
Securement: sterile tape	25 (6.1%)	2 (0.4%)	**0.322**
Securement: other	6 (1.5%)	0 (0.0%)	**0.172**
No added securement	156 (38.0%)	175 (38.3%)	0.005

[a] Values above 0.10 (bold) may be considered as imbalanced.
[b] PIVC = peripheral intravenous catheter.

and T3 for both patients and peripheral intravenous catheters, except minor differences in proportion of surgical patients, insertion site selection, and securements applied. Bed occupancy (>0.90) and registered nurse staffing levels (>0.25 per patient (McHugh et al., 2020)) remained constant throughout the study.

3.1. Primary outcomes

As shown in Table 2, more patients had a peripheral intravenous catheter in T3 compared to T1 (device utilization ratio 0.42 *vs* 0.50; relative risk [RR] 1.18, 95% CI 1.11, 1.25, $p < 0.001$), however the proportion that were idle reduced (12.7% *vs* 8.3%; RR 0.66, 95% CI 0.44, 0.97, $p = 0.035$). The proportion of patients with insertion site complications also reduced from 16.1% (T1) to 10.9% (T3) (RR 0.68, 95% CI 0.48, 0.96, $p = 0.026$). The proportion of substandard dressings decreased from 24.6% to 19.5% (RR 0.79, 95% CI 0.61, 1.02, $p = 0.067$). No peripheral intravenous catheter-associated primary bloodstream infections occurred in T1 and one occurred in T3 in a patient with a peripheral catheter *in situ* for 5 days with medical approval and the completed vascular access device form was noted as evidence that the catheter had been regularly assessed, with no concerns.

3.2. Interrupted time series analysis of trends in the T1 and T3 periods

See Fig. 1. Peripheral intravenous catheter utilization was higher at the beginning of T3 compared to the end of T1 (known as the intercept, $p = 0.001$) with no change in the trend (slope) over time ($p = 0.927$). The proportion of idle catheters and catheters with complications had similar intercepts ($p = 0.429$ and $p = 0.427$, respectively) and slopes ($p = 0.968$ and $p = 0.149$, respectively) at T1 and T3. There was a rise in substandard dressings ($p = 0.021$), but the rate of decline over time was similar ($p = 0.356$).

3.3. Secondary outcomes

The proportion of patients reporting their nurse had assessed their peripheral catheter in the past 8 h increased from 75% in T1 to 87% in T3. The proportion of patients who observed that the nurse had performed hand hygiene and scrubbed the needleless connector prior to catheter access increased (68% to 81% and 70% to 80%, respectively). (See Table 3) With the introduction of I-DECIDED®, all items of catheter documentation improved except 'identify if a peripheral intravenous catheter is *in situ*', which was already high (89% in T1 and 86% in T3, see Table 4).

4. Discussion

In this study spanning three hospitals and 825 patients, implementation of the I-DECIDED® tool led to important benefits. There was a one-third (RR 0.66) reduction in the incidence of idle peripheral intravenous catheters, in addition to a one-third (RR 0.68) reduction in catheter complications: both clinically and statistically significant findings. These improvements occurred despite an overall increase (relative 120%) in device utilization (*i.e.*, more patients had peripheral intravenous catheters overall). While the time-trend analysis detected a rise in the incidence of substandard dressings in T3, the relative and absolute differences indicated a likely overall reduction; a larger study would be needed to confirm this effect. Peripheral intravenous catheter-associated bloodstream infection rates remained extremely low throughout the study.

The pre-intervention period showed differences between hospitals in idle catheter prevalence, but all hospitals reduced their idle catheter rates following the implementation, suggesting the intervention was consistently effective and thus can be recommended for other hospitals. By comparison, reported idle catheter rates range between 16% and 50% (Becerra et al., 2016; Gledstone-Brown and McHugh, 2018). Neglecting the removal of idle catheters is a risk factor for adverse patient outcomes including bloodstream infection, therefore several implementation studies have attempted to tackle the problem of idle catheters. A de-implementation study in the Netherlands reported an absolute reduction of 6.7% in idle peripheral intravenous catheters following an educational initiative to raise staff awareness of the need to remove unnecessary lines (Laan et al., 2020). Of course, avoiding cannulation in the first place should always be considered. A study in an Australian emergency department demonstrated a reduction in peripheral

Table 2
Primary outcomes.

	N	Pre-intervention	Post-intervention	Difference (95% CI)	Ratio (95% CI)	Significance p
Device utilization ratio	4954	1052/2502 (0.420)	1216/2452 (0.496)	**7.5% (4.8, 10.3)**	**1.18 (1.11, 1.25)**	**<0.001**
PIVC idle	867	52 (12.7%)	38 (8.3%)	**−4.4% (−8.5, −0.3)**	**0.66 (0.44, 0.97)**	**0.035**
Substandard dressings	867	101 (24.6%)	89 (19.5%)	−5.2% (−10.7, 0.4)	0.79 (0.61, 1.02)	0.067
Complications	867	66 (16.1%)	50 (10.9%)	**−5.2% (−9.7, −0.6)**	**0.68 (0.48, 0.96)**	**0.026**
Infection	867	0 (0.0%)	1 (0.2%)	0.2% (−0.2, 0.6)	n/c	

PIVC = peripheral intravenous catheter; CI = confidence interval; n/c = cannot be calculated; bold = statistically significant.

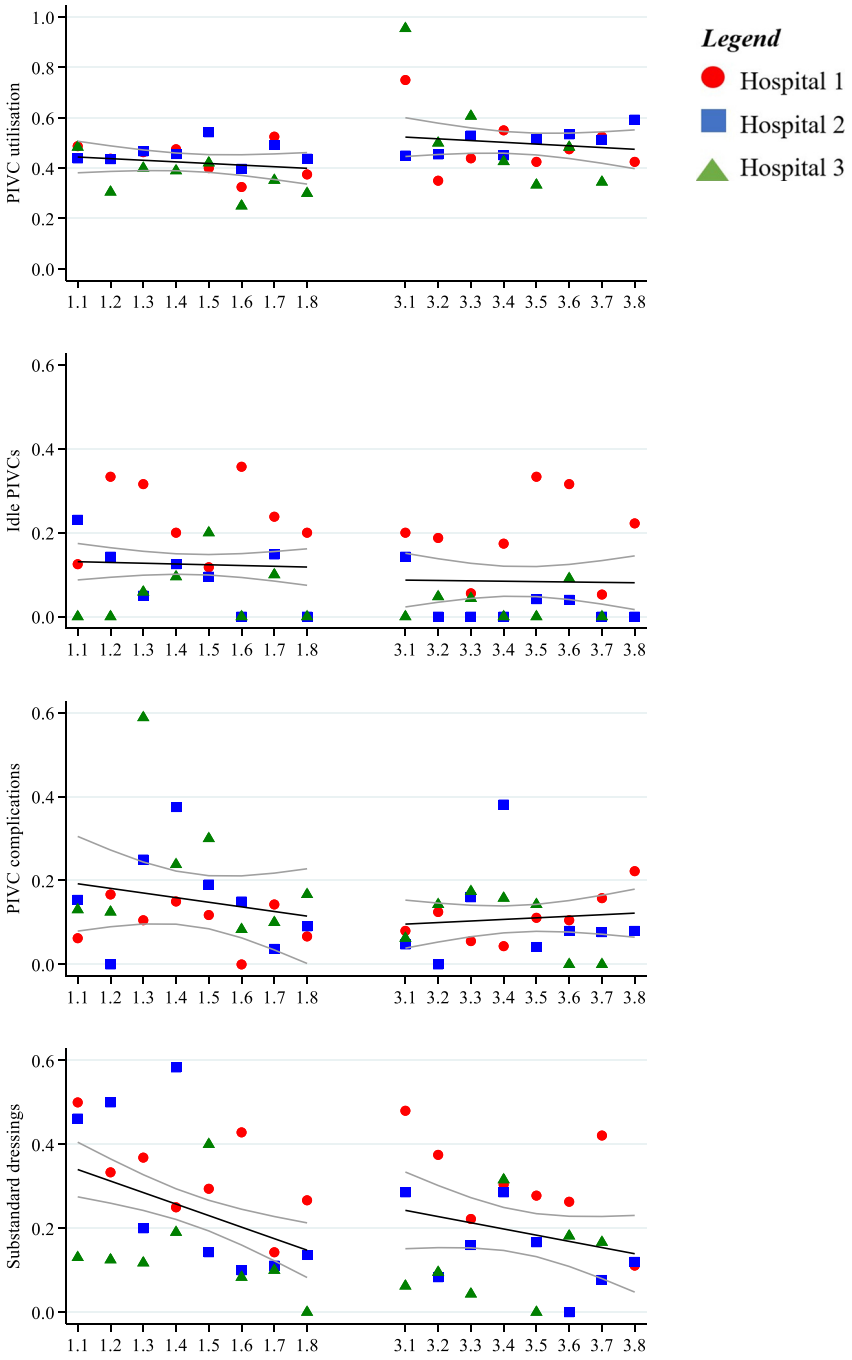

Fig. 1. Interrupted time series analysis of primary outcomes (proportions) between study phases T1 and T3 (including prediction lines and their 95% confidence bounds).

intravenous catheter placement following an initiative to remind staff to consider device necessity prior to inserting a catheter (Hawkins et al., 2018).

Despite improved peripheral intravenous catheter assessment, site complications were still experienced by 11% of patients during the post-intervention period; however, this improved from baseline (16%) in the pre-post analysis. The flattening of the over-time trend in complications is probably due to the values already relatively low, *i.e.*, less likely to keep getting lower from this intervention alone. By improving the quality of nursing assessment and documentation it is possible that more complications were detected and recorded. This is a beneficial effect if it heightens awareness and action to resolve complications. The most common site complications were pain alone or as a composite measure of phlebitis.

Our findings were inconclusive for substandard dressings. The 5% absolute average decrease post-intervention suggested that the increased focus on catheter assessment led to improved dressing quality. However, the interrupted time-series analysis found more dressings were substandard immediately after the intervention (possibly due to improved assessment), as well as an underlying decreasing trend over both periods which suggests there was already a tendency to improved dressing quality occurring independently of the study. A larger study may confirm the beneficial effect of I-DECIDED® on dressing quality, but regardless, the overall prevalence of substandard dressings remained unacceptably high (19%) post-intervention, indicating this is an ongoing and important issue. Despite the wide range of dressing and securement products available, intravenous catheter dressing integrity is an ongoing concern worldwide due to infection and

Table 3
PIVC assessment findings using the I-DECIDED® tool.

	Pre-intervention $N = 410$	Post-intervention $N = 457$	Difference (95% CI)	Ratio (95% CI)
IDENTIFY if a PIVC is *in situ*				
Insertion date documented (in chart or on dressing)	384 (93.7%)	428 (93.7%)	−0.0% (−3.3, 3.2)	1.00 (0.97, 1.04)
Insertion time documented	159 (38.8%)	268 (58.6%)	**19.9% (13.3, 26.4)**	**1.51 (1.31, 1.75)**
Name or position of inserter documented	222 (54.1%)	309 (67.6%)	**13.5% (7.0, 19.9)**	**1.25 (1.12, 1.39)**
DOES the patient need this PIVC?				
PIVC has been used or likely to be used within 24 h	358 (87.3%)	419 (91.7%)	**4.4% (0.3, 8.5)**	**1.05 (1.00, 1.10)**
No obvious use	52 (12.7%)	38 (8.3%)	−4.4% (−8.5, −0.3)	0.66 (0.44, 0.97)
EFFECTIVE function?				
IV infusion running or PIVC flushed (no concerns)	322 (78.5%)	383 (83.8%)	**5.3% (0.1, 10.5)**	**1.07 (1.00, 1.14)**
Unknown (not flushed, not infusing in past 8 h)	88 (21.5%)	71 (15.5%)	**−5.9% (−11.1, −0.7)**	**0.72 (0.55, 0.96)**
Catheter blocked	0 (0.0%)	3 (0.7%)	0.7% (−0.1, 1.4)	n/c
COMPLICATIONS or CONCERNS?				
Insertion site clearly visible	371 (90.5%)	440 (96.3%)	**5.8% (2.5, 9.1)**	**1.06 (1.03, 1.10)**
No clinical symptoms	344 (83.9%)	407 (89.1%)	**5.2% (0.6, 9.7)**	**1.06 (1.00, 1.12)**
Patient-reported pain ≥2 out of max. 10	18 (4.4%)	21 (4.6%)	0.2% (−2.6, 3.0)	1.05 (0.57, 1.94)
Redness >1 cm from insertion site	16 (3.9%)	9 (2.0%)	−1.9% (−4.2, 0.3)	0.50 (0.23, 1.13)
Swelling >1 cm from insertion site	7 (1.7%)	1 (0.2%)	**−1.5% (−2.8, −0.2)**	**0.13 (0.02, 1.04)**
Discharge or purulence at site	3 (0.7%)	7 (1.5%)	0.8% (−0.6, 2.2)	2.09 (0.54, 8.04)
Hardness at site	0 (0.0%)	2 (0.4%)	0.4% (−0.2, 1.0)	n/c
Phlebitis (pain, redness, swelling, purulence, or hardness)	35 (8.5%)	38 (8.3%)	−0.2% (−3.9, 3.5)	0.97 (0.63, 1.51)
Infiltration (IV fluid in tissues)	0 (0.0%)	1 (0.2%)	0.2% (−0.2, 0.6)	n/c
Itch	3 (0.7%)	0 (0.0%)	n/c	n/c
Dislodgement	1 (0.2%)	0 (0.0%)	−0.2% (−0.7, 0.2)	n/c
Other (bruising)	2 (0.5%)	1 (0.2%)	−0.3% (−1.1, 0.5)	0.45 (0.04, 4.93)
INFECTION prevention (as reported by patient)				
Nurse performed hand hygiene prior to PIVC access	279 (68.0%)	368 (80.5%)	**12.5% (6.7, 18.3)**	**1.18 (1.09, 1.28)**
Nurse scrubbed the hub and allowed it to dry	286 (69.8%)	364 (79.6%)	**9.9% (4.1, 15.7)**	**1.14 (1.06, 1.24)**
Patient unsure if nurse took infection prevention measures	120 (29.3%)	89 (19.5%)	**−9.8% (−15.5, −4.1)**	**0.67 (0.52, 0.85)**
DRESSING and SECUREMENT				
Clean, dry, and intact	309 (75.4%)	368 (80.5%)	5.2% (−0.4, 10.7)	1.07 (0.99, 1.15)
No securement	156 (38.0%)	175 (38.3%)	0.2% (−6.23, 6.72)	1.01 (0.85, 1.19)
EVALUATE and EDUCATE (as reported by patient)				
Nurse assessed PIVC today	284 (75.1%)	381 (87.4%)	**12.3% (6.9, 17.6)**	**1.16 (1.09, 1.25)**
Patient had concerns about PIVC	28 (6.8%)	19 (4.2%)	−2.7% (−5.7, 0.4)	0.61 (0.35, 1.07)
Patient had concerns about PIVC and notified nurse	15 (3.7%)	12 (2.6%)	−1.0% (−3.3, 1.3)	0.72 (0.34, 1.52)
DOCUMENT the DECISION				
Documentation of decision to continue or remove PIVC	38 (9.8%)	246 (59.0%)	**49.1% (43.6, 54.7)**	**5.99 (4.38, 8.19)**

PIVC = peripheral intravenous catheter; CI = confidence interval; IV = intravenous; n/c = cannot be calculated; bold = statistically significant.

dislodgement risk. A previous global audit identified 21% of peripheral intravenous catheter dressings were not clean, dry and intact (Alexandrou et al., 2018), and even higher rates have been observed in some countries (Rodriguez-Calero et al., 2020). Multivariate analysis from a prevalence study in Germany identified that substandard dressings were more common when the peripheral catheter was idle and had not been assessed in the previous 24 h (Aghdassi et al., 2019). The optimal dressing and securement approach for peripheral intravenous catheters has not yet been established, despite multiple randomized controlled trials (Bahl et al., 2021; Corley et al., 2023; Marsh et al., 2018; Rickard et al., 2018).

The study results indicate that the I-DECIDED® tool provides an effective framework to incorporate guidelines at the point of care. International infection control guidelines and standards for nursing care stress the integral role of catheter assessment in early detection of site complications and infection prevention (Denton et al., 2016; Gorski et al., 2021; Loveday et al., 2016; O'Grady et al., 2011). However, peripheral intravenous catheter assessment has traditionally targeted timed rather than timely removal, and phlebitis scoring rather than comprehensive assessment. While phlebitis is a painful and important consideration, catheter assessment should be more comprehensive than phlebitis detection (Göransson et al., 2017; Ray-Barruel and Alexander,

Table 4
PIVC documentation audit results.

	Pre-intervention $N = 410$	Post-intervention $N = 457$	Difference (95% CI)	Ratio (95% CI)
IDENTIFY if a PIVC is *in situ*	363 (88.5%)	393 (86.0%)	−2.5% (−7.0, 1.9)	0.97 (0.92, 1.02)
DOES patient need this PIVC?	299 (72.9%)	339 (74.2%)	1.3% (−4.6, 7.1)	1.02 (0.94, 1.10)
EFFECTIVE function? (patency)	112 (27.3%)	260 (56.9%)	**29.6% (23.3, 35.8)**	**2.08 (1.74, 2.49)**
COMPLICATIONS at PIVC site	231 (56.3%)	266 (58.2%)	1.9% (−4.7, 8.5)	1.03 (0.92, 1.16)
INFECTION prevention	3 (0.7%)	230 (50.3%)	**49.6% (44.9, 54.3)**	**68.8 (22.2, 213)**
DRESSING and SECUREMENT	1 (0.2%)	232 (50.8%)	**50.5% (45.9, 55.1)**	**208 (29.3, 1477)**
EVALUATE and EDUCATE patient	10 (2.4%)	228 (49.9%)	**47.5% (42.6, 52.3)**	**205 (11.0, 38.0)**
DOCUMENT the DECISION	38 (9.3%)	246 (53.8%)	**44.6% (39.2, 49.9)**	**5.81 (4.24, 7.95)**

PIVC = peripheral intravenous catheter; CI = confidence interval; n/c = cannot be calculated; bold = statistically significant.

2023; Ray-Barruel et al., 2014; Rickard and Ray-Barruel, 2017). Following the success of central line bundles in reducing central line-associated bloodstream infection, many hospitals have implemented peripheral intravenous catheter insertion and maintenance bundles to reduce catheter-associated bloodstream infection; however, a systematic review identified that bundles varied in their components and compliance reporting (Ray-Barruel et al., 2019). A daily prompt to review catheter need featured in several peripheral intravenous catheter bundles, with some authors reporting an associated reduction in bloodstream infection (Ray-Barruel et al., 2019). In our study, bloodstream infection rates were low, making comparison impractical for this outcome, but in settings with higher baseline infection rates it is possible that by reducing idle catheters and catheter complications, I-DECIDED® use may also result in bloodstream infection reductions. The I-DECIDED® mnemonic intentionally begins with identifying the presence of a device and then assessment of the continued need for the device because these factors are integral in prompt removal of idle catheters and key for the implementation of clinically indicated removal policies (Gorski et al., 2021; Loveday et al., 2016).

In previous studies, consumers have reported dissatisfaction with a lack of communication and recognition of individual vascular access needs by clinicians (Cooke et al., 2018; Larsen et al., 2017). Some patients may be reluctant to speak up despite having concerns (Fisher et al., 2019); therefore, I-DECIDED® includes a prompt for evaluating the patient's understanding of treatment and providing education as needed. In the intervention period, patient reports that the nurse had assessed their peripheral catheter increased. Interestingly, more patients reported that nurses performed infection prevention measures including hand hygiene and scrubbing the needleless connector prior to access. It is unlikely that this was a chance finding because it improved at all hospitals after implementation. Possibly, the increased education focus on peripheral catheter assessment or use of the trial form provided a visual reminder for nurses to ask the patient about the catheter and be more cognizant of the patients' infection risk. Further work is planned to identify how the tool might improve patient inclusion in device care.

Implementation of the tool required substantial changes to how nurses assessed peripheral intravenous catheters and documented their assessment. While documentation of catheter assessment and decision-making markedly improved (44.5%), compliance varied between hospitals, largely dependent on their pre-study documentation processes. Hospitals with a prior culture of documenting vascular access device insertion and daily assessment had higher compliance with the trial form. This was not surprising because nurses often feel swamped with paperwork (Cowin, 2014). Prior to the introduction of the tool, nurses' routine documentation of peripheral intravenous catheter assessment was limited to phlebitis scores, requiring a culture shift to a broader assessment focus. Implementation of a new peripheral catheter assessment and documentation process was expected to pose a challenge for busy clinicians, who tend to overlook risks of these ubiquitous devices (Bourgault et al., 2021). The project lead prepared for this by holding multiple stakeholder meetings and education sessions. Existing hospital catheter policies were not changed, nor did we provide peripheral catheter insertion training or product education. The only change was the expectation that nurses would complete their peripheral intravenous catheter assessment using the I-DECIDED® tool, make an informed decision about the necessity of the catheter, and remove those deemed no longer necessary or patent.

Understanding and accommodating the unique context of the three hospitals and various medical and surgical wards was essential, with the PARiHS framework used to guide implementation (Harvey and Kitson, 2016; Kitson et al., 2008; Rycroft-Malone, 2004). This provided valuable insight into how different contexts implemented the intervention in different ways. As wards self-nominated to participate, nurse manager support for the study was positive, which is integral to the success of clinical implementation initiatives (Henderson et al., 2014). The project lead met with multidisciplinary stakeholders at each hospital at the beginning of T1 and T3, and then regularly throughout the study with nurse managers and educators to discuss the project, clarify any uncertainties, and provide support. In turn, the nurse managers reiterated their commitment to the project, nominated ward champions, and allocated time for collaborative staff education sessions.

Implementation projects are challenging, and sustained improvements can be elusive. Following the study, one hospital modified their nursing care plan to include I-DECIDED®, another reverted to their previous documentation (phlebitis score only), and the third implemented an electronic medical record and included I-DECIDED® for staff education regarding peripheral intravenous catheters. Further implementation of the I-DECIDED® tool across hospital settings has the potential to improve catheter care and subsequent patient outcomes through the provision of a structured, comprehensive assessment and decision-making framework to align care with best practice recommendations for catheter maintenance, securement, and removal.

Interest in the I-DECIDED® tool has been strong so far. The tool has been translated into several languages and several concurrent trials are examining its effectiveness in different settings and populations in a range of countries. Moving forward, we encourage nurse educators and academics to promote the tool in undergraduate and hospital training programs and encourage clinicians to use I-DECIDED® as a routine checklist for daily peripheral intravenous catheter assessment and management to ensure that best practice is followed, including timely removal of idle catheters. With the help of an informatician, we foresee the tool could easily be implemented into electronic medical records, with automated prompts for daily review of device necessity. Ongoing routine invasive device audits are strongly recommended.

Our study has several strengths. The protocol was published *a priori* (Ray-Barruel et al., 2018) and clinimetric evaluations demonstrated strong validity and inter-rater reliability for peripheral intravenous catheter assessment (Ray-Barruel et al., 2020). The PARiHS framework was used to contextualize implementation. The robust interrupted time-series study design over an 11-month period with 16 data collection time-points allowed greater confidence that changes in the study outcomes were due to the intervention rather than other changes in risk profiles over the two periods and gave staff time to adjust to the process. The usual hospital processes for inserting peripheral intravenous catheters remained constant throughout the study, with catheter assessments and chart audits undertaken by research nurses, not the project lead. Some ward nurse champions demonstrated high engagement with the project, *e.g.*, creating extra written resources for staff to encourage compliance. Our multi-site testing increases confidence with the beneficial effects of the intervention, *e.g.*, peripheral catheter documentation improved in all wards, even where staff expressed frustration with the added paperwork.

4.1. Limitations

Potential confounders including patient demographics such as age, comorbidity, diagnosis and length of stay were not collected. The study limitations include no control wards, however each ward served as its own control. Nurse managers self-nominated their wards to participate so may have had an intrinsic positive bias, but it is unlikely that this could influence all nurses' documentation. We were unable to test the intervention throughout entire hospitals, which may have reduced ideal documentation in the study wards since intra-hospital transferred patients did not initially have the vascular access device form in use. Electronic medical records were not used at these hospitals during the study, so our results reflect this paper-based context. Further, only nurses (not doctors or phlebotomy staff) used the vascular access device forms so our results are nursing focussed. Nurses may have been prompted to document peripheral intravenous catheter assessment when the research nurses were present (Hawthorne effect), and research nurses' assigning endpoints were not blinded, but this was

unavoidable due to the study design and budget. The original protocol included 'think aloud' assessments, which would have provided more information on how nurses and patients interact during the catheter assessment, but these were not possible due to nursing staff unavailability when the lead author was available and competing priorities for staff education. The robust measures undertaken in the study (including clinimetric evaluation, repeated catheter assessments, chart audits, focus groups) provide strong data to support the use of I-DECIDED® for peripheral intravenous catheter assessment and decision-making and further work is planned to investigate its efficacy in other contexts and for other invasive devices.

5. Conclusions

Peripheral intravenous catheter documentation and patient engagement in peripheral catheter care improved after implementation of the I-DECIDED® tool. Coupled with education and supportive leadership, I-DECIDED® reduced the prevalence of idle catheters, insertion site complications, and substandard dressings despite higher numbers of peripheral catheters in the study wards overall. There was no detectable effect on bloodstream infection, however its incidence was very low.

Nurses' ability to conduct a comprehensive device assessment and make an informed decision to continue, remediate, or remove the catheter should not be undervalued. Patient acuity in hospitals is increasing, courtesy of an aging population and an increase in patients with chronic and complex healthcare needs for whom venous depletion is a real concern. Using a structured assessment and decision framework such as I-DECIDED® will promote greater awareness of the importance of removing unneeded or symptomatic catheters, ensuring effective dressings, and preserving vessel health among vulnerable populations.

Funding

GRB received postdoctoral fellowship funding from Griffith University and grant funding from the Australasian College of Infection Prevention and Control to undertake this project. GRB also received funding support from the Australian Government Endeavour Executive Leadership Program to undertake a research exchange fellowship at the University of Michigan in 2019.

CRediT authorship contribution statement

Gillian Ray-Barruel: Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Vineet Chopra:** Writing – review & editing, Methodology, Formal analysis. **Paul Fulbrook:** Writing – review & editing, Project administration. **Josephine Lovegrove:** Writing – review & editing, Investigation. **Gabor Mihala:** Writing – review & editing, Formal analysis. **Michael Wishart:** Writing – review & editing, Project administration. **Marie Cooke:** Writing – review & editing, Supervision, Methodology. **Marion Mitchell:** Writing – review & editing, Methodology. **Claire M. Rickard:** Writing – review & editing, Supervision, Methodology, Formal analysis.

Data availability

Data sharing statement for this article

Will individual participant data be available (including data dictionaries)?	Yes
What data in particular will be shared?	Individual participant data that underlie the results reported in this article, after de-identification (text, tables, figures and appendices).
What other documents will be available?	Study Protocol, Participant information sheet, Vascular access device assessment form, Data collection form (available in supplementary file)
When will data be available (start and end dates)?	Immediately following publication. No end date.
With whom?	Researchers who provide a methodologically sound proposal.
For what types of analyses?	To achieve aims in the approved proposal.
By what mechanism will data be made available?	Proposals should be directed to g.ray-barruel@griffith.edu.au or g.raybarruel@uq.edu.au

Declaration of Competing Interest

GRB reports investigator-initiated research grants, speaker fees and consultancy payments provided to her employer (Griffith University or The University of Queensland) by product manufacturers (3M, BBraun, BD-Bard) and education providers (Ausmed, Wolters Kluwer, Continulus), unrelated to this project.

CMR discloses that her employer (Griffith University or The University of Queensland) has received on her behalf: investigator-initiated research grants from BD-Bard, Cardinal Health and Eloquest; and consultancy payments for lectures or opinion from 3M, BBraun, BD-Bard, ITL Biomedical; unrelated to current project.

VC receives funding from the National Institutes of Health, Bethesda, MD, and royalties for books published with Oxford University Press and Wolters Kluwer publishers.

PF: None.

JL: None.

GM: None.

MW: None.

MC: None.

MM: None.

Acknowledgments

Thank you to the nursing directors, nurse managers, nurse educators, and nursing staff at the participating hospitals. We thank Peter Brown for his unwavering support of the study and Katherine Roberts and Elizabeth Herron for their assistance with data collection. We also thank Mari Takashima for assisting with the statistical calculations. We thank TimerTag and Becton Dickinson for their unfunded support in promoting the I-DECIDED® tool.

I-DECIDED® is a registered trademark of Griffith University. It may be freely downloaded from the AVATAR® website (https://www.avatargroup.org.au/i-decided.html) and used for non-profit clinical and education purposes. Permission to use the tool for commercial purposes must be obtained in writing from Griffith University.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnurstu.2023.104604.

References

Aghdassi, S.J.S., Schroder, C., Gruhl, D., Gastmeier, P., Salm, F., 2019. Point prevalence survey of peripheral venous catheter usage in a large tertiary care university hospital in Germany. Antimicrob. Resist. Infect. Control 8, 15. https://doi.org/10.1186/s13756-019-0468-8.

Alexandrou, E., Ray-Barruel, G., Carr, P.J., Frost, S.A., Inwood, S., Higgins, N., Lin, F., Alberto, L., Mermel, L., Rickard, C.M., OMG Study Group, 2018. Use of short peripheral intravenous catheters: characteristics, management, and outcomes worldwide. J. Hosp. Med. 13 (5). https://doi.org/10.12788/jhm.3039.

Australian Commission on Safety and Quality in Health Care, 2021. Management of Peripheral Intravenous Catheters: Clinical Care Standard. ACSQHC Retrieved July 29, 2021 from https://www.safetyandquality.gov.au/sites/default/files/2021-05/management_of_peripheral_intravenous_catheters_clinical_care_standard_-_accessible_pdf.pdf.

Bahl, A., Gibson, S.M., Jankowski, D., Chen, N.W., 2021. Short peripheral intravenous catheter securement with cyanoacrylate glue compared to conventional dressing: a randomized controlled trial. J. Vasc. Access https://doi.org/10.1177/11297298211024037.

Becerra, M.B., Shirley, D., Safdar, N., 2016. Prevalence, risk factors, and outcomes of idle intravenous catheters: an integrative review. Am. J. Infect. Control 44 (10), e167–e172. https://doi.org/10.1016/j.ajic.2016.03.073.

Berger, S., Winchester, K., Principe, R.B., Culverwell, E., 2022. Prevalence of peripheral intravenous catheters and policy adherence: a point prevalence in a tertiary care university hospital. J. Clin. Nurs. 31 (15–16), 2324–2330. https://doi.org/10.1111/jocn.16051.

Bourgault, A.M., Penoyer, D.A., Upvall, M.J., 2021. It depends. J. Infus. Nurs. 44 (2), 103–112. https://doi.org/10.1097/nan.0000000000000418.

Cooke, M., Ullman, A.J., Ray-Barruel, G., Wallis, M., Corley, A., Rickard, C.M., 2018. Not "just" an intravenous line: consumer perspectives on peripheral intravenous cannulation (PIVC). An international cross-sectional survey of 25 countries. PLoS One 13 (2), e0193436. https://doi.org/10.1371/journal.pone.0193436.

Corley, A., Ullman, A.J., Marsh, N., Genzel, J., Larsen, E.N., Young, E., Booker, C., Harris, P.N. A., Rickard, C.M., 2023. A pilot randomized controlled trial of securement bundles to reduce peripheral intravenous catheter failure. Heart Lung 57, 45–53. https://doi.org/10.1016/j.hrtlng.2022.07.015.

Cowin, S., 2014. Not waving drowning: challenging the documentation arms race in nursing. Austr. Nurs. Midwifery J. 21 (10), 25.. https://search.informit.org/doi/10.3316/informit.264001753392043.

Denton, A., Bodenham, A., Conquest, A., Davies, A., Davidson, A., Portsmouth, J., Doherty, J., York, N., Oulds, S., Shrestha, S., Rowlands, S., Gallagher, R., Bayliss, A., McIntosh, T., Currie, L., Ferdosian, M., 2016. Standards for Infusion Therapy. 4th ed. Royal College of Nursing. https://www.rcn.org.uk/professional-development/publications/pub-005704.

Evison, H., Sweeny, A., Ranse, J., Carrington, M., Marsh, N., Byrnes, J., Rickard, C.M., Carr, P. J., Keijzers, G., 2021. Idle peripheral intravenous cannulation: an observational cohort study of pre-hospital and emergency department practices. Scand. J. Trauma Resusc. Emerg. Med. 29 (1), 126. https://doi.org/10.1186/s13049-021-00941-y.

Fisher, K.A., Smith, K.M., Gallagher, T.H., Huang, J.C., Borton, J.C., Mazor, K.M., 2019. We want to know: patient comfort speaking up about breakdowns in care and patient experience. BMJ Qual. Saf. 28 (3), 190–197. https://doi.org/10.1136/bmjqs-2018-008159.

Gledstone-Brown, L., McHugh, D., 2018. Review article: idle 'just-in-case' peripheral intravenous cannulas in the emergency department: is something wrong? Emerg. Med. Australas. 30 (3), 309–326. https://doi.org/10.1111/1742-6723.12877.

Göransson, K., Förberg, U., Johansson, E., Unbeck, M., 2017. Measurement of peripheral venous catheter-related phlebitis: a cross-sectional study. Lancet Haematol. 4 (9), e424–e430. https://doi.org/10.1016/S2352-3026(17)30122-9.

Gorski, L.A., Hadaway, L., Hagle, M.E., Broadhurst, D., Clare, S., Kleidon, T., Meyer, B.M., Nickel, B., Rowley, S., Sharpe, E., Alexander, M., 2021. Infusion therapy standards of practice, 8th edition. J. Infus. Nurs. 44 (1S Suppl 1), S1–S224. https://doi.org/10.1097/NAN.0000000000000396.

Harris, P., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., Conde, J., 2009. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J. Biomed. Inform. 42 (2), 377–381. https://doi.org/10.1016/j.jbi.2008.08.010.

Harvey, G., Kitson, A., 2016. PARIHS revisited: from heuristic to integrated framework for the successful implementation of knowledge into practice. Implement. Sci. 11, 33. https://doi.org/10.1186/s13012-016-0398-2.

Hawkins, T., Greenslade, J.H., Suna, J., Williams, J., Rickard, C.M., Jensen, M., Donohue, M., Cho, E., Hise, C.V., Egerton-Warburton, D., Cullen, L., 2018. Peripheral intravenous cannula insertion and use in the emergency department: an intervention study. Acad. Emerg. Med. 25 (1), 26–32. https://doi.org/10.1111/acem.13335.

Henderson, A., Burmeister, L., Schoonbeek, S., Ossenberg, C., Gneilding, J., 2014. Impact of engaging middle management in practice interventions on staff support and learning culture: a quasi-experimental design. J. Nurs. Manag. 22 (8), 995–1004. https://doi.org/10.1111/jonm.12090.

Høvik, L.H., Gjeilo, K.H., Lydersen, S., Solligard, E., Damas, J.K., Gustad, L.T., 2020. Use of peripheral venous catheters in two Norwegian hospitals. Tidsskr. Nor. Laegeforen. 140 (8). https://doi.org/10.4045/tidsskr.19.0653.

Hudson, J., Fielding, S., Ramsay, C.R., 2019. Methodology and reporting characteristics of studies using interrupted time series design in healthcare. BMC Med. Res. Methodol. 19 (1), 137. https://doi.org/10.1186/s12874-019-0777-x.

Jones, T.L., Hamilton, P., Murry, N., 2015. Unfinished nursing care, missed care, and implicitly rationed care: state of the science review. Int. J. Nurs. Stud. 52 (6), 1121–1137. https://doi.org/10.1016/j.ijnurstu.2015.02.012.

Kalisch, B.J., Xie, B., 2014. Errors of omission: missed nursing care. West. J. Nurs. Res. 36 (7), 875–890. https://doi.org/10.1177/0193945914531859.

Kalisch, B.J., Xie, B., Dabney, B.W., 2014. Patient-reported missed nursing care correlated with adverse events. Am. J. Med. Qual. 29 (5), 415–422. https://doi.org/10.1177/1062860613501715.

Kitson, A.L., Rycroft-Malone, J., Harvey, G., McCormack, B., Seers, K., Titchen, A., 2008. Evaluating the successful implementation of evidence into practice using the PARiHS framework: theoretical and practical challenges. Implement. Sci. 3, 1. https://doi.org/10.1186/1748-5908-3-1.

Laan, B.J., Maaskant, J.M., Spijkerman, I.J.B., Borgert, M.J., Godfried, M.H., Pasmooij, B.C., Opmeer, B.C., Vos, M.C., Geerlings, S.E., 2020. De-implementation strategy to reduce inappropriate use of intravenous and urinary catheters (RICAT): a multicentre, prospective, interrupted time-series and before and after study. Lancet Infect. Dis. 20 (7), 864–872. https://doi.org/10.1016/S1473-3099(19)30709-1.

Larsen, E., Keogh, S., Marsh, N., Rickard, C., 2017. Experiences of peripheral IV insertion in hospital: a qualitative study. Br. J. Nurs. 26 (19), S18–S25. https://doi.org/10.12968/bjon.2017.26.19.S18.

Loveday, H.P., Wilson, J.A., Prieto, J., Wilcox, M.H., 2016. epic3: revised recommendation for intravenous catheter and catheter site care. J. Hosp. Infect. 92 (4), 346–348. https://doi.org/10.1016/j.jhin.2015.11.011.

Marsh, N., Larsen, E., Genzel, J., Mihala, G., Ullman, A.J., Kleidon, T., Cadigan, S., Rickard, C. M., 2018. A novel integrated dressing to secure peripheral intravenous catheters in an adult acute hospital: a pilot randomised controlled trial. Trials 19 (1), 596. https://doi.org/10.1186/s13063-018-2985-9.

Marsh, N., Larsen, E.N., Takashima, M., Kleidon, T., Keogh, S., Ullman, A.J., Mihala, G., Chopra, V., Rickard, C.M., 2021. Peripheral intravenous catheter failure: a secondary analysis of risks from 11,830 catheters. Int. J. Nurs. Stud. 124, 104095. https://doi.org/10.1016/j.ijnurstu.2021.104095.

McHugh, M.D., Aiken, L.H., Windsor, C., Douglas, C., Yates, P., 2020. Case for hospital nurse-to-patient ratio legislation in Queensland, Australia, hospitals: an observational study. BMJ Open 10 (9), e036264. https://doi.org/10.1136/bmjopen-2019-036264.

Mermel, L.A., 2017. Short-term peripheral venous catheter-related bloodstream infections: a systematic review. Clin. Infect. Dis. 65 (10), 1757–1762. https://doi.org/10.1093/cid/cix562.

National Healthcare Safety Network, 2022. NHSN patient safety component manual. Ctr. Dis. Control Prev. January 2022, 1–48 Chapter 4 https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf.

O'Grady, N.P., Alexander, M., Burns, L.A., Dellinger, E.P., Garland, J., Heard, S.O., Lipsett, P.A., Masur, H., Mermel, L.A., Pearson, M.L., Raad, I.I., Randolph, A.G., Rupp, M.E., Saint, S., 2011. Guidelines for the prevention of intravascular catheter-related infections. Am. J. Infect. Control 39 (4 Suppl 1), S1–34. https://doi.org/10.1016/j.ajic.2011.01.003.

Ogrinc, G., Mooney, S.E., Estrada, C., Foster, T., Goldmann, D., Hall, L.W., Huizinga, M.M., Liu, S.K., Mills, P., Neily, J., Nelson, W., Pronovost, P.J., Provost, L., Rubenstein, L.V., Speroff, T., Splaine, M., Thomson, R., Tomolo, A.M., Watts, B., 2008. The SQUIRE (Standards for QUality Improvement Reporting Excellence) guidelines for quality improvement reporting: explanation and elaboration. Qual. Saf. Health Care 17 (Suppl. 1), i13–i32. https://doi.org/10.1136/qshc.2008.029058.

Penfold, R.B., Zhang, F., 2013. Use of interrupted time series analysis in evaluating health care quality improvements. Acad. Pediatr. 13 (6 Suppl), S38–S44. https://doi.org/10.1016/j.acap.2013.08.002.

Ray-Barruel, G., Alexander, M., 2023. CE: evidence-based practice for peripheral intravenous catheter management. Am. J. Nurs. 123 (1), 32–37. https://doi.org/10.1097/01.Naj.0000905568.37179.01.

Ray-Barruel, G., Polit, D.F., Murfield, J.E., Rickard, C.M., 2014. Infusion phlebitis assessment measures: a systematic review. J. Eval. Clin. Pract. 20 (2), 191–202. https://doi.org/10.1111/jep.12107.

Ray-Barruel, G., Cooke, M., Mitchell, M., Chopra, V., Rickard, C.M., 2018. Implementing the I-DECIDED clinical decision-making tool for peripheral intravenous catheter assessment and safe removal: protocol for an interrupted time-series study. BMJ Open 8 (6), e021290. https://doi.org/10.1136/bmjopen-2017-021290.

Ray-Barruel, G., Xu, H., Marsh, N., Cooke, M., Rickard, C.M., 2019. Effectiveness of insertion and maintenance bundles in preventing peripheral intravenous catheter-related complications and bloodstream infection in hospital patients: a systematic review. Infect. Dis. Health 24 (3), 152–168. https://doi.org/10.1016/j.idh.2019.03.001.

Ray-Barruel, G., Cooke, M., Chopra, V., Mitchell, M., Rickard, C.M., 2020. The I-DECIDED clinical decision-making tool for peripheral intravenous catheter assessment and safe removal: a clinimetric evaluation. BMJ Open 10 (1), e035239. https://doi.org/10.1136/bmjopen-2019-035239.

Rickard, C.M., Ray-Barruel, G., 2017. Peripheral intravenous catheter assessment: beyond phlebitis. Lancet Haematol. 4 (9), e402–e403. https://doi.org/10.1016/S2352-3026(17)30145-X.

Rickard, C.M., Marsh, N., Webster, J., Runnegar, N., Larsen, E., McGrail, M.R., Fullerton, F., Bettington, E., Whitty, J.A., Choudhury, M.A., Tuffaha, H., Corley, A., McMillan, D.J., Fraser, J.F., Marshall, A.P., Playford, E.G., 2018. Dressings and securements for the prevention of peripheral intravenous catheter failure in adults (SAVE): a pragmatic, randomised controlled, superiority trial. Lancet 392 (10145), 419–430. https://doi.org/10.1016/S0140-6736(18)31380-1.

Rodriguez-Calero, M., De Pedro-Gomez, J., Fernandez-Fernandez, I., Blanco-Mavillard, I., Castro-Sanchez, E., Parra-García, G., Sánchez-Rojas, C., 2020. Adherence of nurses to the recommendations for insertion, maintenance and management of peripheral intravenous catheters analyzed using a structured audit tool. J. Vasc. Access 21 (6), NP45. https://doi.org/10.1177/1129729820953.

Rycroft-Malone, J., 2004. The PARIHS framework—a framework for guiding the implementation of evidence-based practice. J. Nurs. Care Qual. 19 (4), 297–304. https://doi.org/10.1097/00001786-200410000-00002.

Sato, A., Nakamura, I., Fujita, H., Tsukimori, A., Kobayashi, T., Fukushima, S., Fujii, T., Matsumoto, T., 2017. Peripheral venous catheter-related bloodstream infection is associated with severe complications and potential death: a retrospective observational study. BMC Infect. Dis. 17 (1), 434. https://doi.org/10.1186/s12879-017-2536-0.

Tatsuno, K., Ikeda, M., Wakabayashi, Y., Yanagimoto, S., Okugawa, S., Moriya, K., 2019. Clinical features of bloodstream infections associated with peripheral versus central venous catheters. Infect. Dis. Ther. 8 (3), 343–352. https://doi.org/10.1007/s40121-019-00257-6.

Wagner, A.K., Soumerai, S.B., Zhang, F., Ross-Degnan, D., 2002. Segmented regression analysis of interrupted time series studies in medication use research. J. Clin. Pharm. Ther. 27 (4), 299–309. https://doi.org/10.1046/j.1365-2710.2002.00430.x.

Webster, J., Osborne, S., Rickard, C.M., Marsh, N., 2019. Clinically-indicated replacement versus routine replacement of peripheral venous catheters. Cochrane Database Syst. Rev. 1, CD007798. https://doi.org/10.1002/14651858.CD007798.pub5.