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Review Article

Effective nursing interventions for infection prevention and control in acute and critically ill patients with a peripherally inserted venous catheter: an umbrella review

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ABSTRACT

Introduction: Infections related to peripherally inserted venous catheters are among the most serious and frequent complications in acute and critical care. If unaddressed, these infections markedly escalate morbidity, mortality, and healthcare expenditures.

Objective: To synthesize scientific evidence about effective nursing interventions that prevent and control infections in acute and critically ill patients with peripherally inserted venous catheters.

Methods: This umbrella review followed Joanna Briggs Institute guidelines and the PRISMA statement for reporting systematic reviews. A systematic search was carried out in CINAHL, MEDLINE, JBI Evidence Synthesis, Cochrane Database of Systematic Reviews, Web of Science, and SCOPUS. Rayyan software supported study extraction and selection. Each study was assessed for methodological quality, grade of recommendation, and level of evidence.

Results: Six systematic reviews were included, allowing the identification of nursing-led interventions that demonstrably reduce catheter-related infection. Evidence supports infection risk reduction through chlorhexidine gluconate for skin preparation, insertion and maintenance bundles, and strategies to support bundle implementation. Additional effective interventions include in-line filters, limiting device dwell time, minimizing continuous antibiotic infusions, and avoiding using Teflon cannulas, instead of polyethylene or Vialon cannulas. For patients with peripherally inserted central catheters (PICCs), quantified grip exercises improved circulation and reduced infection and thrombosis risk. Integrated short peripheral catheters were associated with significantly fewer complications than non-integrated ones.

Conclusions: Nurses are pivotal in preventing peripherally inserted venous catheter-related infection through specific evidence-based interventions. Nurse leaders should also prioritize selecting lower-risk devices to enhance patient outcomes and reduce complications.

Implications for clinical practice: This review underscores the need for nurses to consistently implement evidence-based interventions to prevent infections related to venous catheters, reduce complications, and improve patient outcomes. It reinforces the importance of ongoing education, institutional support, and leadership in fostering safer practices in acute and critical care environments.

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Introduction

Healthcare-associated infections (HAI) are acquired infections that were not present at the patient's admission or in the first 48 h of hospital stay [1]. They are associated with increased mortality, morbidity, and healthcare costs [2] and are among acute and critical care's most frequent and severe complications [2,3,4].

In Europe, one in every 20 patients will acquire a HAI, which leads to an increase in costs of around 7 billion euros annually. Worldwide, 7 % to 10 % of hospitalised patients will acquire at least one HAI [2,3].

Bloodstream infection is the fourth most common HAI [5], and it could be linked to venous catheterisation due to infiltration, occlusion, phlebitis, and other causes [6]. Peripheral inserted venous catheterisation is the most common invasive procedure in hospitals [6], performed with different types of catheters, which differ in tip location and placement technique [7,8]. Despite the catheter's type, such as short peripheral venous catheters (e.g., BD Insyte™ Autoguard, Vasofix® Safety), long peripheral venous catheters (PowerGlide Pro™ Extended Dwell Catheter, LeaderCath® Extended Dwell), midline catheters (e.g., PowerMidline™ Catheter, Arrow® Midline by Teleflex), or peripherally inserted central catheters – PICC (e.g., PowerPICC™ by BD, Groshong® PICC by Bard, Arrow® PICC by Teleflex), the presence of these devices can lead to a wide range of complications [9].

Local infection (e.g., phlebitis, pain) or systemic infection (e.g., bloodstream infection) is not merely a statistical concern [9]. They pose serious risks to patients' well-being and emphasise the need for preventive care practices, namely, insertion and maintenance procedures [10], where nursing-led intervention is a key component of any patient safety programme [2,3,4].

Emerging evidence suggests considerable variability in adherence to clinical guidelines and ongoing knowledge and implementation gaps among healthcare professionals [6,7,8,10]. Furthermore, increasing healthcare complexity and the need for context-specific protocols warrant a critical reassessment of current preventive measures. Consistent with global infection prevention and control (IPC) priorities, such as those outlined by the World Health Organisation (WHO) [3,4], a systematic overview of existing evidence on IPC procedures specific to peripherally inserted venous catheters (PIVC) is essential to enhance patient safety, reduce HAI and support evidence-based clinical decision-making.

An umbrella review, a systematic overview of existing systematic reviews [11], addresses this gap by providing an integrative analysis of the most effective interventions in preventing PIVC-associated infection. Moreover, by quantifying the consistency and strength of the recommendations, using standardized appraisal tools, namely GRADE, clarifies where confidence is justified and where uncertainty remains. Accordingly, this umbrella review aims to synthesise scientific evidence effective nursing interventions that prevent and control infections in acute and critically ill patients with PIVC, thereby generating robust, evidence-informed recommendations to support clinical decision-making, enhancing patient safety, and contributing to effective infection prevention strategies in high-risk healthcare settings.

Methods

The present umbrella review was conducted according to the internationally recognised methodological guidance of the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [11]. The protocol was predefined and registered on the PROSPERO Platform to ensure transparency, reproducibility, and methodological rigour.

Research question

The research question was formulated using the mnemonic PI[C]O [11,12]: Which effective nursing interventions (I) prevent and control infections (O) in acute and critically ill patients who need a peripherally inserted venous catheter (P)?

Eligibility criteria

In this research, the inclusion criteria encompass the study type (all types of systematic reviews), involving a population aged 18 years or older with an acute or critical illness, who required a PIVC, and whose nursing interventions were performed directly or indirectly to prevent or control infection related to a PIVC. The outcomes considered were the incidence and prevalence of infection associated with PIVC (primary outcome), local infection rates, bloodstream infection, phlebitis, costs, length of stay, and readmissions (secondary outcomes). As exclusion criteria, patients with non-critical and non-acute conditions (e.g., patients undergoing home hospitalization due to chronic illness), and those under 18 years of age; interventions solely performed by other health professionals, without the participation or collaboration of nurses, and reviews that included only opinion, reflection, and expert consensus.

Search strategy

The research was carried out between January 3 and February 15, 2024, on CINAHL Ultimate, MEDLINE Ultimate, JBI Evidence Synthesis, Cochrane Database of Systematic Reviews, and Scopus databases. Based on the search terms identified (Supplementary file 1), the search strategy combined the adequate terms for each database (Supplementary file 2).

Data extraction and selection

Once the search was complete, the results were exported to Rayyan Software® [13], for selection based on eligibility criteria. Two reviewers performed the selection in blinded mode, first removing the duplicates, followed by excluding articles by reading the title and abstract, and finally, the full text. Disagreements on the selection of the records were solved by team discussion with a third researcher for a final consensus.

The data extraction was then performed using the standardised instrument recommended by JBI for systematic reviews [11], in a tabular format, including the following items: evidence quality, level of evidence, title, authors, year of publication, geographical location, study design, objective(s), number of participants, interventions, and results. Two independent reviewers extracted data; a third was consulted to resolve discrepancies.

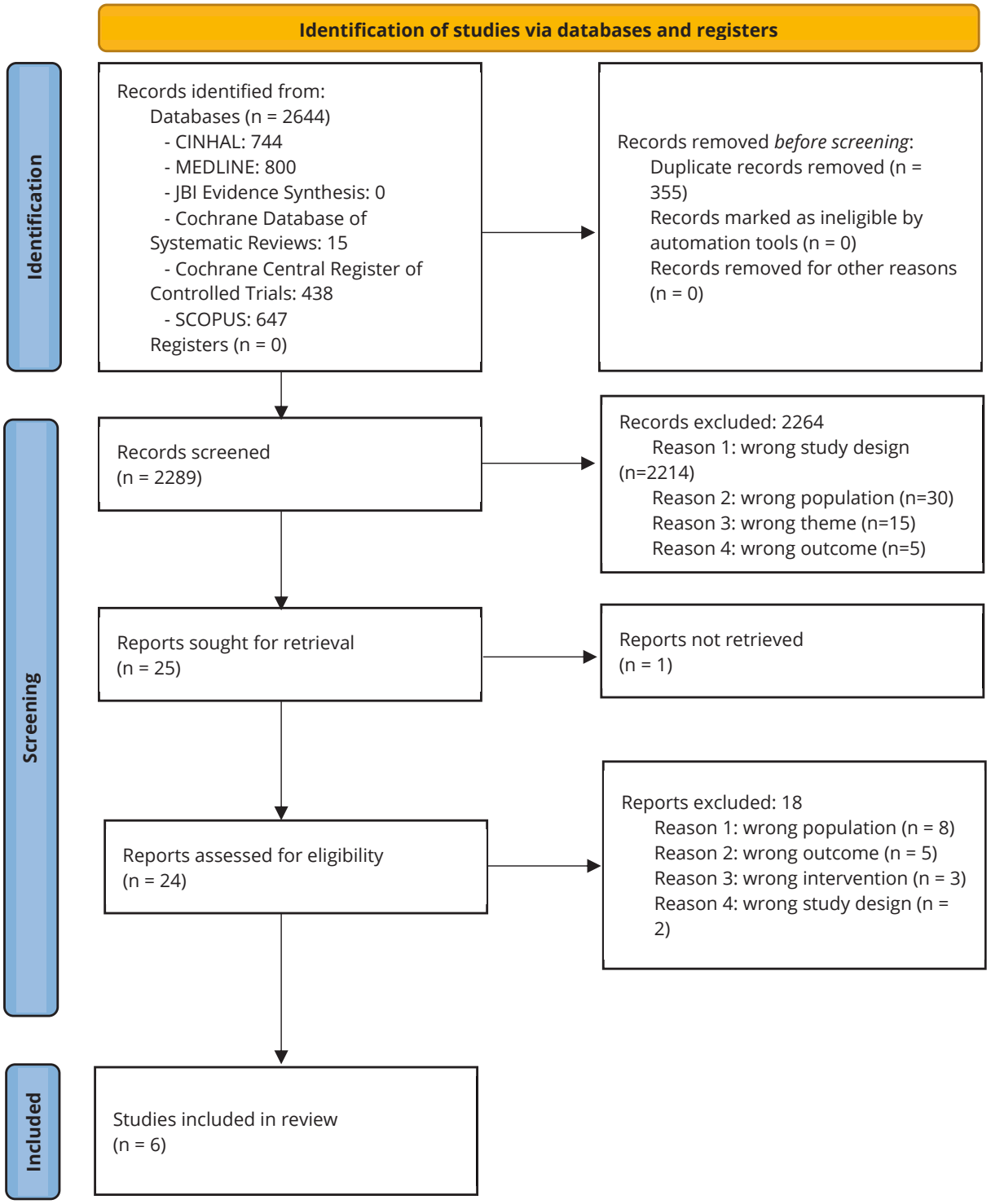
Once the data extraction process was finalised, synthesis was conducted per JBI guidance for umbrella reviews [11]. Data were systematically grouped by type of nursing intervention, patient population characteristics, and reported infection-related outcomes. A convergent narrative synthesis was adopted to integrate and compare findings while preserving contextual details. Greater emphasis was placed on findings from high-quality reviews, while inconsistencies, uncertainties, and gaps in the evidence were explicitly reported. This rigorous process allowed the construction of an overarching evidence map to identify effective nursing interventions for preventing and controlling infections in patients with PIVC, thereby ensuring methodological transparency and reliability of the synthesis.

Quality assessment and level of recommendation

The quality assessment of the reports was carried out following the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses, a validated and widely adopted tool designed to evaluate the methodological rigour and transparency of secondary research. This checklist allows for a comprehensive appraisal of key elements such as the clarity of the review question, the appropriateness of inclusion

criteria, the comprehensiveness of search strategies, the adequacy of critical appraisal processes, and the methods used to synthesise findings [11].

The GRADE assessment was used to assess the evidence's quality and the recommendations' strength. This option represents a key advantage because, unlike traditional appraisal tools that mainly focus on methodological quality or risk of bias, GRADE provides a transparent, structured, and comprehensive framework that considers multiple aspects, such as study limitations, inconsistency, indirectness, imprecision, and publication bias when assessing the certainty of evidence across outcomes [14].



Source: PRISMA flow diagram. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses[15]

Fig. 1. PRISMA flow diagram.

Table 1
Characteristics of the included studies.

Item code	Author/Year/ Location	Study design	Quality of evidence/ level of evidence	Objective	Participants	Interventions	Results
A1	Chaiyakunapruk et al. (2002) EUA	Meta-Analysis (Randomized Controlled Trials (RCT)	9/11 81,82% 1.a	Evaluated the efficacy of skin disinfection with chlorhexidine gluconate compared with povidone-iodine solution in preventing catheter-related bloodstream infection.	3404 participants (8 articles)	Use of chlorhexidine gluconate solution for care of catheter sites compared to use of povidone-iodine solution for preventing vascular catheter–related infections.	A chlorhexidine gluconate solution reduces the risk for catheter-related bloodstream infection by approximately 50%.
A2	Niël-Weise, B. et. al., 2010 Netherlands	Systematic Literature Review (RCT/Quasi-RCT)	10/11 90,91% 1.b	Summarize the evidence of the efficacy of in-line filters in reducing infusion-related phlebitis and assessed the impact of the baseline risk of phlebitis on the effect of in-line filters.	1.681 participants (11 articles)	Use of three types of in-line filters with administration of different types of intravenous solutions into short peripheral catheters (9 trials) and long peripheral catheters (2 trials).	The 11 trials identified (1633 peripheral catheters) showed that the use of in-line filters (826 peripheral catheters) reduced the occurrence of phlebitis in hospitalized patients. The in-line filters in peripheral IV catheters cannot be recommended for routine use, because evidence of their benefit is uncertain.
A3	Ray-Barruel et al. (2019) Australia	Systematic Literature Review (RCT/ Interrupted time series/ before-and-after studies/ cohort studies)	10/11 90,91% 1.a	Synthesize evidence on the effectiveness of peripheral intravenous catheter (PIVC) insertion and maintenance bundles on preventing adverse events.	2.402,988 Participants (13 articles)	Compilation of Bundles components for the insertion and maintenance of peripheral venous catheters and the strategies used to implement the bundles.	Insertion bundles components: 2% chlorhexidine gluconate skin prep, hand hygiene, vessel assessment/ site selection, aseptic technique, integrated closed catheter, transparent film dressing, sterile gloves, nurse self-assessment of PIVC insertion ability, documentation of insertion, dedicated PIVC insertion trolley, cannula size (20e22 G), catheter securement, needleless connectors, extension tubing, alcohol caps, cannula alert stickers, patient activity assessment, *patient comfort plan, and nurse decision to stop PI*VC insertion. Maintenance bundles include components such as assessment of need for PIVC, posting reminders of the bundle intervention, dressing integrity checks, and documentation of insertion and removal. The strategies used to implement the bundles include education, audits and feedback.
A4	Lv and Zhang (2019) China	Meta-analysis (RCT/ Non-randomized prospective/ Retrospective analyses)	7/11 63,64% 1.b	Estimate the incidents of peripheral intravenous catheter- related phlebitis associated to duration of catheters use, the type of medication administered, the local of the peripheral venous catheter	15791 participants (25 articles)	Identify the incidence and risk factors of phlebitis in peripheral intravenous catheter use.	Incidence of phlebitis with the use of peripheral intravenous catheters during infusion is 31%. Severe phlebitis develops in 4% of all patients. That longer dwelling time, antibiotics infusion, female gender, forearm insertion, infectious disease, and use of the cannula are more important risk factors for phlebitis development. The reduce dwelling time, antibiotics infusion, infectious disease, and use of cannulas made from other types of materials instead of Teflon cannula reduced the occurrence of phlebitis.
A5	Luo et al. (2023) China	Systematic Literature Review and Meta-analysis (RCT)	10/11 90,91% 1.a	Evaluate the effects of quantified versus willful grip exercises for the prevention of peripherally inserted central venous catheter (PICC) related thrombosis.	1.741 participants (15 articles)	Use of quantified versus willfull handgrip exercises after PICC placement.	The quantified grip exercises can reduce the incidence of PICC-related thrombosis and infection and improve the venous blood circulation in PICC patients.
A6	Gidaro et al. (2024) Italy	Systematic Literature Review and Meta-analysis (RCT/ Quasi-RCT)	10/11 90,91% 1.b	To compare the risk of catheter failure and each type of complication (occlusion, infiltration, thrombophlebitis, and dislodgement) between integrated short peripheral catheters to non-integrated short peripheral catheters.	4.727 participants (6 articles)	Assess the effect of ISPCs compared to non-integrated SPCs on the risk of occlusion, infiltration, phlebitis and dislodgement.	There are significantly reduced risk of catheter failure (pooling all complications) for ISPCs compared to SPCs ($p = 0.002$ RR 0.65; 95% CI 0.63-0.9). A significant reduction in the risks of occlusion ($p = 0.007$ RR 0.72; 95% CI 0.56-0.92) was observed. As regards the risk of infiltration, thrombophlebitis, and dislodgement, the analysis showed a trend in favor of ISPCs, though not statistically significant.

Results

Study selection

A total of 2644 reports were initially retrieved from the databases. After removing duplicates, 2289 reports were analysed by title and abstract during the first screening step. In this stage, 2214 were excluded due to study design, five had different outcomes, 15 focused on other subjects, and 30 were rejected because of the study's population. During the subsequent screening phase, 24 reports were read in full, resulting in six final studies included. The process is schematically shown in Fig. 1.

Characteristics of the included studies

As for the characteristics of the included studies, Table 1 summarizes their key features. The reviews were published between 2002 and 2024, while the studies within each review cover the years from 1980 to 2024. The study designs included two systematic literature reviews [15,16], two systematic literature reviews with *meta*-analysis [17,18] and two *meta*-analyses [19,20].

The six reviews included hospitalised patients over 18 years old with PIVC, aged from 43 to 76. The studies were conducted in hospital units and involved patients with surgical, medical, oncological, and cardiac conditions, requiring acute or intensive care. The studies' sample sizes ranged from 17 to over 2 million patients, and the number of catheters used in the studies ranged from 49 to 878 [15–20]. The included studies have a methodological quality average score of 85 %, according to the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses [11]. This demonstrates consistency in the review methodology, research question, objectives, and strategies. Table 2 details the critical appraisal results of the included studies.

In terms of evidence level and recommendations strength, the selected studies were classified at levels 1.a and 1.b and the variability of GRADE rating obtained between VERY LOW to HIGH, suggests variable confidence in the effect estimate, related to the presence of heterogeneity (see Table 3) [14].

Based on the findings, summarized in Table 1, most emerging interventions are related to PIVC, specifically using in-line filters, various types of catheter materials and lengths, and disinfection solutions. Insertion and maintenance bundles are also discussed. Regarding PICC, grip exercises are considered.

According to the results obtained, Niël-Weise et al. [15] identify 11 trials that studied the effectiveness and impact of in-line filters in reducing infusion-related phlebitis. These trials concluded that the use of in-line filters reduced the occurrence of phlebitis in hospitalised patients. However, the evidence is highly uncertain, making it difficult to recommend the routine use of these filters.

In another review, 35 studies were selected, analysing the incidence rate of phlebitis in 20,697 peripheral venous catheters [19]. The most probable risk factors for developing phlebitis include the duration of catheter use, the type of medication administered (e.g., antibiotics), female gender, insertion of the peripheral venous catheter in the forearm, prior infectious disease, and the use of Teflon catheters [19].

Additionally, Gidaro et al. [17], in their review of six articles, observed that the risk of catheter failure due to any complication (occlusion, infiltration, thrombophlebitis, or dislodgement) is higher in short non-integrated peripheral venous catheters (short peripheral catheter and extension line and non-integrated pre-assembled needleless connector) compared to short integrated peripheral venous catheters (where the three parts are pre-assembled). Due to their material and design, short integrated peripheral venous catheters could be more easily stabilised on the skin than short non-integrated peripheral venous catheters, minimising the risk of dislodgement and catheter movement within the vein, thus reducing the risk of mechanical phlebitis and the associated costs [17]. The long duration of cannula does not only depend on the choice of peripheral venous catheters, but also on the adoption of appropriate insertion strategies, which should include: aseptic technique during device handling, using the appropriate type of catheter according to compatible infusions, proper flushing with saline solution (when not in use, before and after medication administration), and adequate monitoring of the dressing and insertion site [17].

Chaiyakunapruk et al. [20], focusing on improving care at the vascular catheter insertion site, compared 2 % chlorhexidine gluconate with povidone-iodine solution. The eight reviewed articles found that requiring 2 % chlorhexidine gluconate instead of povidone-iodine reduced the risk of bloodstream infection by approximately 50 % in hospitalised patients who needed a short-term catheter.

Ray-Barruel et al. [16], in their review, aimed to identify the effectiveness of insertion and maintenance bundles for peripheral venous catheters in preventing bloodstream infections, as well as to describe the components included in the bundles and their implementation strategies. The most described components of insertion bundles were skin preparation with 2 % chlorhexidine gluconate, hand hygiene, insertion site assessment, aseptic technique, and the type of dressing used [16]. The most prevalent components of the maintenance bundles included daily review of the need for the peripheral venous catheter, reminders of the bundle intervention, checking the integrity of the dressing, documenting the insertion and removal of the catheter, and hand hygiene [16]. The implementation strategies covered policy updates, documentation reviews, the introduction of checklists, posters, bedside education, procedure training, regular meetings, catheter audits, and feedback [16].

Luo et al.'s [18] review was the only one related to PICC. The authors studied the effects of quantified and intentional grip exercises in nursing care for patients with PICC. From the 15 articles included in this review, it can be concluded that quantified grip exercises are more favourable than intentional grip exercises in reducing the incidence of thrombosis and PICC-related infections, increasing maximum venous velocity and average blood flow in patients with PICC. Since PICC often remain inserted for extended periods, this can cause venous haemodynamic changes, demonstrated by a reduction in venous blood flow velocity, thereby increasing the risk of venous thrombosis, and may lead to treatment interruption, chronic venous occlusion, and increased healthcare costs [18].

Discussion

This umbrella review synthesises current evidence on nursing-led interventions that prevent and control infection among acutely and critically ill patients with PIVC. The evidence centres around four key domains: skin antisepsis, improvements in catheter material (such as in-line filters, alternative materials, different designs, and lengths), structured insertion and maintenance protocols, and techniques that promote better vascular flow. Each area offers practical implications for clinical practice.

Overall, the strongest evidence [14] recommends three interventions that show moderate positive effects with high-certainty evidence. Firstly, skin disinfection of insertion sites using alcohol-based 2 % chlorhexidine gluconate halves catheter-related bloodstream infections and colonization [20]. More recent research, such as the one from Mimoz and Wang's teams [21,22], finds similar results. These results align with the WHO and the Centers for Disease Prevention and Control (CDC), which strongly endorse alcohol-based 2 % chlorhexidine gluconate for skin disinfection at catheter insertion sites to reduce catheter-related bloodstream infections [5,23,24]. Still highly recommended, selecting integrated short peripheral catheters significantly reduces mechanical failure and occlusion, a moderate benefit supported by good-quality trials, although cost-benefit data remains limited [17]. Abdulelah et al.'s research also associated these systems with longer dwell times and statistically significantly lower risks of catheter failure and occlusion [25].

Our review proposes prescribing structured, quantified hand–grip

Table 2
Checklist for Systematic Reviews and Research Syntheses.

	Chaiyakunapruk et al. (2002)	Niël-Weise, B. et. al., 2010	Ray-Barruel et al. (2019)	Lv and Zhang (2019)	Luo et al. (2023)	Gidaro et al. (2024)	
1. Is the review question clearly and explicitly stated?	Y	Y	Y	Y	Y	Y	
2. Were the inclusion criteria appropriate for the review question?	Y	Y	Y	Y	Y	Y	
3. Was the search strategy appropriate?	Y	Y	Y	Y	Y	Y	
4. Were the sources and resources used to search for studies adequate?	Y	Y	Y	Y	Y	Y	
5. Where the criteria for appraising studie appropriate?	Y	Y	Y	Y	Y	Y	
6. Was critical appraisal conducted by two or more reviewers independently?	Y	Y	Y	U	Y	Y	
7. Were there methods to minimize errors in data extraction?	Y	Y	Y	Y	Y	Y	
8. Were the methods used to combine studies appropriate?	Y	Y	Y	Y	Y	Y	
9. Was the likelihood of publication bias assessed?	Y	Y	Y	U	Y	Y	
10. Were recommendations for policy and/or practice supported by the reported data?	U	U	U	U	U	U	
11. Where the specific directives for new research appropriate?	U	Y	Y	U	Y	Y	**Methodological quality mean**
TOTAL	8/11	10/11	10/11	7/11	10/11	10/11	
%	81,8%	90,9%	90,9%	63,6%	90,9%	90,9%	84,83 %

Legend: Y = Yes; N= No; U = Unclear; NA = Not Applicable; I = Include; E = Exclude; SFI = Seek Further Info.

exercises as its third highly recommended intervention [18]. This robust evidence can be adopted as standard supportive care for extended-dwell PICC. It lowers PICC-related thrombosis and infection, especially when patient education is incorporated to promote adherence, and agrees with other findings [26,27].

This umbrella review also acknowledges the value of insertion and maintenance bundles for PIVC and risk-targeted strategies. Still, due to diverse study designs and variable implementation fidelity, the evidence remains of low certainty.

Risk-targeted strategies, such as drug class, insertion site selection, dwell time, and catheter material, are recognised as factors that can reduce the incidence of phlebitis, with evidence emphasising these modifiable risks. However, they are limited by indirectness and diverse definitions. Globally, it can be noted that reducing catheter dwell time to under 96 h lowers infection and phlebitis risk [19] and choosing appropriate catheter materials, such as polyethene or Vialon instead of Teflon [19], decreases inflammation and infection risks [19], as Lulie and Cernuda-Martínez and their teams [28,29], as well as the CDC [30], have also identified.

Despite its limited certainty, these results are consistent with other studies, confirming the significance of bundles and effective work strategies. Key components include hand hygiene, aseptic technique, 2 % chlorhexidine for skin antisepsis, regular site assessment, and proper dressing selection [16,20]. Specifically for maintenance bundles, it is recommended to reassess the necessity of the catheter daily, the integrity of dressings, system changes every 4 to 7 days, proper flushing, minimising three-way stopcocks, and accurate catheter documentation [16,17], in line with other recommendations that emerge from studies focused on evidence-informed development of bundles [31,32] and the analysis of their implementation and results [33,34]. Complementing, implementing standardized protocols and staff training has significantly reduced phlebitis incidence rates significantly [21,22,33].

Using in-line filters during medication infusion has been demonstrated to reduce phlebitis and extend catheter lifespan. However, with minor positive effects due to methodological diversity and small samples of the included studies, this suggests a weaker recommendation [15]. Villa et al. recognized this intervention with the same trend in perioperative PIVC, finding that the incidence of postoperative phlebitis within 48 h was lower with filtration. According to these authors, microparticle-retaining in-line filters strongly protect against early postoperative phlebitis and slightly extend the lifespan of peripheral catheters [35]. On the contrary, Ayres and Mahler also defend that recommendations for using these filters are often predicated upon fragmented and incomplete information. Most observational studies fail to provide sufficient scientific support for broad-based routine use [36]. In the face of this, this specific intervention should be interpreted cautiously and individualized, based on patient context and available resources.

Recovering the broader purpose of this umbrella review, which is to generate evidence-informed recommendations to support clinical decision-making, improve patient safety, and contribute to effective infection prevention strategies in high-risk healthcare settings, led to a more in-depth analysis of our findings.

Anchoring our findings within the Learning-organisation and the Patient-safety-culture frameworks enhances their relevance and durability [37,38]. *Systems thinking* explains why three nursing-led practices – alcohol-based 2 % chlorhexidine skin antisepsis, integrated short peripheral catheters, and structured hand-grip exercise programmes – produce significant downstream benefits, such as fewer catheter-related infections, reduced mechanical failure or occlusion, and lower PICC-associated thrombosis. *Shared vision* and *Team learning* translate this evidence into reliable practice through multidisciplinary bundle roll-outs, bedside coaching, and feedback loops. This challenges legacy mental models (e.g., routine time-based replacement or indiscriminate filter use) with up-to-date data [37]. These actions align with high-reliability safety culture domains: leadership support, open

Table 3
Summary of Findings (GRADE rating).

Effects of quantified versus wilful grip exercises for the prevention of peripherally inserted central venous catheter (PICC) related thrombosis			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of PICC-related thrombosis and infection	Effective improvement with moderate positive effects**	1.741 participants (15 articles)	⊕⊕⊕⊕ HIGH
Efficacy of in-line filters in reducing infusion-related phlebitis			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of infusion-related phlebitis	Effective improvement with small positive effects *	1.681 participants (11 articles)	⊕◯◯◯ VERY LOW
Efficacy of skin disinfection with chlorhexidine gluconate compared with povidone-iodine solution in preventing catheter-related bloodstream infection			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of catheter-related bloodstream infection	Effective improvement with moderate positive effects**	3404 participants (8 articles)	⊕⊕⊕⊕ HIGH
Incidence of Catheter colonization	Effective improvement with moderate positive effects**	3404 participants (8 articles)	⊕⊕⊕⊕ HIGH
The effectiveness of peripheral intravenous catheter (PIVC) insertion and maintenance bundles on preventing adverse events (e.g., phlebitis)			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of phlebitis)	Effective improvement with small positive effects *	200 a 2 millions participants (13 articles)	⊕⊕OOLOW
Incidence of Bloodstream infection	Effective improvement with small positive effects *	200 a 2 millions participants (13 articles)	⊕⊕OOLOW
Estimate the incidence of peripheral intravenous catheter-related phlebitis associated to duration of catheters' use, the type of medication administered, the local of peripheral venous catheter insertion and the use of Teflon catheters versus violon catheters			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of phlebitis	Effective improvement with small positive effects *	15.791 participants (35 articles)	⊕⊕OOLOW
Effects of quantified versus wilfull handgrip exercises for the prevention of peripherally inserted central venous catheter (PICC) related thrombosis			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of PICC-related thrombosis and infection	Effective improvement with moderate positive effects**	1.741 participants (15 articles)	⊕⊕⊕⊕ HIGH
Effect of integrated short peripheral catheters compared to non-integrated short peripheral catheters on the risk of catheter failure, occlusion, infiltration, phlebitis and dislodgement.			
Outcome measures	**Impact**	**N° of participants (studies)**	**certainty of the evidence (GRADE)**
Incidence of catheter failure, occlusion	Effective improvement with moderate positive effects**	4.727 participants (12 articles)	⊕⊕⊕⊕ HIGH
Incidence of infiltration, phlebitis and dislodgement	Effective improvement with small positive effects *	4.727 participants (12 articles)	⊕⊕OOLOW

*The effect is interpreted as small positive because it is less than 0.40 **The effect is interpreted as moderate positive because it is greater than 0.40 and less than 0.80.
GRADE Working Group grades of evidence:
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

communication, and organizational learning [38]. They turn strong evidence into standard work that professionals can consistently apply at the bedside.

For elements supported by lower-certainty evidence – risk-targeted strategies (choice of site, dwell time, and catheter material) and in-line filtration – a just culture is essential: teams should personalize decisions, openly review outcomes, and be willing to de-implement practices when benefits are uncertain or dependent on context. Insertion and maintenance bundles remain valuable, provided organizations invest in training, observation, and rapid-cycle improvement to ensure fidelity (hand hygiene, aseptic technique, 2 % chlorhexidine skin prep, daily device review, and meticulous documentation).

Taken together, the path to safer PIVC care involves what is done, how it is learned and how it complies with the recommendations presented in national and international guidelines [4,7–9,23,24,30]. This consists of integrating evidence into continuous systems, monitoring what is essential, and swiftly adapting to patient risks, local resources, and new data.

Limitations and implications for practice and future research

Most of the identified interventions relate to short peripheral venous catheters, a limitation of the present study. Another major limitation of this umbrella review is the substantial heterogeneity observed among the included systematic reviews regarding study populations, intervention characteristics, and outcome measures, which restricts comparability, synthesis, and the generalisation of findings. To overcome these limitations, future research should explore other types of PIVC and aim to improve methodological consistency by adopting standardized criteria for selecting populations, interventions, and outcome measures.

The findings of this study can assist professionals and organisations in developing practices and healthcare policies to improve care delivery in this area. Specifically, integrating alcohol-based 2 % chlorhexidine gluconate, adopting integrated short peripheral catheters, and implementing structured hand-grip exercise programmes into standard protocols are measures that healthcare organisations can introduce to reduce infection, thrombosis, and mechanical complications related to PIVCs. Simultaneously, strict adherence to insertion and maintenance bundles, supported by staff training, monitoring systems, feedback mechanisms, and the context-sensitive application of lower-certainty strategies, should be incorporated into patient-safety frameworks to ensure consistent, evidence-based, and sustainable vascular access care.

Conclusion

This umbrella review highlights a hierarchy of nursing-driven measures for safeguarding vascular access. Three interventions stand out with the strongest support: antisepsis of the insertion site with 2 % chlorhexidine in alcohol, factory-integrated short peripheral catheters, and prescribed, measured hand-grip regimens for patients with long-dwelling PICCs. Each is supported by moderate-to-high-certainty evidence, leading to significant reductions in bloodstream infection, mechanical device failure, and catheter-related thrombosis. Embedding these practices within a learning-oriented, safety-conscious workplace—where systems thinking, transparent communication, and leadership endorsement are routine—should allow teams to reproduce these benefits reliably at the bedside.

Other strategies remain promising but uncertain, such as fine-tuning dwell time, selecting low-risk insertion sites or alternative catheter materials, and adding in-line filters. Until more robust data are available, their use should be adapted to the situation, guided by real-time audits, open discussions of outcomes, and a willingness to withdraw or modify protocols when benefits are unclear. Although literature still relies heavily on studies of short peripheral catheters and shows a wide variety of methodologies, the overall trend is clear: hospitals that combine the three strongly supported measures with well-structured insertion and maintenance bundles, comprehensive staff training, and immediate feedback mechanisms are more likely to achieve the most sustainable reductions in catheter-associated harm.

CRediT authorship contribution statement

José Costa: Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Joana Teixeira:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Eliana Sousa:** Writing – original draft, Visualization, Software, Methodology. **Maria do Rosário Pinto:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Statement of financial support

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Ethics declarations

This umbrella review is based entirely on previously published systematic reviews and does not involve any new studies with human participants or animals conducted by the authors. The manuscript has not been published previously, is not under consideration elsewhere, and has been approved by all authors. Institutional approval was not required for this type of research. If accepted, this article will not be published elsewhere in the same form, in English or in any other language, including electronically, without the written consent of the copyright-holder.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2025.104250.

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