

Prevention of Injuries in Children with a Peripheral Intravenous Catheter: A Modified Evidence-Based Nursing Practice Guideline

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Abstract

Many children in African hospitals need a peripheral intravenous catheter (PIVC). Babies and children are particularly susceptible to serious harm from PIVC-related injuries. Nurses often regard a PIVC as a routine, low-risk intervention. Globally recommended practices include establishing a structured care pathway, recognising that PIVC management begins before insertion. Evidence-based care for children with PIVCs reduces complications and healthcare costs. Existing guidelines on managing PIVCs in infants and children are generally written for higher-resourced settings or are not specific to a paediatric population. This study aimed to review existing practice guidelines to provide accessible and implementable guidelines for caring for hospitalised babies and children up to the age of 13 years, in lower-resourced paediatric inpatient health facilities in Namibia. We applied a structured process for modifying existing high-quality guidelines developed in higher-resourced settings for implementation in lower-resourced contexts. This process involved identifying suitable guidelines for modification and rigorous guideline modification, resulting in a context-specific guideline. The modified guideline ensured that recommended practices related to pain management, difficult insertions and infection prevention are implementable. However, seeing PIVCs as unlikely to cause serious harm can lead to insufficient assessment and surveillance of PIVC injuries. We therefore produced a user-friendly guideline focused on high-impact areas of nursing practice, emphasising that nurses can avoid injury to children by properly managing a PIVC.

Keywords: injury prevention; nursing; peripheral intravenous catheter; child; South Africa

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Introduction

Prompt insertion of a peripheral intravenous catheter (PIVC) is a mainstay of treatment for many hospitalised children in Africa for conditions including severe dehydration, acute malnutrition and serious infection (World Health Organization [WHO] 2013). Peripheral cannulation is widely regarded by health professionals as a routine, low-risk intervention, but the potential for serious harm arising from sub-optimal practice is under-recognised (Nickel 2020).

Children, especially neonates and infants, are susceptible to PIVC-related injuries because of the following factors (Hackenberg et al. 2021). Firstly, specific anatomical traits of babies and children include thin skin with little subcutaneous fat and smaller blood vessels with fragile walls (Hackenberg et al. 2021). Secondly, babies and children also have different ways of communicating than adults do, which can make it more challenging for healthcare workers to determine whether they are in pain. Furthermore, developmental factors may mean that babies and children are not able to obey instructions to avoid displacing a cannula (Hackenberg et al. 2021; Huang, Huang, and Hu 2021; Suliman et al. 2020; Tripathi, Kaushik, and Singh. 2008).

The introduction of infection through a PIVC is a serious concern. Localised phlebitis in particular can quickly progress to bloodstream infection and infective endocarditis (Nickel 2019; Yasuda et al. 2021). Phlebitis, which is characterised by redness and warmth around the PIVC insertion site or along the vein path, can have infectious, mechanical and chemical causes (Suliman et al. 2020). Early signs, including pain and localised swelling, can be easily missed in a baby or child who is already distressed. Serious harm can result from mechanical and chemical injury associated with PIVCs, in addition to that caused by administered intravenous fluids, blood products, medication with irritant and vesicant properties and parenteral nutrition (Hackenberg et al. 2021; Ullman et al. 2020). Such injury may include complications from nerve and/or tendon damage, scarring, deformities and compartment syndrome, potentially leading to permanent disfigurement, functional impairment and amputation (Hackenberg et al. 2021).

The nature and severity of the damage depend on the nature and volume of the infused or extravasated fluid. Even commonly used infusates regarded by healthcare workers as routine and harmless may lead to serious complications, for example cellulitis and necrosis following glucose infiltration (Ben Abdelaziz et al. 2017; Hackenberg et al. 2021). Less serious complications can delay the administration of urgently needed treatment. Overall, complications from PIVCs can be traumatic for children and their families and can contribute to increased healthcare costs and hospitalisation time (Dos Santos et al. 2022; Hackenberg et al. 2021). A global study of 47 countries from seven continents, including Africa, found widespread sub-optimal practice related to PIVC management (Ullman et al. 2020). Practice commonly fell short in terms of selecting an appropriate insertion site, appropriate catheter size/gauge, securement technique, poor dressing integrity and idle catheters (Ullman et al. 2020).

Guidance on PIVC management in infants and children is widely available but is generally written for health practitioners in higher-resourced settings. Reducing fragmentation of care by creating a care pathway and teaching all stakeholders that a structured process reduces complications from intravenous therapy improve efficiency and lower costs (Moureau 2019). Similarly, fewer PIVC injuries were reported after the implementation of care bundles and guidelines in three mixed-method studies (Chan et al. 2020; Kleidon et al. 2019; Mulemba et al. 2021). Optimal PIVC management entails (1) correct assessment and vein and device selection, (2) correct insertion and training, (3) correct management, and (4) correct evaluation (Moureau 2019).

The principal investigator has wide experience of nursing new-borns and children in various Namibian neonatal and paediatric intensive care units, in both state and private hospitals. PIVC-related injuries have been observed among new-borns and infants in these in-patient settings. Corresponding to nursing practice globally (Nickel 2020), Namibian hospitals that were the target for this project tended not to have a consistent approach to categorising or reporting PIVC-related injuries. Nurses typically regarded PIVCs as benign and unlikely to cause serious harm and showed little awareness of preventing, recognising or managing harm arising from a failing PIVC. Widespread variations in practice were observed, and practice did not conform to global best practices.

The authors were not aware of evidence-based guidelines specifically developed for nurses in lower-resourced settings. This was the central knowledge gap this project set out to address. In Namibia, as with many other African health systems, nurses struggled to implement guidelines from higher-resourced settings. The feasibility of implementing existing PIVC-related guidelines in settings where patients are often hyperacute and unstable, patient turnover is high and staffing levels are low is a further consideration.

Aim of the Study

The central question addressed by this study was how to prevent avoidable injury and harm from PIVCs by modifying existing evidence-based guidelines to provide a feasible and accessible nursing-practice guideline for caring for hospitalised new-borns and children (up to age 13) in Namibia.

The aim of this study was to identify suitable guidelines for modification and perform rigorous guideline modification with a view to develop evidence-based recommendations focused on high-impact areas of nursing practice.

Process

The approach developed by the South African Guidelines Excellence Project (Dizon, Machingaidze, and Grimmer 2016) was used to generate the abovementioned guideline. This process involved the following steps: (1) identification of existing guidelines, (2)

appraisal using the International Centre for Allied Health Evidence (iCAHE) guideline quality appraisal tool, (3) compilation of all evidence-based recommendations and rationales (4) modification of recommendations, (5) assigning of level of evidence and grade of recommendation, and (6) development of an end-user flow chart. Because these steps proceeded iteratively, we present the methods and results together in this section. Attention is drawn to the full table of recommendations, which is attached as a supplementary file.

We followed a purpose-designed approach to modifying existing high-quality guidelines developed in higher-resourced settings (Dizon, Machingaidze, and Grimmer 2016). This avoided the pitfalls of unnecessary and resource-intensive *de novo* guideline development, following a structured approach to modification which preserved the desired purpose and outcome of the recommendation while considering the country's economic status and health system. These modification strategies promoted inclusive evidence-based practice (Dizon, Machingaidze, and Grimmer 2016; Kredo et al. 2016). Given nurses' high workloads, designing new clinical practice guidelines can be time consuming, costly and discouraging. This influences the quality of care provided to patients and decreases the use of evidence-based care. Therefore, finding rigorous but realistic methods to support evidence-based care is essential.

Step 1: Identification of Existing Guidelines

A structured and inclusive search was carried out to identify clinical practice guidelines, standards, best practices or recommendations on the management of PIVCs in hospitalised children. Key words and search terms were selected with advice from a specialist librarian and included “peripheral intravenous catheter,” “management OR care” and “children” or MESH equivalents. The search was executed in January 2022 in six guideline libraries and portals: The Royal Children's Hospital Melbourne (TRCHM) (<https://www.rch.org.au/home/>), SickKids Toronto Clinical Practice Guidelines (<https://www.sickkids.ca/en/care-services/for-health-care-providers/clinical-practice-guidelines/>), Children's Health Ireland at Crumlin (<https://childrenshealthireland.ie/>), Guidelines International Network (<https://g-i-n.net/>), United Kingdom National Institute for Health and Care Excellence (<https://www.nice.org.uk/>), and Scottish Intercollegiate Guidelines Network (<https://www.sign.ac.uk/>). PubMed and CINAHL were searched, but the search was limited to items published in English between 2018 to 2022 with full text available. Google Scholar searches were limited to the first 20 items (Dobbins 2017). No limitations were placed on publication type, as piloting suggested that this would excessively limit the results (Graham and Harrison 2005; Rush University Medical Center 2022). Items for inclusion were selected by one researcher working independently, following a three-step screening process (titles, abstracts and full text).

The search yielded 374 unique items (Figure 1). Following de-duplication and relevance screening by title and abstract, four items met the inclusion criteria and were selected for further appraisal (Table 1). Two items were guidelines on “Peripheral Intravenous

(IV) Device Management” by The Royal Children’s Hospital Melbourne (2018) and “Management of Peripheral Intravenous Catheters Clinical Care Standard” by the Australian Commission on Safety and Quality in Health Care (2021); two were care bundles: “Implementation of a Paediatric Peripheral Intravenous Catheter Care Bundle: A Quality Improvement Initiative” (Kleidon et al. 2019) and “S.T.I.C.K: A Quality Improvement Pediatric IV Infiltration Prevention Bundle” (Watterson et al. 2018).

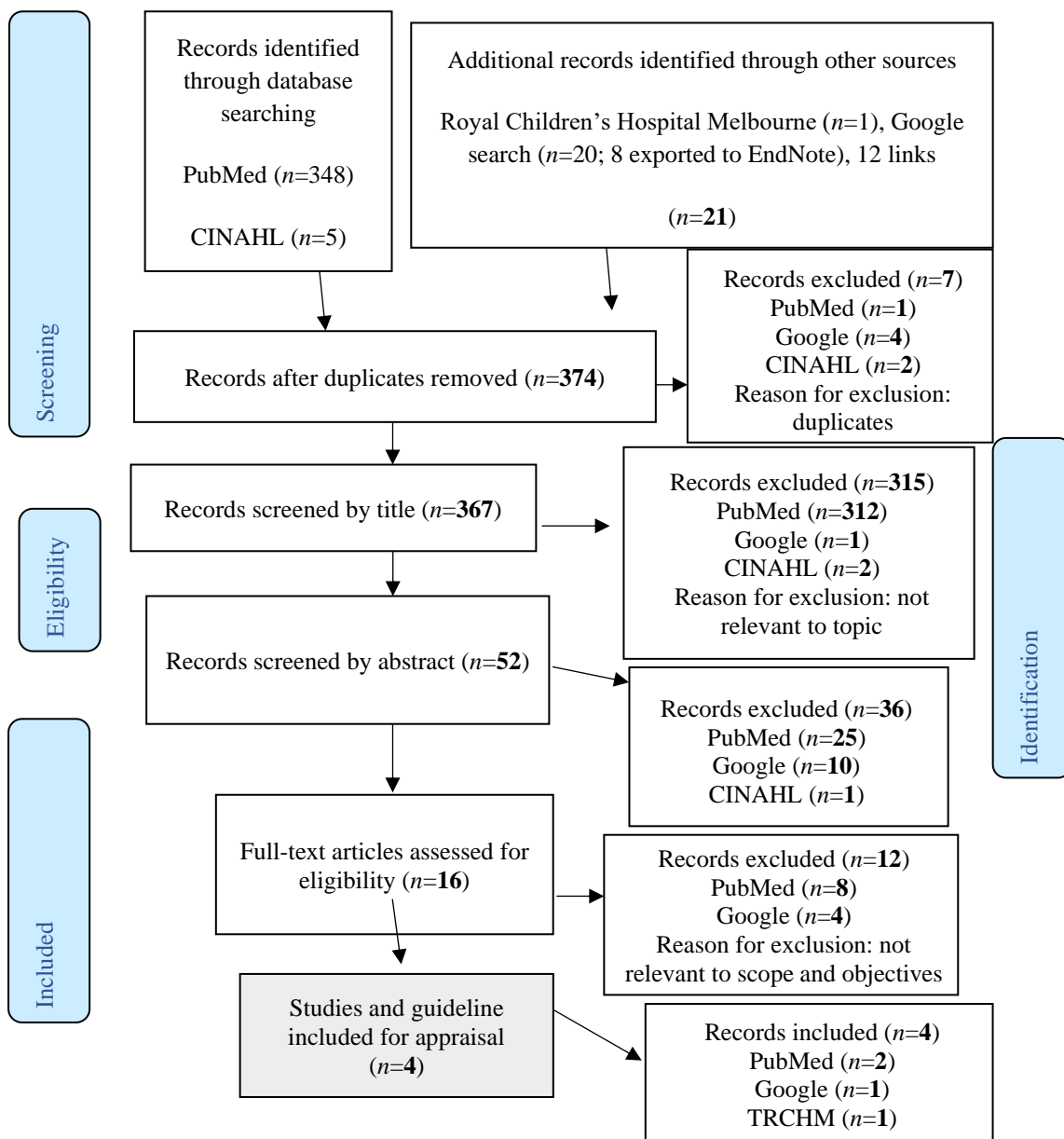


Figure 1: PRISMA flow diagram

Table 1: Summary of existing peripheral intravenous catheter (PIVC) guidelines identified through database searching

Author	Clinical practice guideline	Organisation	Year	Population	Scope	Place of publication
Australian Commission on Safety and Quality in Health Care	“Management of Peripheral Intravenous Catheter Clinical Care Standard”	The Australian Commission on Safety and Quality in Health Care	May 2021	Children and adults (all ages)	PIVC insertion, management and removal	Australia
The Royal Children’s Hospital Melbourne	“Peripheral Intravenous (IV) Device Management”	The Royal Children’s Hospital Melbourne	2018 (Currently under review)	Children	PIVC insertion, management and removal	Australia
Watterson et al.	“S.T.I.C.K: A Quality Improvement Pediatric IV Infiltration Prevention Bundle”	United States	2018	Paediatric	To reduce PIVC infiltration incidents	United States
Kleidon et al.	“Implementation of a Paediatric Peripheral Intravenous Catheter Care Bundle: A Quality Improvement Initiative”	Australia	2019	Paediatric	Quality improvement strategies for PIVC insertion and management	Australia

Step 2: Appraisal of Existing Guidelines

Critical appraisal was performed to ensure that the guidelines identified above were formulated according to recommended standards and to determine the rigour of development (Summers and Payakachat 2006) to select high-quality guidelines for synthesis and modification (Grimmer et al. 2016). The South African Guidelines

Excellence Project recommended the iCAHE quality appraisal tool as a rapid and efficient quality assessment tool specifically for busy healthcare workers (Grimmer et al. 2016; University of South Australia n.d.). The guidelines were scored across the seven domains of the iCAHE tool by one researcher working independently (Table 2).

Table 2: Peripheral intravenous catheter guideline appraisal using iCAHE quality appraisal tool

Guideline details	Availability	Date	Underlying evidence	Developed by	Guideline purpose and users	Ease of use	Total score (%)
Title: “Management of Peripheral Intravenous Catheter Clinical Care Standard” Author: Australian Commission on Safety and Quality in Health Care Year: 2021 Institution: N/A Country: Australia	3	2	4	2	1	1	93
Title: “Peripheral Intravenous (IV) Device Management” Author: The Royal Children’s Hospital Melbourne Year: 2018 Institution: The Royal Children’s Hospital Melbourne Country: Australia	3	3	2	2	1	1	86
Title: “Implementation of a Paediatric Peripheral Intravenous Catheter Care Bundle: A Quality Improvement	2	2	1	2	1	1	64

Initiative” Author: Kleidon et al. Year: 2019 Institution: Queensland Children’s Hospital Country: Australia							
Title: “S.T.I.C.K.: Quality Improvement Pediatric IV Infiltration Prevention Bundle” Author: Watterson et al. Year: 2018 Institution: Arnold Palmer Hospital for Children, Orlando, FL Country: USA	2	2	1	2	1	1	64

Scores ranged from 94 to 64%. The two clinical practice guidelines demonstrated a high level of rigour of development and integrated strong evidence from multiple sources, which enhanced their credibility. The two care bundles were both presented as primary research papers but had less strength as single studies. However, relevance was also a key consideration. For this reason, the Australian Commission on Safety and Quality in Health Care guideline on “Management of Peripheral Intravenous Catheters Clinical Care Standard” was chosen because of its high score and relevance to the scope and objectives of this study. The care bundle developed by Kleidon et al. (2019) was also selected for modification. Despite receiving a lower iCAHE score, its purpose and results were highly relevant to the scope and purpose of this study, and aspects of its user-friendly structure could be integrated with the Australian Commission on Safety and Quality in Health Care guideline. The remaining two items were excluded at this stage, as they were deemed less accessible to nurses in Namibia.

Step 3: Compilation of Evidence Base

As part of our rigorous guideline development process, we assessed the quality of the evidence prior to guideline modification, thus ensuring that recommendations were based on standardised criteria rather than the reviewers’ opinions. This not only guaranteed that high-quality information was extracted but could also improve consumer adherence to the implemented guideline and overall quality of patient care

(Summers and Payakachat 2006; University of South Australia n.d). All recommendations and associated evidence-based rationales were tabulated.

Scrutiny of the evidence-based rationales for the recommendations established that the highest impact interventions were infection prevention and control, assessment or inspection of the PIVC site for early detection of phlebitis, and prompt removal of the PIVC when it malfunctions or is no longer needed. When medications with irritant or vesicant properties are administered, the evidence strongly indicated that extreme caution should be exercised.

Step 4: Modification of Recommendations

The tabulated recommendations and associated evidence-based rationales were assessed for applicability to the intended setting. Because these recommendations were developed in higher-resourced settings, generalisability into a low- to middle-income health system required consideration of contextual factors that may hinder uptake and implementation. Dizon, Machingaidze, and Grimmer's (2016) approach is designed to support modification while maintaining the intended purpose and achieving the expected outcomes of the primary recommendation. The goal of modifying clinical practice guidelines is to enhance support and uptake during implementation without harming patients or dramatically increasing costs. Furthermore, considering the context is vital in terms of end-user attitude, acceptance, implementation and compliance with guidelines (Dizon, Machingaidze, and Grimmer 2016).

Areas where current practice varied from the evidence-based recommendations were identified, drawing on the principal investigator's knowledge of current practice in the target setting, where nurses are often busy and overstretched. Some widely observed aspects of nursing practice were of particular concern, including hand washing, hand disinfection, PIVC insertion, PIVC fixation or securing technique, assessment of the PIVC site, disinfection of key parts (access port) and caution when administering infusions with irritant and vesicant properties. These variations from evidence-based practice were likely to be contributing to injuries. This insight gave structure to the presentation of the modified recommendations.

Each recommendation was considered and evaluated using the modification steps (adopt, contextualise and adapt). Recommendations can be adopted when they require no modification for implementation in the intended setting. Contextualisation addresses barriers to effective implementation and seeks additional information to ensure feasible implementation of the recommendation without changing the desired purpose and outcome. Adapting recommendations ensures that a safe alternative with a similar purpose and outcome but different intervention is selected.

Researchers need to consider the economic status of the country, health system, workforce, availability of essential resources and capacity to provide training as part of an inclusive evidence-based approach (Dizon, Machingaidze, and Grimmer 2016;

Kredo et al. 2016). In this case, relevant considerations included the availability of technological resources, such as infrared lighting, chlorhexidine and transparent dressing, which are not always available or in stock in the target setting(s). Ben Abdelaziz et al. (2017) reported similar considerations in other lower-resourced settings. This required adaptation and contextualisation of recommendations related to pain management, difficult insertions and securing of canulae.

Knowledge of current nursing practice in the target setting was also related to the high-impact areas of the recommendations for prioritisation. Current local practice was noted to be at variance with evidence-based recommendations regarding assessment and understanding of intravenous access needs, maximising first attempt, routine use (inspection, access and flushing) and ongoing review of need.

It was noted at this step that the recommendations of both selected sources broadly followed the four quadrants of care established by Moureau (2019) in that optimal PIVC management involves (1) correct assessment and vein and device selection, (2) correct insertion and training, (3) correct management and (4) correct evaluation (Moureau 2019). This was integrated with the steps of the nursing process (Toney-Butler and Thayer 2022) and used as a framework for grouping and synthesising recommendations from the original guidelines based on similarity in meaning as well as relevance to the scope and purpose of this study to produce a set of draft modified recommendations.

Step 5: Assignment of Level of Evidence and Grade of Recommendations

The modified recommendations were appraised for level of evidence and grade of recommendation with reference to the “Oxford Centre for Evidence-Based Medicine: Levels of Evidence (March 2009)” (University of Oxford 2009). The levels of evidence of the final modified recommendation were scored from levels I to V, with level I representing highly robust evidence and level V representing primary studies of lower quality when assessed individually. The grades of recommendation ranged from A to D, with A encompassing studies consistent with level I studies and D encompassing those consistent with level V studies or troublingly inconsistent or inconclusive studies of any level. Recommendations involving legal or regulatory requirements were also indicated. The table with the final modified recommendations, level of evidence and grade of recommendation is provided as a supplementary file.

Step 6: Development of End-User Flow Chart

Flow charts can communicate, teach or refresh complex concepts in simple and engaging ways (Kimber, Cromley, and Molnar-Kimber 2018). They can assist team members in developing a shared understanding of a process and applying that knowledge to collect data, identify problems, focus discussions and identify resources (Institute for Healthcare Improvement 2017). Using a flow chart as an end-user document improves adherence and provides an easy-to-follow guide (Kimber, Cromley, and Molnar-Kimber 2018). Our flow chart design (Figure 2) was influenced by

Moureau’s four quadrants of PIVC care aligned with the nursing process, which is a familiar concept to nurses.

Further consultation with two additional paediatric nurse specialists and educators about the flow chart prompted revision of the initial draft to improve signposting of the most relevant points. Discussion with consultees helped us to reach consensus on the escalation pathway.

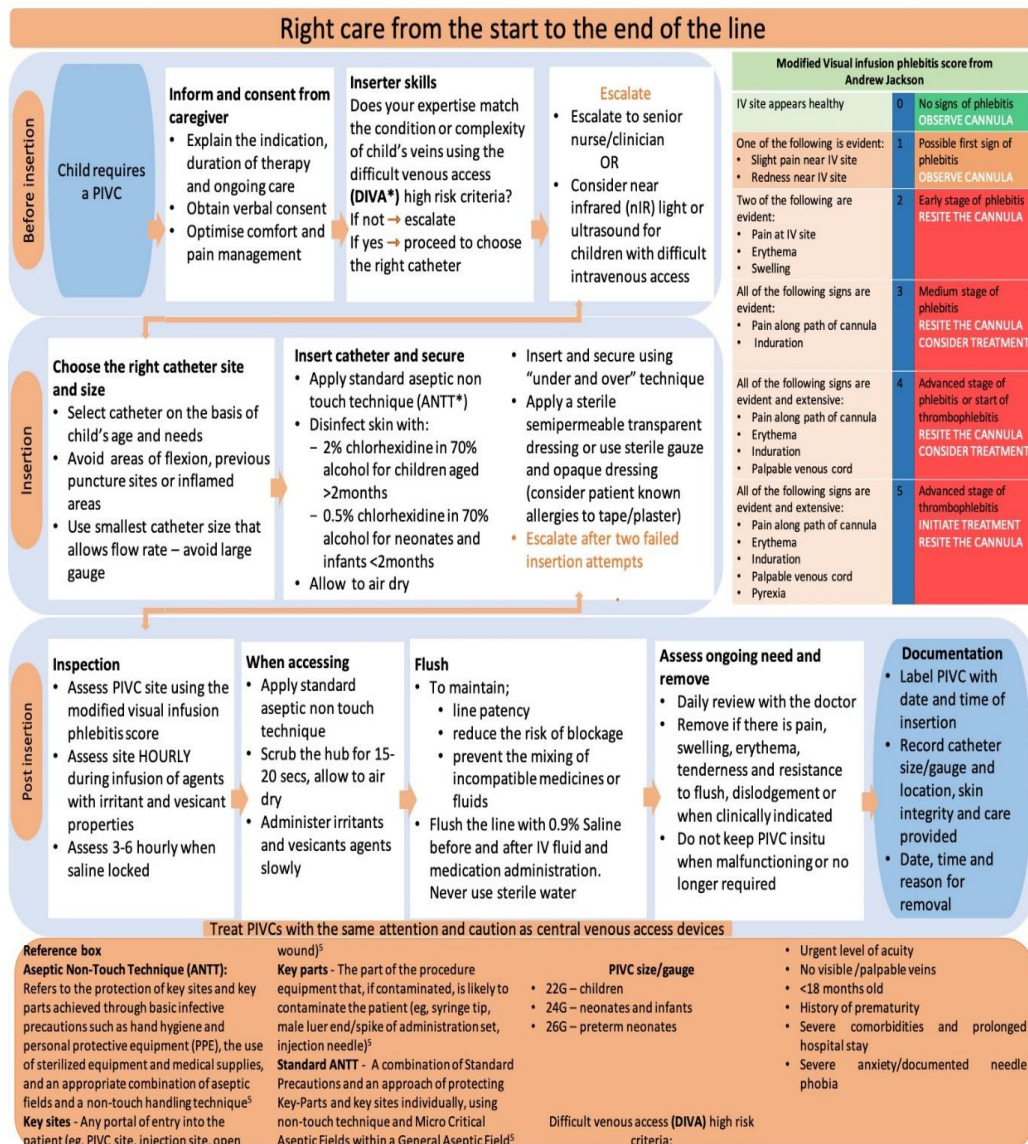


Figure 2: Flow chart of recommended nursing practice when a peripheral intravenous catheter (PIVC) is required in a paediatric patient

Obtaining Expert Input

All six steps above were supported by expert input via consultative activities. During Step 2 (appraisal of existing guidelines), as recommended by Dizon, Machingaidze, and Grimmer (2016), suitable expert clinicians were identified and asked to advise on the study. The purpose of this consultation was to re-examine and discuss the modified recommendations to ensure alignment with the local context and to highlight standards pertinent to good PIVC outcomes. Consultation maximises the application of a range of thoughts and reduces bias in situations where no scientific evidence exists, aiding the formulation of relevant recommendations and standardising clinical decision-making processes (Aromataris and Munn 2020; WHO Western Pacific Region 2012). Experts consulted included a senior paediatric nurse specialist at a tertiary hospital in Namibia with experience in neonatal and paediatric intensive care nursing and an advanced practice paediatric nurse specialising in critical care and nephrology. Co-consultation was done with peers who were Master of Nursing students in child nursing at the University of Cape Town, South Africa. This co-consultation focused on evaluating the type of modification, adequacy, effectiveness, applicability and attainability of the recommendations in lower-resourced African hospitals.

Consultation revealed broad support for the modified recommendations as well as adaptations and contextualisation that had been carried out. A small number of additional context-specific clarifications were suggested and included to improve implementation. One consultee shared the “Phlebotomy, Blood Donation and Parenteral Therapy” guideline of the Namibian Ministry of Health and Social Services, which has a section on paediatric and neonatal patients. These recommendations were subsequently benchmarked. They recommended the use of 70% isopropyl alcohol swabs and avoidance of chlorhexidine, if possible, in very young infants (Ministry of Health and Social Services [MOHSS] 2015). This guideline did not explicitly state that this is contraindicated for neonates because of the risk of skin burns. The issue was discussed with consultees, and consensus was reached to include a skin-disinfecting recommendation specific to neonates and a note to increase awareness of the risk of using 2% chlorhexidine in this population.

Discussion

The structured six-step process reported above resulted in a modified and context-specific guideline designed specifically for nurses in lower-resourced paediatric inpatient health facilities in Namibia. PIVC management does not begin after its insertion but involves careful planning beforehand, which includes assessment of its need, exploring alternative routes, the inserter’s competency and skills, hand hygiene, the right size catheter for the child’s age, correct securing technique, correct type of dressing and prompt removal when the catheter is no longer needed (Australian Commission on Quality and Safety Health Care 2021; Kleidon et al. 2019). The guideline was aimed at reducing preventable injuries from infectious, mechanical and chemical causes while ensuring a less costly and traumatic hospital stay.

The modified recommendations were faithful to the original guidelines produced in higher-resourced Australian settings but differed in important areas. Key areas of difference included pain management, recommendations regarding difficult insertions and recommendations regarding infection prevention.

Pain management is an important aspect of care when preparing a child for PIVC insertion. However, the topical anaesthetic creams recommended in the original guidelines were not listed in the Namibian hospital formulary and are not widely available in the target setting. Non-nutritive sucking using a pacifier was also recommended in babies, but the use of pacifiers is prohibited in many Namibian hospitals due to breastfeeding policies. Review of the evidence established that breastfeeding was a suitable evidence-based alternative for babies and that the presence of a family caregiver (usually the mother) could be effective in comforting an older child (Naik, Mantha, and Rayani 2019; North et al. 2020; Pillai Riddell et al. 2015; Power et al. 2021).

For difficult insertions, the original recommendations advised use of ultrasound equipment. However, this may not be achievable in the target setting, and thus we provided an additional recommendation to use an alternative, such as infrared light technology, to aid vein visualisation while sharing evidence-based recommendations to aid resource advocacy (Gorski et al. 2021).

The single most important strategy for preventing healthcare-associated infections is effective hand hygiene. Access to hand-washing facilities (soap and water) and alcohol-based hand rub is pivotal (Loveday et al. 2014; National Health and Medical Research Council [NHMRC] 2019; O’Grady et al. 2011).

Conclusions

This project was able to produce a modified evidence-based practice guideline that answered the question, “How can avoidable injury and harm from PIVCs be prevented?” The project successfully addressed the absence of existing context-specific guidelines by modifying existing evidence-based guidelines to provide a feasible and accessible nursing-practice guideline for caring for hospitalised new-borns and children (up to age 13) in Namibia.

Hospitalisation is often a distressing experience for children, especially if healthcare-associated injuries from a PIVC are involved. These injuries are associated with serious physical, mental and even legal implications, and therefore nurses need to focus on preventing them. Seeing this intervention as least harmful can lead to insufficient prevention, assessment and surveillance of related injuries. The guideline developed was aimed at sensitising nurses to the evidence-based principles of managing a PIVC in hospitalised children.

Recommendation for Nursing Practice

Nurses' 24-hour bedside presence is key to PIVC assessment and management. Managing this device should align with the components of the nursing process (Toney-Butler and Thayer 2022): (1) assessment and diagnosis, (2) planning, (3) implementation, and (4) evaluation. Assessment and diagnosis involve identifying the need for a PIVC and the viability of alternative routes. Planning ensures that the required resources for PIVC insertion are available, e.g., the correct catheter size, an adequate light source, vein visualisation aids and the inserter's skills and competence. Implementation involves the insertion of the catheter, correct securing technique and application of transparent or clean opaque dressing. Evaluation encompasses the routine care of the PIVC site before and after fluid or medication administration as well as assessing the integrity of the site and ongoing need for a catheter.

Nurses need to be aware of intravenous fluid and medication that could increase the risk of phlebitis and promptly recognise early stages of injury. Documentation of skin integrity around the PIVC site is crucial, not only for recording, but it may also help to establish which medications contain irritant and vesicant properties. This could inform nurses about which medications to pay special attention to. Reporting of injuries is suboptimal, and data are needed to inform quality improvement.

Further Research

Further research to quantify the extent and impact of PIVC-related injuries in babies and children in the African context would help to raise awareness of this important issue and provide a baseline for improvement.

It was challenging to reconcile the recommendations related to use of single-use sterile gloves (Recommendation 4) and topical anaesthetics (Recommendation 2), neither of which are affordable in the target context. While evidence-based alternatives were identified, research to assess affordable evidence-based alternatives to practices involving higher-cost drugs and disposables would be of value.

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