Rev Rene. 2025;26:e94280.
DOI: 10.15253/2175-6783.20252694280
www.periodicos.ufc.br/rene

Original Article

Knowledge of pediatric nursing professionals about infiltration and extravasation in newborns and children

Conhecimento dos profissionais da enfermagem pediátrica sobre infiltração e extravasamento em recém-nascidos e crianças

How to cite this article:
Cerqueira EAC, Bittencourt IS, Caldas MOL, Silva BSM, Manzo BF, Rocha PK, et al. Knowledge of pediatric nursing professionals about infiltration and extravasation in newborns and children. Rev Rene. 2025;26:e94280. DOI: https://doi.org/10.15253/2175-6783.20252694280

Erika Anny Costa Cerqueira[1]
Isaiane Santos Bittencourt[2]
Mariana de Oliveira Lima Caldas[3]
Bianka Sousa Martins Silva[1]
Bruna Figueiredo Manzo[4]
Patrícia Kuerten Rocha[5]
Luciano Marques dos Santos[1]

[1]Universidade Estadual de Feira de Santana. Feira de Santana, BA, Brazil.
[2]Universidade do Estado da Bahia. Senhor do Bonfim, BA, Brazil.
[3]Hospital Martagão Gesteira. Salvador, BA, Brazil.
[4]Universidade Federal de Minas Gerais. Belo Horizonte, MG, Brazil.
[5]Universidade Federal de Santa Catarina. Florianópolis, SC, Brazil.

Corresponding author:
Erika Anny Costa Cerqueira
Av. Transnordestina, s/n - Novo Horizonte.
CEP: 44036-900. Feira de Santana, BA, Brazil.
E-mail: anny_c@live.com

Conflict of interest: the authors have declared that there is no conflict of interest.

ABSTRACT

Objective: describe the knowledge of nursing professionals regarding infiltration and extravasation in children using peripheral intravenous catheters. **Methods:** cross-sectional study carried out with 68 professionals from the nursing team of a pediatric hospital. Data collection took place using a structured questionnaire and we used descriptive statistics to analyze the information acquired. **Results:** regarding the concept, signs/symptoms, and management of complications, the rate of correct answers was considered low. Regarding risk factors, correct answer rates were medium or high. When it comes to classification, there was a low rate of right responses in the 1st and 3rd degrees of infiltration and in regard to the mechanisms that lead to both types of complication. **Conclusion**: the rate of correct answers regarding infilgration and extravasation was considered low for most questions. **Contributions to the practice:** the study may show how necessary it is for pediatric hospitals to plan institutional policies that enable the nursing team to provide the best intravenous therapy practices in order to help improve the quality of the assistance provided to newborns and children.

Descriptors: Pediatric Nursing; Catheterization, Peripheral; Patient Safety; Infant, Newborn; Health Knowledge, Attitudes, Practice.

RESUMO

Objetivo: descrever o conhecimento dos profissionais da enfermagem sobre infiltração e extravasamento em recém-nascidos e crianças em uso de cateteres intravenosos periféricos. **Métodos:** estudo transversal realizado com 68 profissionais da equipe de enfermagem de um hospital pediátrico. A coleta de dados ocorreu por meio de um questionário estruturado e, para a análise das informações obtidas, utilizou-se a estatística descritiva. **Resultados:** quanto ao conceito, sinais/sintomas e manejo das complicações, a taxa de acertos foi considerada baixa. Sobre os fatores de risco, as taxas de acertos foram médias ou altas. Em relação *à* classificação, foi identificada baixa taxa de acertos nos graus 1 e 3 de infiltração e quanto aos mecanismos de ocorrência de ambas as complicações. **Conclusão:** a taxa de acertos sobre infiltração e extravasamento foi considerada baixa para a maioria das questões. **Contribuições para a prática:** o estudo poderá despertar a necessidade de hospitais pediátricos realizarem o planejamento de políticas institucionais que possibilitem o acesso da equipe de enfermagem às melhores práticas da terapia intravenosa a fim de contribuir para uma assistência de qualidade aos neonatos e crianças.

Descritores: Enfermagem Pediátrica; Cateterismo Periférico; Segurança do Paciente; Recém-Nascido; Conhecimentos, Atitudes e Prática em Saúde.

Received: Oct. 4th 2024; Accepted: Nov. 28th 2024.

Introduction

In the neonate and pediatric population, infiltration and extravasation are the most common complications when it comes to the use of short Vascular Access Devices (VADs)[1-4], with a high frequency of infiltration and extravasation among newborns, with rates of 55.9%[1] and 22.2%[1], respectively. Among children, infiltrations take place from 2.1%[3] to 33.3%[2] of cases, while extravasation has a prevalence of 4.4 cases per 1000 children/day[4], and an incidence of 1%[5].

The difference between infiltration and extravasation is associated with the type of medication being infused. In infiltrations, the medication may be irritating, but it is not vesicant, while in extravasation, the drug is vesicant[6-7].

An irritating medication provokes inflammation in the endothelium of the vein in which it is being infused, and triggers pain and local discomfort[7]. This inflammation is usually self-limiting, and not associated with long-term sequelae. This type of drug causes venous irritation and chemical phlebitis at the catheter insertion site, with no likelihood of tissue necrosis[8]. Vesicant drugs, on the other hand, damage the tissue they infiltrate, forming blisters and causing necrosis and tissue loss[7].

When there is an infiltration, the medication moves from the vein into surrounding tissues, causing no tissue loss[7]. Extravasation, on the other hand, can lead to damage such as skin blisters and tissue necrosis[6,9]. Tissue injuries can be related to non-physiological pH and osmolarity, vasoconstriction, cytotoxicity, and resistance to the absorption of drugs[9].

Infiltration and extravasation can take place through three different mechanisms: mechanic, inflammatory, and obstructive. The mechanical type happens when the device is displaced from inside the vase when inserted, or when the opposite wall of the vein is pierced by the needle when it is inserted. The inflammatory mechanism takes place when the inflammatory action of drugs or cytotoxic solutions on the wall of the vein cause a separation between cells, enough for the fluid to escape into the extravascular space. Obstructive mechanic takes place when, before the attempted catheterization, thrombi are formed which makes it harder for blood and fluid to pass, causing its dislocation into the extravascular space[10].

Many factors increase the likelihood of infiltration and extravasation[7]. In children and adolescents, prolonged intravenous therapy, history of complications, prior difficult peripheral catheterizations, having veins that are difficult to palpate and visualize[11], having difficult venous access, and being hospitalized before a surgery[12] are risk factors for extravasation. In the same population, factors that increase the likelihood of infiltrations include being female; being malnourished; using vesicant, non-irritant, and nonvesicant drugs; and using irritant/vesicant electrolytes[4].

Both complications cause discomfort and pain to the neonate and the child. Extravasations, in addition to these symptoms, may increase the length of hospital stay and surgical intervention, in addition to provoking permanent aesthetic and functional defects in the case of nervous lesions extensive and deep necroses[6,9]. Furthermore, extravasation decreases the quality of life of children undergoing chemotherapy[13].

Considering the responsibility of the nursing team in the planning and execution of intravenous therapies and complications that may arise from the infiltration and extravasation, professionals must know how to define and identify associated risk factors, in addition to classifying and managing these complications.

It is essential to identify the knowledge of nursing professionals about infiltration and extravasation, in order to reach better clinical results. Research on the topic suggest that professionals have different levels of knowledge, depending on the context[14-15]. Thus, it is relevant to identify which elements of knowledge are present in the researched reality.

Therefore, considering the role of nursing workers in this process, its repercussions for children, their families, and health institutions, as well as the potential to highlight which types of improvements are needed[16], we propose the following research question: What do nursing professionals from a public hospital in Bahia know about infiltration and extravasation in newborns and children using a peripheral VAD?

Thus, this study aimed to describe the knowledge of nursing professionals regarding infiltration and extravasation in children using peripheral intravenous catheters.

Methods

This is a cross-sectional study following the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE). It was carried out in a pediatric hospital in Bahia, a philanthropic institution that is a reference in pediatrics and provides high complexity services such as oncology, neurology, and cardiology, assisting newborns, children, and adolescents from the entire state of Bahia. The hospital has 220 inpatient beds, including nursing wards and Intensive Care Units (ICU), in addition to outpatient care for many specialties and imaging exams.

Data collection took place from January to April 2021, in the surgical and oncology wards, neonate and pediatric ICUs, and training and dehospitalization units. The population was formed by nursing and technicians from these units.

The eligible population for this study included nurses and nursing technicians from the surgical and oncology wards, pediatric and neonate ICUs, and training and dehospitalization units. Sample selection was non-probabilistic, being formed by 68 professionals that were in accordance with the eligibility criteria of the study; there were no losses. Research included nurses and nursing technicians with at least one year of experience working with hospitalized newborns and children. We did not include professionals from units responsible for treating children with suspected/diagnosed cases of coronavirus infection.

Data collection was carried out using a self-administered questionnaire, based on the recommendations of the Manual of Standards and Practices for Infusion Therapy by the North-American Infusion Nurses Society (INS)[17]. The instrument included 15 objective, multiple-choice questions, with a single right alternative.

We investigated demographic variables as well as those related to the complications studied. Regarding variables related to demographic factors, training, and work experience, we collected information on occupational category, age, sex, educational level, time of education, experience (time working with the neonate and/or pediatric population, working on which unit), and participation in courses about peripheral intravenous therapy. Variables related to complications included concepts, risk factors, signs and symptoms, classification, and management.

Before data collection started, the project was presented to the nurse that was the leader of each sector, and the data collection instrument was made available during the work shift of the professional. Data collection took place during the COVID-19 pandemic and the adequate protective measures were adopted, such as the use of N-95 masks. Additionally, patients were requested to use their own pens to fill out the questionnaire and clean their hands before doing so.

Collection took place in the morning or afternoon shifts, and was carried out by a single researcher. In the day of collection the research would go to the units and invite professionals to participate in the research. They were approached individually, in a private environment, including an explanation about the goal of research, the method of data collection, and all other ethical questions involved; at this time, they also read and could sign the informed consent.

Data collected was tabulated in electronic spre-

adsheets in the software SPSS, version 22.0. To describe the categorical variables, we used absolute and relative frequency measures, as well as central tendency and dispersion measures to describe numerical variables, depending on their adherence to the normal distribution, as verified by the application of the Shapiro Wilk test.

Regarding their time of training, professionals who had finished graduation less than three years prior were considered beginners[18]. Thus, time of training and experience were both categorized as below or above three years. Age, in turn, was categorized according with a study that characterized Brazilian nursing workers, finding a higher percentage of 40-year-old or younger professionals[19].

Considering the lack of specific criteria to define the level of knowledge about infiltration and extravasation, this study chose to use the score found a questionnaire elaborated on the topic in order to describe the knowledge of nursing workers. The percentage of correct answers was classified as high (> 80% of correct answers), medium (betweedn 79 and 60% of correct answers), or low (60% of correct answers), considering the relative frequency found in each question about infiltration and extravasation[20].

This research was approved by the Research Ethics Committee of Climério de Oliveira Maternity Ward, under opinion number 4,398,907/2020, and Certificate of Submission for Ethical Appreciation 39519420.5.0000.5543. Professionals could only participate after having signed, in writing, the Informed Consent.

Results

The sample included 68 professionals. Most were 40 years old or younger and had more than three years of training and practical experience. Most interviewees worked in surgical and oncology wards, and did not take part in the course about peripheral intravenous therapy (Table 1).

Table 1 – Demographic characterization, training, and experience of pediatric hospital nursing professionals (n=68). Salvador, BA, Brazil, 2021

Variable	n (%)
Occupational category	
Nurse	22 (32.4)
Nursing technician	46 (67.6)
Age (years)*	
Up to 40	47 (69.1)
> 40	21 (30.9)
Educational level	
Technician	46 (67.6)
Graduation	3 (4.4)
Specialization	19 (27.9)
Time since graduation (years)†	
≤ 3	8 (11.8)
> 3	60 (88.2)
Professional experience in neonatal and/or pediatric units (years)‡	
≤ 3	24 (35.3)
> 3	43 (63.2)
Works in which unit	
Surgical and oncology wards	31 (45.6)
Training and dehospitalization units	5 (7.4)
Pediatric Intensive Care Unit	16 (23.5)
Neonate Intensive Care Unit	16 (23.5)
Participated of a course on peripheral intravenous therapy in the hospital	
Yes	22 (32.4)
No	46 (67.6)

*Mean ± Standard deviation: 36.3±6.7; †Median/Interquartile Range: 7.0 7.0; ‡Median/Interquartile Range: 4.0 7.0

Among the variables investigated regarding infiltration and extravasation, the question with the highest number of right answers was regarding the knowledge that inserting the VAD in the back of the hand, in the antecubital fossa, and in the upper arm would be a risk factor for these complications.

Professionals interviewed presented a medium level of knowledge regarding the definitions of irritant and vesicant medications, permanence in the insertion site for longer than 72 hours as a risk factor for complications, and 2nd degree classification for the infiltration. Low percentages of correct answers were found regarding the definitions of infiltration and extravasation, signs and symptoms, classification in degrees 1 to 3, and mechanisms to develop and manage these complications (Table 2).

Table 2 – Percentage and classification of correct answers from nursing workers regarding infiltration and extravasation in newborns and children using vascular access devices (n=68). Salvador, BA, Brazil, 2021

Variables	Correct answers n (%)	Incorrect answers n (%)	Classification of the percentage of correct answers*
Grade			
Irritant drug	52 (76.5)	16 (23.5)	Medium
Vesicant drug	52 (76.5)	16 (23.5)	Medium
VAD infiltration	13 (19.1)	55 (80.9)	Low
VAD Extravasation	19 (27.9)	49 (72.1)	Low
Risk factors			
VAD inserted into the back of the hand, antecubital fossa, and upper arm	58 (85.3)	10 (14.7)	High
Permanence of the VAD at the insertion site for more than 72 hours	49 (72.1)	19 (27.9)	Medium
Signs and symptoms			
Infiltration	17 (25.0)	51 (75.0)	Low
Extravasation	14 (20.6)	54 (79.4)	Low
Classification of infiltration			
Level 1	31 (45.6)	37 (54.4)	Low
Level 2	43 (63.2)	25 (36.8)	Medium
Level 3	22 (32.4)	46 (67.6)	Low
Classification pertaining to the mechanism of occurrence	38 (55.9)	30 (44.1)	Low
Description of the mechanisms of occurrence of infiltration/extravasation	40 (58.8)	28 (41.2)	Low
Infiltration/extravasation management			
Interventions performed immediately after diagnosis of infiltration/extravasation	24 (35.3)	44 (64.7)	Low
Interventions performed after the removal of the intravenous device upon diagnosis of infiltration/extravasation	17 (25.0)	51 (75.0)	Low

*Classification of the percentage of correct answers: high (> 80%), medium (between 79 and 60%) and low (<60%); VAD: Vascular Access Devices

Discussion

This research showed that nursing professionals have different mean percentages of knowledge regarding the concept of extravasation and infiltration, risk factors, classification of complications, classification of mechanisms of occurrence, management, and interventions related to infiltration and extravasation. Most items evaluated are considered to have a low percentage of right answers.

Intravenous therapy is often used to treat and prevent in-hospital health issues. It is a common type of peripheral therapy in emergency units, nursing and surgical wards, and intensive care units. Therefore, nursing health workers must have the necessary knowledge for its establishment and continuity.

In this study, more than half the professionals did not participate in a training session about peripheral intravenous therapy in the institution where they worked. Activities targeted at improving the knowledge and practice of these workers is essential for safe and high-quality assistance.

Permanent education has been essential to improve the work process of nurses[21-22], considering that its aim is implementing assertive evidence-based actions. Additionally, training sessions and knowledge about how to insert and maintain peripheral catheters in children increase the confidence of professionals when carrying out these procedures[21]. Therefore, since this intervention is quite common during the hospitalization of newborns and children, the nursing professional must be encouraged to update the necessary knowledge to implement intravenous therapies.

Regarding the percentage of right answers, the worst results were in questions about the definition of infiltration and signs and symptoms of both complications. Literature shows that these complications are common in the neonate[1] and pediatric[2,5] popu-

lations. Therefore, the conceptual knowledge of the complication and the signs and symptoms can have a direct impact on the notification of cases, interfere in the early identification and in the selection of adequate treatments.

Infiltration and extravasation can cause relevant lesions, whose severity is determined by the type, volume, and concentration of the drug infiltrated[6]. The direct action of a vesicant drug can damage tissues and cause changes in lesions due to the compression of the tissues caused by the hydrostatic pressure of the infiltrated liquid, or owing to the vasoconstriction caused by the infiltrated drug[10].

These lesions can be painful, increase hospitalization time, require surgical intervention[9-10,23], and reduce quality of life[13]. Thus, there are additional financial costs to the families and health institutions, in addition to a greater emotional exhaustion of the child and their family. Therefore, adequate planning of the intravenous therapy and knowledge about risk factos that lead to the development of complications are essential to ensure the safety of patients using peripheral VADs[7].

Nursing workers must know the main recommendations about VAD insertion, stabilization, coverage, and management, in order to provide safe, free-of-complication care. To do so, they must participate in educational programs made to disseminate this information[20].

Nursing workers who participated in the study recognized that VADs on the back of the hand, the antecubital fossa, and the upper arm are more likely to present complications. The nursing workers must know the risk factors, owing to the fact that this type of knowledge enables an assertive planning of intravenous therapy and the implementation of preventive care. Thus, it does have an impact on the reduction of cases of infiltration and extravasation[24].

Most professionals could not classify the infiltration/extravasation according to the degrees established by a translated and validated scale[25]. The use of these tools in care practice helps detecting, classifying, and managing these complications, which in turn contributes for patient safety[26]. The Infusion Nursing Society recommends hospitals to adopt a validated, reliable scale, appropriate for the pediatric population[7], and there is a scale translated into Brazilian Portuguese and validated by specialists[25].

The mechanism of infiltration can be mechanic, inflammatory, or obstructive[13]. Recognizing the different types is relevant so the professional can understand what is the proper technique to insert the peripheral VAD, its fixation, in addition to the selection of thicker veins to infuse irritant and vesicant fluids, allowing for effective hemodilution, and determining the best place to insert the device, considering the full extension of the vase[6-7].

Most workers interviewed could not identify the interventions to manage infiltrations and extravasations. The correct identification of complications reduces damage to newborns and children, allowing for immediate interventions such as suspending the infusion, evaluating the location, aspiration of the device, raising of the limb, in addition to those inherent to the specific drug/solution infiltrated[7].

The use of algorithms based on scientific literature and validated by specialists is also noteworthy[27]. Adopting this clinical tool in daily practice allows implementing specific interventions for the pediatric public, who develops these complications[28]. Using instruments to guide the treatment of complications helps select and standardize instituted conducts[29], contributing for all newborns and children to have access to safe, evidence-based care.

Although lesions caused by infiltration and extravasation are common in pediatric health care, interventions are seldom investigated. Also, the studies are often of low quality and find no consensus regarding treatment or results[30]. With no evidence indicating which specific treatment is better, the type of therapy remains an individual decision, vulnerable to the risks associated with off-label interventions that are implemented in the clinical practice of neonate and pediatric units[27].

Study limitations

A limitation of this research is its low sample size, considering that a greater number of participants could lead to a better evaluation. It is worth noting that this research used a convenience sample, preventing the generalization of the findings to the hospital that was its setting. Another limitation is the fact the study was carried out in a single center, and should be expanded into other Brazilian institutions.

Contributions to practice

Identifying the level of knowledge of nursing workers about infiltration and extravasation can encourage the planning of institutional policies in pediatric hospitals, seeking to ensure that the health team has access to the best intravenous therapy practices, thus contributing to provide a quality care to neonates and children.

Conclusion

The knowledge presented by the professionals about infiltration and extravasation in this research was considered to be low for most questions about the concept, signs and symptoms, and classification and management of complications in newborns and children using peripheral intravenous catheters. Their knowledge regarding risk factors varied from medium to high.

Authors' contributions

Design and project or analysis and interpretation of data; writing of the manuscript or relevant critical revision of the intellectual content; and final approval of the version to be published: Cerqueira EAC, Bittencourt IS, Caldas MOL, Silva BSM, Manzo BF, Rocha PK, Santos LM. Responsible for all aspects of the text, to guarantee that the manuscript in its entirety and all its isolated parts are accurate and have integrity: Cerqueira EAC, Santos LM.

References

1. Tseng JH, Elaine Chen YF, Chang SP, Wang HC, Kuo YT. Factors affecting the patency and complications of peripheral intravenous catheters in newborns. Pediatr Neonatol. 2023;64(3):239-46. doi: https://10.1016/j.pedneo.2022.07.011
2. Qin KR, Ensor N, Barnes R, Englin A, Nataraja RM, Pacilli M. Standard versus long peripheral catheters for multiday IV therapy: a randomized controlled trial. Pediatrics. 2021;147(2):e2020000877. doi: https://doi.org/10.1542/peds.2020-000877
3. Pohl CE, Harvey H, Foley J, Lee E, Xu R, O'Brien NF, et al. Peripheral IV Administration of Hypertonic Saline: Single-Center Retrospective PICU Study. Pediatr Crit Care Med. 2022;23(4):277-85. doi: https://doi.org/10.1097/PCC.0000000000002903
4. Santos LM, Figueredo IB, Silva CSG, Catapano UO, Silva BSM, Avelar AFM. Risk factors for infiltration in children and adolescents with peripheral intravenous catheters. Rev Bras Enferm. 2022;75(4):e20210176. doi: https://doi.org/10.1590/0034-7167-2021-0176
5. Kluckow E, Perera S, Clifford I, Wilks D, Cooper MS. Increased risk of complications in lower versus upper limb peripheral intravenous cannulation in children with severe neurological impairment. Child Care Health Dev. 2024;50(2):e13250. doi: https://doi.org/10.1111/cch.13250
6. Phillips LD, Gorski L. Manual of I.V. therapeutics: evidence-based practice for infusion therapy. Philadelphia: F. A. Davis Company; 2018.
7. Gorski LA, Hadaway L, Hagle ME, Broadhurst D, Clare S, Kleidon T, et al. Infusion therapy standards of practice. J Infus Nurs. 2021;44(1S Suppl 1):S1-S224. doi: https://dx.doi.org/10.1097/NAN.0000000000000396
8. Beall V, Hall B, Mulholland JT, Gephart SM. Neonatal extravasation: An overview and algorithm for evidence-based treatment. Newborn Infant Nurs Rev. 2013;13(4):189-95. doi: https://dx.doi.org/10.1053/j.nainr.2013.09.001
9. Ong J, Gerpen RV. Recommendations for management of noncytotoxic vesicant extravasations. J Infus Nurs. 2020;43(6):319-43. doi: https://doi.org/10.1097/NAN.0000000000000392

10. Hadaway L. Infiltration and extravasation. Am J Nurs. 2007;107(8):64-72. doi: https://dx.doi.org/10.1097/01.NAJ.0000282299.03441.c7

11. Santos LM, Cerqueira LF, Almeida AHV, Silva BSM, Gomes e Silva CSG, Avelar AFM. Risk factors for extravasation in peripheral catheters in children with cancer. Acta Paul Enferm. 2022;35:eAPE0059966. doi: https://dx.doi.org/10.37689/acta-ape/2022AO005996

12. Mecoli MD, Ding L, Yang G, McSoley JW, Doellman DA, Rineair SA, et al. Factors associated with intraoperative intravenous catheter extravasation in children. Anaesth Intensive Care. 2022;50(4):306-11. doi: https://dx.doi.org/10.1177/0310057X211062614

13. Kalaycı E, Çalışkan Z. The quality of life and influencing factors in Turkish children receiving cancer treatment. J Pediatr Nurs. 2021;61:213-8. doi: http://dx.doi.org/10.1016/j.pedn.2021.06.003

14. Atay S, Üzen Cura Ş, Efil S. Nurses' knowledge and experience related to short peripheral venous catheter extravasation. J Vasc Access. 2023;24(4):848-53. doi: https://dx.doi.org/10.1177/11297298211045589

15. Yilmaz DU, Yilmaz D, Karaman D. Clinical nurses' knowledge and practices on routine care related to the prevention of complications of peripheral intravenous therapy: a cross-sectional study. J Vasc Access. 2023;24(2):277-83. doi: https://dx.doi.org/10.1177/11297298211033380

16. Zingg W, Barton A, Bitmead J, Eggimann P, Pujol M, Simon A et al. Best practice in the use of peripheral venous catheters: A scoping review and expert consensus. Infect Prev Pract. 2023;5(2):100271. doi: http://dx.doi.org/10.1016/j.infpip.2023.100271

17. Gorski LA, Hadaway L, Hagle ME, Broadhurst D, Clare S, Kleidon T, et al. Infusion therapy standards of practice. J Infus Nurs. 2021;44(suppl 1):S1-S224. doi: http://dx.doi.org/10.1097/NAN.0000000000000396

18. Benner P. From novice to expert. Am J Nurs [Internet]. 1982 [cited Aug 13, 2024];82(3):402-7. Available from: https://journals.lww.com/ajnonline/citation/1982/82030/from_novice_to_expert.4.aspx

19. Machado MH, Aguiar Filho W, Lacerda WF, Oliveira E, Lemos W, Wermelinger M, et al. Caracteristicas gerais da enfermagem: o perfil sócio demográfico. Enferm Foco. 2015;6(1/4):11-7. doi: https://doi.org/10.21675/2357-707x.2016.v7.nesp.686

20. Xu B, Zhang J, Hou J, Ma M, Gong Z, Tang S. Nurses' knowledge of peripherally inserted central catheter maintenance and its influencing factors in Hunan province, China: a cross-sectional survey. BMJ Open. 2020;10(5):e033804. doi: https://dx.doi.org/10.1136/bmjopen-2019-033804

21. Indarwati F, Munday J, Keogh S. Nurse knowledge and confidence on peripheral intravenous catheter insertion and maintenance in pediatric patients: a multicentre cross-sectional study. J Pediatr Nurs. 2022;62:10-6. doi: https://doi.org/10.1016/j.pedn.2021.11.007

22. Mulemba T, Bank R, Sabantini M, Chopi V, Chirwa G, Mumba S, et al. Improving peripheral intravenous catheter care for children with cancer receiving chemotherapy in Malawi. J Pediatr Nurs. 2021;56:13-7. doi: https://dx.doi.org/10.1016/j.pedn.2020.09.019

23. Yan G. Extravasation of concentrated potassium chloride: a case report. Curr Ther Res Clin Exp. 2021;95:100646. doi: https://dx.doi.org/10.1016/j.curtheres.2021.100646

24. Litao H, Yuxuan R, Yongxia S. Infiltration and extravasation of intravenous infusions in children-value of high-quality care on outcome. J Pak Med Assoc. 2021;71(4):1181-3. doi: https://dx.doi.org/10.47391/JPMA.02-194

25. Rodrigues EC, Cardoso MVLML, Campos FMC, Gazelle TGA, Nobre KSS, Oliveira NR. Content translation and validation of the Pediatric PIV Infiltration Scale into Brazilian Portuguese. Rev Bras Enferm. 2020;73(4):e20190300. doi: https://dx.doi.org/10.1590/0034-7167-2019-0300

26. Cline GJ, Pohlod V, Burger KJ, Amankwah EK. Measuring the validity and reliability of the vascular access complication staging and treatment instrument in a pediatric population. J Infus Nurs. 2021;44(4):225-43. doi: https://dx.doi.org/10.1097/NAN.0000000000000431

27. Hackenberg RK, Kabir K, Müller A, Heydweiller A, Burger C, Welle K. Extravasation injuries of the limbs in neonates and children—development of a treatment algorithm. Dtsch Arztebl Int. 2021;118(33-34):547-54. doi: http://dx.doi.org/10.3238/arztebl.m2021.022

28. Santos LM, Nunes CJ, Silva CSG, Kusahara DM, Rodrigues EC, Avelar AFM. Elaboration and validation of an algorithm for treating peripheral intravenous infiltration and extravasation in children. Rev Latino-Am Enfermagem. 2021;29:e3435. doi: https://doi.org/10.1590/1518-8345.4314.3435

29. Gibian JT, Zakria D, March C, Schaheen B, Drolet BC. Outcomes and management of peripheral intravenous infiltration injuries. Hand (NY). 2022;17(1):148-54. doi: https://dx.doi.org/10.1177/1558944720906494

30. Dufficy M, Takashima M, Cunninghame J, Griffin BR, McBride CA, August D, et al. Extravasation injury management for neonates and children: a systematic review and aggregated case series. J Hosp Med. 2022;17(10):832-42. doi: https://dx.doi.org/10.1002/jhm.12951