European Society for Paediatric Research
Society for Pediatric Research
www.nature.com/pr

SPECIAL ARTICLE

Check for updates

Enhancing neonatal vascular access: proposing a patient-centered framework based on 7-Rights

Matheus F. P. T. van Rens[1,2✉], Kevin Hugill[2,3], Robin van der Lee[1], Fiammetta Piersigilli[4], Bernhard Schwaberger[5], Silke Mader[6] and Agnes van den Hoogen[7]

Neonatal vascular access (VA) is a critical component of neonatal intensive care. However, VA remains a high-risk procedure associated with pain and serious complications. Despite the availability of evidence-based guidelines, variability in practice persists, leading to inconsistent patient outcomes. A standardized, patient-centered approach could enhance patient safety, experience, and outcomes. The '7-Rights Framework for Neonatal VA' emerged through international expert consensus. This framework uses the concept of patient rights, the '7-Rights' - Right Patient, Right Care Team, Right Comfort Measures, Right VA Device, Right Blood Vessel, Right Care of the Infusion and Device, and Right Therapy Duration and Device Removal to integrate best evidence-based practice, ethical considerations, and family involvement. Recognizing the need for a standardized approach to VA and simultaneously considering individual needs, the framework readily provides guiding principles for developing individualized Vascular Access Management Plans (VAMP). In addition to proposing the 7-Rights framework, this article advocates for its operationalization in a VAMP that encompasses the entire VA process, from planning, device selection, insertion, maintenance, monitoring, and quality control. A VAMP based on the 7-Rights framework has the potential to individualize VA care, improve consistency, enhance patient safety, and facilitate quality improvement initiatives.

Pediatric Research; https://doi.org/10.1038/s41390-025-04521-z

IMPACT: Key message

- Introduces the 7-Rights Framework as a structured, patient-centered model to guide neonatal vascular access (VA) decisions.

What it adds

- Translates human rights principles into clinical VA practice, integrating ethical standards and family involvement.
- Proposes the use of individualized Vascular Access Management Plans (VAMPs) to operationalize the framework.

Impact

- Addresses current gaps in standardization, safety, and consistency across NICUs.
- Provides a universal guide to support clinicians in reducing complications and improving neonatal outcomes.

INTRODUCTION

Neonates admitted to the neonatal intensive care unit (NICU) frequently require vascular access (VA) for essential treatments, including fluid resuscitation, nutrition, medication administration, and blood sampling. Despite being a routine procedure, VA is associated with pain, infection, thrombosis, and extravasation, leading to short and long-term complications.[1–4] Neonates, particularly preterm infants, have fragile vasculature and immature skin, making them more susceptible to vascular trauma and other VA-related injuries.[3]

Although evidence-based guidelines exist, variability in VA practice remains a major challenge. Differences in device selection, insertion techniques, securement methods, and maintenance protocols contribute to inconsistent clinical outcomes.[5–8] Furthermore, VA is often treated as a technical necessity rather than a patient-centered intervention, leading to inadequate attention to pain management, parental involvement, long-term vessel preservation, and preventing long-term adverse sequelae.[9–11]

To address these gaps, we propose the so-called 7-Rights Framework for Neonatal VA, developed through international expert consensus. This framework integrates best practices in VA, ethical considerations, and a patient- and family-centered approach. It aims to ensure optimal safety, precision, and consistency in VA procedures while also embedding human rights principles into neonatal care.

[1]Neonatal Intensive Care Unit, Radboudumc Amalia Children's Hospital, Nijmegen, The Netherlands. [2]Formerly of Neonatal Intensive Care Unit, Women's Wellness and Research Center, Doha, Qatar. [3]Independent Scholar, Cumbria, UK. [4]Neonatal Intensive Care Unit, Louvain University, Saint Luc, Brussels, Belgium. [5]Division of Neonatology, Department of Paediatrics and Adolescent Medicine, Medical University of Graz, Graz, Austria. [6]The European Foundation for the Care of Newborn Infants (EFCNI), München, Germany. [7]Division Woman and Baby Wilhelmina Children's Hospital Utrecht, Utrecht University, Utrecht, The Netherlands. ✉email: Roland.vanRens@radboudumc.nl

Received: 27 March 2025 Revised: 24 July 2025 Accepted: 14 September 2025
Published online: 22 October 2025

PATIENT RIGHTS IN NEONATAL CARE

Patient rights are rooted in international human rights frameworks, shaping modern healthcare policies and standards.[12–16] In 1989, the UN Convention on the Rights of the Child formally recognized children's healthcare rights, emphasizing their entitlement to protection from harm, ethical treatment, and the highest standard of medical care.[17–23] Historically, neonates have been underrepresented in patient rights discussions, as decision-making is often centered around clinicians and parents rather than the neonates themselves. However, in recent years, advocacy for neonatal patient rights has gained prominence.[24–26]

While this global agreement has shaped healthcare policies worldwide, its implementation in neonatal care, particularly in areas such as vascular access management, remains inconsistent. Neonates often undergo invasive procedures without adequate pain management or consideration of less traumatic alternatives, highlighting the gap between policy and practice in safeguarding their rights.

Key gaps in neonatal patient rights include:

- Pain management: Many neonates experience inadequate pain relief during VA procedures.
- Informed decision-making: Parental involvement is often limited, despite their role as advocates for their child's care.
- Standardization of best practices: A lack of uniform guidelines contributes to variability in device selection, site assessment, and securement strategies.

The proposed 7-Rights Framework addresses these challenges by integrating patient rights and patient-centered principles into neonatal VA care.

METHOD

Development of the 7-Rights Framework

The 7-Rights Framework for Neonatal Vascular Access was developed through an internationally coordinated consensus process involving interdisciplinary neonatal vascular access (VA) experts. The foundation was built upon the earlier 5Rs mnemonic—Right device, Right vein, Right therapy, Right duration, and Right patient—initially implemented prior to 2019 in the NICU, Doha, Qatar.[5] This early model served to align device selection, therapy requirements, and individual patient needs.[5,27,28]

Between 2019 and 2023, this initial model was expanded upon in a short series of workshops involving a group of invited panelists working remotely (due to prevailing COVID-related restrictions and geographical separation). To ensure methodological rigor and transparency in the development of the 7-Rights Framework, a structured consensus process was used. This process was informed by and in line with established principles of formal consensus development.[29–31]

Panelists were selected based on clinical expertise, diversity of professional roles, and their involvement in neonatal VA research and/or implementation. The group included three neonatologists, two neonatal nurses, one vascular access specialist, and two representatives from parental organizations, affiliated with NEVAT and ESPR SIG-IV.

An initial draft of the 7-Rights Framework was circulated individually amongst panelists, and feedback was gathered via structured discussions and written input. The process was facilitated by a non-voting coordinator, ensuring documentation, neutrality, and methodological rigor.

Three iterative rounds of discussion took place between 2019 and 2023. In each round, expert input was reviewed and used to revise and refine the framework. Panelists were encouraged to reconsider prior input, considering group feedback. Agreement was determined by the absence of substantive objections.

Key elements of the framework, such as patient-centeredness, standardized terminology, and parental involvement, were retained or revised based on consensus. A detailed account of the panel process, participant roles, and statement evolution is available in the supplementary materials file, including areas of disagreement and the final agreed-upon content.

In 2023, the refined version was validated through additional international expert consultation and an integrative review.[32,33] This review informed final adjustment and ensured alignment with emerging rights-based models and current clinical evidence.

For further methodological details, including literature search terms, expert panel composition, decision-making process, and statement validation, see Supplementary File.

Integrative literature review. To inform the development of each of the seven rights in neonatal vascular access (VA), an integrative review, based on established guidance, was conducted to synthesize evidence-based, rights-based, and patient-centered principles.[32,33] This review was supplemented by professional body guidelines and expert panel input to ensure relevance and practical alignment with current neonatal vascular access practices.

Inclusion criteria. Eligible studies met the following criteria:

- Published in English;
- Focused on vascular access in neonates;
- Addressed patient safety, ethical principles, or procedural best practices.

Search strategy. We conducted a structured literature search using MEDLINE, CINAHL, Embase, PubMed, and Cochrane databases. MeSH terms and free-text keywords included:

- "vascular access devices"
- "neonate" OR "infant, newborn"
- "patient-centered care"
- "catheterization"
- "infiltration" AND/OR "extravasation"
- "ethics"
- "clinical guidelines"

Boolean operators were applied to combine terms effectively. In addition, we screened guidelines and technical reports from the Infusion Nursing Society (INS), Association of Vascular Access (AVA), Global Vascular Access Network (GloVANet), World Congress Vascular Access (WoCoVA), and relevant medical device manufacturers. Reference lists of all included studies were also hand-searched to identify additional eligible sources. Although the structured search was conducted across five databases, the majority of eligible studies were identified via PubMed.

Screening and selection.

- Articles retrieved: 1082 (with PubMed accounting for the majority; searches in Embase, CINAHL, MEDLINE, and Cochrane contributed overlapping records that were removed during deduplication)
- After deduplication and abstract/full-text screening: 92 full-text articles assessed
- Final inclusion: 48 articles

Two reviewers (MFPTvR and KH) independently screened all articles for relevance and duplication. Discrepancies were resolved by consensus.

Evidence appraisal. Evidence quality was appraised using the European Foundation for the Care of Newborn Infants (EFCNI) criteria and the GRADE system,[34–36] categorizing findings as follows:

- A: Research-based evidence
- B: Evidence derived from cultural values and best practices
- C: Evidence based on legal laws, regulations, and court rulings

Each source was further classified by evidence quality (high, moderate, low, or very low), ensuring a rigorous assessment of reliability.[34]

Application of findings. The results of this integrative review informed the refinement and validation of the 7-Rights Framework, ensuring it reflects current clinical evidence and internationally accepted care standards.

Operationalizing the 7-Rights components. This section operationalizes the 7-Rights Framework for Neonatal VA (Fig. 1), providing structured recommendations to improve patient safety, procedural success, and long-term vascular health. The framework is designed to standardize neonatal VA care, ensuring consistency across patient assessment, device selection, procedural techniques, and post-insertion care (Table 1).

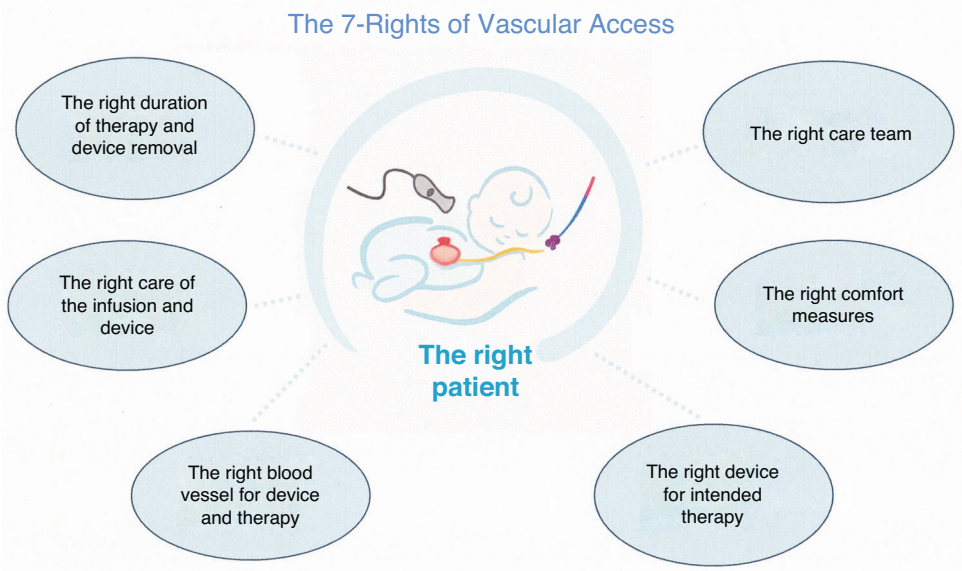

Fig. 1 The 7-Rights Framework for Neonatal Vascular Access.

Table 1. Essential Components of the 7-Rights Framework for Neonatal Vascular Access.

Right	Components
Right Patient	Ensuring patient safety through accurate identification, ethical decision-making, informed consent, and individualized VA planning based on clinical need.
Right Care Team	Involves a multidisciplinary team of trained professionals and includes parents as active participants in VA decisions.
Right Comfort Measures	Prioritizing proactive pain prevention and management, using both pharmacological (analgesia, sedation) and non-pharmacological (skin-to-skin contact, sucrose, swaddling) strategies.
Right VA Device for intended therapy	Selecting the most appropriate catheter type based on intended therapy duration, fluid characteristics, and patient-specific factors.
Right Blood Vessel for the device and therapy	Utilizing advanced vessel assessment tools (e.g., ultrasound, near-infrared spectroscopy) to ensure optimal vein selection and longevity.
Right Care of the Infusion and Device	Emphasizing infection prevention, securement techniques, site monitoring, and complication management to reduce failure rates and adverse events.
Right Therapy Duration and Device Removal	Regular assessment of catheter necessity, ensuring timely removal to minimize risks of thrombosis, infection, and vascular damage.

The Right Patient: Ensures patient safety and individualized care by emphasizing accurate patient identification, risk assessment, and compliance with international best practices.

- Confirm patient identity according to international safety standards to prevent misidentification and reduce errors. *(B, C, High-quality evidence)*[23,37–43]
- Develop and implement institutional VA guidelines aligned with recommendations from professional organizations (e.g., NEVAT, INS, AVA, EFCNI). *(A, Moderate-quality evidence)*[8,35,44–49]
- Use standardized documentation templates to facilitate accurate and consistent recording of VA procedures. *(A, Low-quality evidence)*[5,8,38,42,43]
- Consider patient-specific factors in VA planning, such as gestational age, birth weight, vascular health, skin integrity, and underlying medical conditions. *(A, Low-quality evidence)*[48,50–52]
- Regular audits and structured documentation improve consistency in applying VA best practices across patient encounters. *(A, B, Low-quality evidence)*[8,23,30,53]

The Right Care Team: Emphasizes multidisciplinary collaboration and parental involvement to optimize neonatal VA outcomes.

- Recognize parents as active members of the care team through family-centered rounds, shared decision-making, and structured education. *(A, B, C, Moderate-quality evidence)*[19,22,23,35,53–60]
- Ensure healthcare teams possess VA competencies across the entire spectrum of neonatal VA, from "basic" peripheral intravenous catheter placement to advanced catheterization techniques. *(A, High-quality evidence)*[8,30,61–64]
- Utilize competency-based training (e.g., simulation, skills assessment, ongoing education) to ensure staff proficiency. *(A, Moderate-quality evidence)*[65–68]
- Develop training programs for Difficult Intra Venous Access (DIVA) and advanced techniques, including ultrasound guidance, Modified Seldinger Technique, intracavity ECG navigation. *(A, Moderate-quality evidence)*[69–76]

The Right Comfort Measures: Addresses pain prevention and procedural stress through both pharmacological and non-pharmacological strategies.

- Establish a culture of compassionate care, ensuring neonates are treated with kindness and empathy. *(A, B, C, Moderate-quality evidence)*[25,35,54–60]
- Engage parents in comfort strategies, providing training to help them recognize neonatal stress cues. *(A, Moderate-quality evidence)*[11,35,53,56,77,78]
- Implement validated neonatal pain assessment tools (e.g., NIPS, PIPP) to evaluate and manage procedural distress. *(A, B, Moderate-quality evidence)*[11,55,56,77–86]

- Use gentle handling techniques, including slow movements, swaddling, skin-to-skin contact, and soothing verbal cues, alongside pharmacological pain relief when necessary. *(A, B, Moderate-quality evidence)*[11,55,56,77–86]

The Right VA Device for intended therapy: Encourages systematic device selection based on patient needs, therapy duration, and infusate properties.

- Use structured VA decision algorithms that consider:
  Patient-specific factors (age, weight, vascular health).
  Therapy needs (duration, frequency of administration).
  Infusate properties (pH, osmolarity, vesicatory nature). *(A, Moderate-quality evidence)*[3,5–8,44,45,50–52,87,88]
- Select the least invasive device with the smallest outer diameter and fewest lumens that still meets the clinical performance requirements for the patient. *(A, Moderate-quality evidence)*[2,6,8,50–52,87,88]
- Consider design features of the administration set (e.g., integrated valves, closed intravenous systems) to reduce infection risks and enhance patient comfort (evidence pertains beyond the catheter itself). *(A, Moderate to low-quality evidence)*[2,6,8,89]

The Right Blood Vessel for device and therapy: Focuses on advanced vessel assessment and selection to support long-term VA success and minimize vascular trauma. This helps address the increasing challenges associated with rising DIVA prevalence.

- Develop individualized Vascular Access Management Plans (VAMPs) to guide blood vessel selection and preservation. *(A, B, Moderate-quality evidence)*[44,45,48,50–52,89–94]
- Select appropriate veins based on therapy needs, distinguishing between central and peripheral devices based on catheter tip location (e.g., central veins for hyperosmolar solutions and peripheral veins for short-term therapy). *(A, High-quality evidence)*[8,44,45,49–52,95,96]
- Use ultrasound guidance to optimize vessel identification, first-attempt success rates, and catheter tip placement. *(A, High-quality evidence)*[8,45,74–76,97,98]
- Use institutional pharmacopoeia guidelines to evaluate infusate compatibility with vessel type, reducing the risk of thrombosis and extravasation. *(A, High-quality evidence)*[8,45,50,99]

The Right Care of the Infusion and Device: Ensures infection prevention, device stability, and early detection of complications.

- Adhere to aseptic technique and infection prevention bundles to reduce catheter-related bloodstream infections (CRBSI). *(A, High-quality evidence)*[8,48,87,99–113]
- Implement dedicated VA teams and use preventive care bundles (e.g., sutureless fixation and stabilization devices, cyanoacrylate for catheter securement and infection prevention, closed intravenous systems) to enhance VA safety. Evidence in neonates for the use of antibiotic-impregnated catheters or silver-coated UVCs is limited or outdated. *(A, Moderate to low-quality evidence)*[8,30,48,61–64]
- Secure VA devices properly using sutureless securement devices or cyanoacrylate-based adhesives to reduce mechanical phlebitis and accidental dislodgment, skin harm, and medical adhesive-related skin injury (MARSI). *(A, Moderate-quality evidence)*[8,35,45–48,99–125]
- Monitor insertion sites at least hourly and consider integrating parental observations with optical sensor technology for earlier PIVIE detection. *(A, Moderate-quality evidence)*[8,38,67,126–128]
- Ensure staff are trained in infusion management, using validated neonatal syringe pumps and infusion devices. *(A, High-quality evidence)*[8,50,65,68,129–132]

The Right Therapy Duration and Device Removal: Optimizes therapy duration and safe removal to minimize complications.

- Follow VA decision algorithms to select devices based on intended therapy duration and dwell time guidelines. *(A, High-quality evidence)*[1–3,8,45,48,50–52,95,133,134]
- Promptly remove catheters when therapy is complete or if complications arise that cannot be managed effectively while the catheter remains in place. *(A, High-quality evidence)*[8,46,48,99–102,133,134]
- Use proper removal techniques, ensuring slow, controlled extraction with pressure application to minimize hematoma formation. *(A, Moderate-quality evidence)*[8,121–125,135]
- Integrate comfort measures during removal, including parental involvement and non-pharmacological pain relief. *(A, Moderate-quality evidence)*[4,8–11,25,26,35,48,56–60,77–86]
- Regularly audit of VA device use, including tracking insertion details, dwell times, complications, and removal, to improve the quality of care. *(A, Moderate-quality evidence)*[5,8,23,35,38,61,62,68,90,91]
- Promote a culture of continuous quality improvement through targeted education, training, and active participation in clinical audits. *(B, Moderate-quality evidence)*[55,56,65,66,68,81,89,91,99–101,126]

DISCUSSION

Despite advancements in vascular access device (VAD) design, insertion techniques, and care protocols, neonates remain at risk for VA-related complications such as pain, infection, thrombosis, extravasation, long-term vascular damage, and adverse developmental effects.[1,2,4,8–11,79] These risks highlight the need for more systematic and patient-centered approaches to VA that prioritize safety, precision, and consistency of care and treatment across NICUs.

Unwarranted variation in clinical practice leads to performance variability, less consistency in care and treatment, and contributes to poorer patient outcomes.[35,37–41,136,137] Consequently, across healthcare internationally, there are various approaches, strategies, and directives directed toward minimizing needless variation, improving standardization, and patient outcomes.[35,37–41,61,138–140]

VA is a complex undertaking with multiple interrelated factors (including the environment of care, health professionals' knowledge, behavior, and skill, patient characteristics, device, and software) operating simultaneously, which affect therapy success and patient outcomes. Variations in VA practice – due to institutional policies, available resources, and provider expertise – often result in suboptimal device selection, inconsistent site assessment, and variable securement practices.[5,8,27,49–52,62–64] These inconsistencies contribute to treatment delays, higher procedural failure rates, and preventable harm. Although evidence-based guidelines exist, inconsistent implementation remains a significant challenge. Furthermore, few guidelines fully account for the individual rights of neonates in clinical practice.

The 7-Rights Framework for Neonatal VA proposes a structured, evidence-based solution to these challenges. It bridges the gap between best practices, ethical decision-making, family involvement, and individual rights around healthcare, offering a comprehensive approach that:

- Aligns VA practices with patient rights, ensuring ethical and safe decision-making.
- Positions VA as a fundamental component of neonatal outcomes, reinforcing its role beyond a routine technical task.
- Promotes parental involvement, ensuring families are informed, engaged, and empowered in VA decision-making.
- Minimizes painful procedures and ensures effective pain management through appropriate pharmacological and/or non-pharmacological approaches.
- Establishes evidence-based recommendations and guidelines across NICUs, reducing variability and improving procedural success rates.

Operationalizing the principles of the 7-Rights Framework using a systematic and standardized approach to VA planning, a VAMP

offers the potential to ensure that the principles of the 7-Rights are cohesively applied in practice. While VAMPs are routinely used in other areas of patient care, such as renal dialysis therapy, their use in neonatal care, with a few exceptions, is seldom advocated for.[48,141] Nevertheless, using a VAMP to structure care and planning around all aspects of neonatal VA and based upon the 7-Rights Framework offers a novel opportunity to provide consistency and standardization in neonatal VA management that is currently lacking.

However, further research, validation, and expert consensus are required to assess the feasibility of adopting a VAMP based on the 7-Rights before it can be formally recommended as the standard of care.

We advocate that to truly improve neonatal VA care, system-wide adoption of this framework within a VAMP is necessary to ensure that every neonate receives safe, effective, and compassionate VA care. However, to achieve this ambition the completeness and robustness of the evidence base guiding neonatal VA needs expanding, the education, training and competence of the interdisciplinary healthcare team around VA needs standardization in and between units, family engagement needs to be universally the norm, rather than the exception, technological advancements like device securement adjuncts, point of care ultrasound, optical sensor and the like need applying in everyday practice.

CONCLUSION

The 7-Rights Framework for Neonatal VA proposes a structured, rights-based, patient-centered approach to optimizing VA precision and safety. By integrating evidence-based practice, ethical considerations, and multidisciplinary collaboration, this framework enhances VA safety and procedural success, reduces variability in clinical practice, and ultimately improves patient outcomes while prioritizing family involvement and well-being. The framework's adaptability ensures that it can evolve alongside technological advances, new research findings, and ethical developments, making it applicable not only in neonatal settings but also in broader VA care.

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article and its supplementary information files. No additional datasets were generated.

REFERENCES

1. Legemaat, M. et al. Peripheral intravenous cannulation: complication rates in the neonatal population: a multicenter observational study. *J. Vasc. Access.* **17**, 360–365 (2016).
2. van Rens, M. F. P. T. et al. Evaluation of unmodifiable and potentially modifiable factors affecting peripheral intravenous device-related complications in neonates: a retrospective observational study. *BMJ Open* **11**, e047788 (2021).
3. Hugill, K. Vascular access in neonatal care settings: selecting the appropriate device. *Br. J. Nurs.* **25**, 171–176 (2016).
4. Carbajal, R. et al. Epidemiology and treatment of painful procedures in neonates in intensive care units. *JAMA* **300**, 60–70 (2008).
5. van Rens, M. F. P. T. et al. The ABBA project (Assess Better Before Access): a retrospective cohort study of neonatal intravascular device outcomes. *Front. Pediatr.* **10**, 980725 (2022).
6. van Rens, M. F., Hugill, K., Mahmah, M. A., Francia, A. L. & van Loon, F. H. Effect of peripheral intravenous catheter type and material on therapy failure in a neonatal population. *J. Vasc. Access.* **24**, 1284–1292 (2023).
7. Scott-Warren, V. & Morley, R. Paediatric vascular access. *BJA Educ.* **15**, 199–206 (2015).
8. Nickel, B. et al. Infusion therapy standards of practice, 9th ed. *J. Infus. Nurs.* **47**, S1–S285 (2024).
9. Williams, M. D. & Lascelles, B. D. X. Early neonatal pain-a review of clinical and experimental implications on painful conditions later in life. *Front. Pediatr.* **8**, 30 (2020).
10. Racine, N. M. et al. Systematic review: predisposing, precipitating, perpetuating, and present factors predicting anticipatory distress to painful medical procedures in children. *J. Pediatr. Psychol.* **41**, 159–181 (2016).
11. Sipkema, P., Van Rens, M., & Hugill K. Maintaining parent-infant skin-to-skin contact during peripheral intravenous catheter insertion in a Dutch neonatal unit. *J. Neonatal Nurs.* https://doi.org/10.1016/j.jnn.2024.01.004 (2024).
12. Ishay, M. R. The history of human rights: from ancient times to the globalization era. Berkeley, CA: University of California Press; 2008.
13. Mold, A. Patients' rights and the National Health Service in Britain, 1960s-1980s. *Am. J. Public Health* **102**, 2030–2038 (2012).
14. Morikawa, I. Patients' rights in Japan: progress and resistance. *Kennedy Inst. Ethics J.* **4**, 337–343 (1994).
15. European Commission, Directorate-General for Health and Food Safety. *Patients' Rights in the European Union - Mapping Exercise- Final Report* (Publications Office of the European Union, Luxembourg, 2018.
16. United Nations (UN) General Assembly. *Universal Declaration of Human Rights.* New York United Nations; 1948.
17. United Nations Convention on the Rights of the Child (UNCRC). https://www.unicef.org.uk (1989).
18. National Assembly for Wales. *Rights of Children and Young Persons (Wales) Measure 2011 (nawm 2)* (Stationery Office, London, 2011).
19. European Commission, Directorate-General for Justice and Consumers. *The European Union's Plan for Children's Rights*. https://doi.org/10.2838/707665. (Publications Office of the European Union, Luxembourg, 2021).
20. Archard, D. *Children, Rights and Childhood* 3rd edn (Routledge, London, 2014).
21. Alderson, P. *Young Children's Rights: Exploring Beliefs, Principles and Practice* 2nd edn (Jessica Kingsley, London, 2008).
22. Sahlberg, S., Karlsson, K. & Darcy, L. Children's rights as law in Sweden-every health-care encounter needs to meet the child's needs. *Health Expect.* **23**, 860–869 (2020).
23. iSupport Team Editorial: getting it right first time and every time; re-thinking children's rights when they have a clinical procedure. *J. Pediatr. Nurs.* **61**, A10–A12 (2021).
24. NICU Parent Network. *NICU Baby's Bill of Rights* https://nicuparentnetwork.org/bill-of-rights/ (2020).
25. Foundation for Premature Infants. *Premature Infant Bill of Rights* https://www.foundationforprematureinfants.org/wp-content/uploads/2018/01/preemie-bill-of-rights.pdf (2018).
26. Bliss. *Bliss Neonatal Services for the Future: A Manifesto* https://Bliss.org.uk (2023).
27. van Rens, M. et al. Outcomes of establishing a neonatal peripheral vascular access team. *Arch. Dis. Child Fetal Neonatal Ed.* **108**, 88–89 (2023).
28. Steere, L., Ficara, C., Davis, M. & Moureau, N. Reaching one peripheral intravenous catheter (PIVC) per patient visit with lean multimodal strategy: the PIV5-Rights™ bundle. *J. Assoc. Vasc. Access* **24**, 31–43 (2019).
29. Rotondi, A. J., Kvetan, V., Carlet, J. & Sibbald, W. J. Consensus conferences in critical care medicine. Methodologies and impact. *Crit. Care Clin.* **13**, 417–439 (1997).
30. Kea, B. & Sun, B. C. Consensus development for healthcare professionals. *Intern. Emerg. Med.* **10**, 373–383 (2015).
31. Manera, K., Hanson, C. S., Gutman, T., & Tong, A. Consensus methods: nominal group technique. In *Handbook of Research Methods in Health Social Sciences* (ed. Liamputtong, P.) 737–750 (Springer, Singapore, 2019).
32. Toronto, C. E. & Remington, R. *A Step-by-Step Guide to Cconducting an Integrative Review* (Springer, London, 2020).
33. Hopia, H., Latvala, E. & Liimatainen, L. Reviewing the methodology of an integrative review. *Scand. J. Caring Sci.* **30**, 662–669 (2016).
34. Lindacher, V. et al. European standards of care for newborn health-a project protocol. *Acta Paediatr.* **110**, 1433–1438 (2021).
35. European Foundation for the Care of Newborn Infants (EFCNI). *European Standards of Care for Newborn Health* (EFCNI, Munich, 2019).
36. Guyatt, G. H. et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* **336**, 924–926 (2008).
37. Department of Health & Social Care (DHSC). *The NHS Constitution for England* (DHSC, London, 2023).
38. Joint Commission International (JCI). *JCI Accreditation Standards for Hospitals and Academic Medical Centers* 7th edn (JCI, Oakbrook Terrace, IL, 2020).
39. European Patients' Forum (EPF). *EPF Position Paper on Quality of Care* (EPF, Brussels, 2017).
40. Care Quality Commission (CQC). *Key Questions and Quality Statements* (CQC, London, 2023).
41. Care Quality Commission (CQC). *The Fundamental Standards* (CQC, London, 2022).
42. Upadhyay, S. & Hu, H. F. A qualitative analysis of the impact of electronic health records (EHR) on healthcare quality and safety: clinicians' lived experiences. Health Serv. Insights 15, 11786329211070722 (2022).

43. Uslu, A. & Stausberg, J. Value of the electronic medical record for hospital care: update from the literature. *J. Med. Internet Res.* **23**, e26323 (2021).
44. Timsit, J. F. et al. Expert consensus-based clinical practice guidelines management of intravascular catheters in the intensive care unit. *Ann. Inten. Care* **10**, 118 (2020).
45. Sharpe, E. L., Curry, S. & Wyckoff, M. M. NANN neonatal peripherally inserted central catheters: guideline for practice, 4th ed. *Adv. Neonatal Care* **24**, 313–315 (2024).
46. Brandon, D. et al. *Neonatal Skin Care: Evidence-Based Clinical Practice Guideline* 4th edn (AWHONN, Washington, DC, 2018).
47. Pinelli, F. et al. GAVeCeLT-WoCoVA Consensus on subcutaneously anchored securement devices for the securement of venous catheters: current evidence and recommendations for future research. *J. Vasc. Access.* **22**, 716–725 (2021).
48. Neonatal European Vascular Access Team (NEVAT). *Ten Recommendations to Guide Neonatal Vascular Access* (NEVAT, 2025).
49. van Rens, M. R. et al. The NAVIGATE project: a GloVANet-WoCoVA position statement on the nomenclature for vascular access devices. J. Vasc. Access 24, 11297298241291248 (2024).
50. Ullman, A. J. et al. The Michigan appropriateness guide for intravenous catheters in pediatrics: miniMAGIC. *Pediatrics* **145**, S269–S284 (2020).
51. Pittiruti, M. et al. European recommendations on the proper indication and use of peripheral venous access devices (the ERPIUP consensus): a WoCoVA project. *J. Vasc. Access.* **24**, 165–182 (2023).
52. Barone, G. et al. The neonatal DAV-expert algorithm: a GAVeCeLT/GAVePed consensus for the choice of the most appropriate venous access in newborns. *Eur. J. Pediatr.* **182**, 3385–3395 (2023).
53. Bray, L. et al. Developing rights-based standards for children having tests, treatments, examinations and interventions: using a collaborative, multi-phased, multi-method and multi-stakeholder approach to build consensus. *Eur. J. Pediatr.* **182**, 4707–4721 (2023).
54. Gallagher, K., Shaw, C., Aladangady, N. & Marlow, N. Parental experience of interaction with healthcare professionals during their infant's stay in the neonatal intensive care unit. *Arch. Dis. Child Fetal Neonatal Ed.* **103**, F343–F348 (2018).
55. British Association of Perinatal Medicine (BAPM). *Family Integrated Care-A Framework for Practice* (BAPM, London, 2021).
56. Balice-Bourgois, C., Zumstein-Shaha, M., Simonetti, G. D. & Newman, C. J. Interprofessional collaboration and involvement of parents in the management of painful procedures in newborns. *Front. Pediatr.* **8**, 394 (2020).
57. Toivonen, M., Lehtonen, L., Löyttyniemi, E., Ahlqvist-Björkroth, S. & Axelin, A. Close collaboration with parents intervention improves family-centered care in different neonatal unit contexts: a pre-post study. *Pediatr. Res.* **88**, 421–428 (2020).
58. De Bernardo, G., Svelto, M., Giordano, M., Sordino, D. & Riccitelli, M. Supporting parents in taking care of their infants admitted to a neonatal intensive care unit: a prospective cohort pilot study. *Ital. J. Pediatr.* **43**, 36 (2017).
59. Adama, E. A., Adua, E., Bayes, S. & Mörelius, E. Support needs of parents in neonatal intensive care unit: an integrative review. *J. Clin. Nurs.* **31**, 532–547 (2020).
60. Torbert, N. et al. Providing "compassionate care" in the neonatal intensive care unit through infant and family needs-based care. *Am. J. Perinatol.* **41**, e863–e869 (2024).
61. National Health Service (NHS) Health Education England. *Human Factors and Healthcare. Evidencing the Impact of Human Factors Training to Support Improvements in Patient Safety and to Contribute to Cultural Change* (NHS, London, 2019).
62. Legemaat, M. M., Jongerden, I. P., van Rens, R. M., Zielman, M. & van den Hoogen, A. Effect of a vascular access team on central line-associated bloodstream infections in infants admitted to a neonatal intensive care unit: a systematic review. *Int. J. Nurs. Stud.* **52**, 1003–1010 (2015).
63. Taylor, T. et al. Effect of a dedicated percutaneously inserted central catheter team on neonatal catheter-related bloodstream infection. *Adv. Neonatal Care* **11**, 122–128 (2011).
64. Bayoumi, M. A. A. et al. Effect of implementing an epicutaneo-caval catheter team in neonatal intensive care unit. *J. Vasc. Access.* **22**, 243–253 (2021).
65. Bayoumi, M. A. A. et al. Neonatal simulation program: a 5 years educational journey from Qatar. *Front. Pediatr.* **10**, 843147 (2022).
66. Moss, C. R. Neonatal fragile skin: novel use of simulation to improve knowledge and confidence for neonatal nurse practitioner students. *Nurse Educ.* **48**, E122–E125 (2023).
67. Cincinnati Children's. *Vascular Access Materials for Healthcare Professionals* (Cincinnati Children's Hospital, Cincinnati, OH, 2024).
68. Rigo, C. et al. Vascular access and clinical competency: which elements matter? The development of three bottom-up and evidence-grounded self-assessment tools. *J. Vasc. Access.* **24**, 191–197 (2023).
69. Hugill, K. & van Rens, M. Inserting central lines via the peripheral circulation in neonates. *Br. J. Nurs.* **29**, S12–S18 (2020).
70. Gibb, J. J., MacLeod, R., Mahoney, L. & Elanjikal, Z. Modified Seldinger technique for neonatal epicutaneo-caval catheter insertion: a non-randomised retrospective study. *J. Vasc. Access.* **24**, 780–785 (2023).
71. Wald, M. et al. A. modified Seldinger technique for 2-French peripherally inserted central venous catheters. *Arch. Dis. Child.* **93**, Ps368 (2008).
72. MacLeod, R., Gibb, J., MacLeod, R., & Elanjikal, Z. 55 Modified Seldinger technique for neonatal peripherally inserted central catheter placement. *BMJ. Paediatr. Open* https://doi.org/10.1136/bmjpo-2021-RCPCH.35 (2021).
73. Pereira, H. P., Secco, I. L., Arrue, A. M., Pontes, L. & Danski, M. T. R. Implementation of modified Seldinger technology for percutaneous catheterization in critically ill newborns. *Rev. Esc. Enferm. Usp.* **57**, e20220347 (2023).
74. D'Andrea, V. et al. The intracavitary ECG method for tip location of ultrasound-guided centrally inserted central catheter in neonates. *J. Vasc. Access.* **24**, 1134–1139 (2023).
75. D'Andrea, V., Pittiruti, M., Prontera, G., Vento, G., & Barone, G. The SIECC protocol: a novel insertion bundle to minimize the complications related to epicutaneo-cava catheters in neonates. *J. Vasc. Access* https://doi.org/10.1177/11297298241239699 (2024).
76. Raphael, C. K. et al. Ultrasound-guided arterial cannulation in the paediatric population. *Cochrane Database Syst. Rev.* **3**, CD011364 (2023).
77. Popowicz, H., Kwiecień-Jaguś, K., Mędrzycka-Dąbrowska, W., Kopeć, M. & Dyk, D. Evidence-based nursing practices for the prevention of newborn procedural pain in neonatal intensive therapy-an exploratory study. *Int. J. Environ. Res. Public Health* **19**, 12075 (2022).
78. Carozza, S. & Leong, V. The role of affectionate caregiver touch in early neurodevelopment and parent-infant interactional synchrony. *Front. Neurosci.* **14**, 613378 (2021).
79. Campbell-Yeo, M., Eriksson, M. & Benoit, B. Assessment and management of pain in preterm infants: a practice update. *Children* **9**, 244 (2022).
80. Malin, K. J. et al. Scoping review of early toxic stress and epigenetic alterations in the neonatal intensive care unit. *Nurs. Res.* **72**, 218–228 (2023).
81. Altimier, L. & Phillips, R. The neonatal integrative developmental care model: advanced clinical applications of the seven core measures for neuroprotective family-centered developmental care. *Newborn Infant Nurs. Rev.* **16**, 230–244 (2016).
82. Giordano, V. et al. Pain and sedation scales for neonatal and pediatric patients in a preverbal stage of development: a systematic review. *JAMA Pediatr.* **173**, 1186–1197 (2019).
83. Mencía, S. et al. Evaluation and treatment of pain in fetuses, neonates and children. *Children* **9**, 1688 (2022).
84. Cozzi, G., Valerio, P. & Kennedy, R. A narrative review with practical advice on how to decrease pain and distress during venepuncture and peripheral intravenous cannulation. *Acta Paediatr.* **110**, 423–432 (2021).
85. Bueno, M. et al. The effectiveness of repeated sucrose for procedural pain in neonates in a longitudinal observational study. *Front. Pain. Res.* **4**, 1110502 (2023).
86. Thakkar, P. et al. To evaluate and compare the efficacy of combined sucrose and non-nutritive sucking for analgesia in newborns undergoing minor painful procedure: a randomized controlled trial. *J. Perinatol.* **36**, 67–70 (2016).
87. Paterson, R. S. et al. Selection and insertion of vascular access devices in pediatrics: a systematic review. *Pediatrics* **145**, S243–S268 (2020).
88. Zanaboni, C. et al. Caliber of the deep veins of the arm in infants and neonates: the VEEIN study (Vascular Echography Evaluation in Infants and Neonates). *J. Vasc. Access* **25**, 1114–1120 (2024).
89. van Rens, M. F. P. T. et al. Closed intravenous systems for central vascular access: a difference maker for CLABSI rates in neonates?. *J. Vasc. Access* **24**, 1390–1397 (2023).
90. Schults, J. A. et al. Improving peripheral venous cannula insertion in children: a mixed methods study to develop the DIVA key. *BMC Health Serv. Res.* **22**, 220 (2022).
91. Tofani, B. F. et al. Quality improvement project to reduce infiltration and extravasation events in a pediatric hospital. *J. Pediatr. Nurs.* **27**, 682–689 (2012).
92. Hallam, C. et al. UK vessel health and preservation (VHP) framework: a commentary on the updated VHP 2020. *J. Infect. Prev.* **22**, 147–155 (2021).
93. Moureau, N. L. (Ed.). *Vessel Health and Preservation: The Right Approach for Vascular Access* (Springer Open, Cham, 2019).
94. Fiorini, J. et al. Vessel health and preservation: an integrative review. *J. Clin. Nurs.* **28**, 1039–1049 (2019).
95. Ainsworth, S. B. & McGuire, W. Peripherally inserted central catheters vs peripheral cannulas for delivering parenteral nutrition in neonates. *JAMA* **315**, 2612–2613 (2016).
96. Gibson, K. et al. Adverse events associated with umbilical catheters: a systematic review and meta-analysis. *J. Perinatol.* **41**, 2505–2512 (2021).

97. Spagnuolo, F. et al. Systematic application of SICA-PED protocol for central venous catheterization in neonates: a prospective clinical study on 104 cases. J. Vasc. Access 27, 11297298241239998 (2024).
98. Barone, G., Pittiruti, M. & D'Andrea, V. Ultrasound-guided catheter tip location in neonatal central venous access. Focus on well-defined protocols and proper ultrasound training. *J. Pediatr.* **247**, 181 (2022).
99. Centers for Disease Control and Prevention (CDC). *CDC's Core Infection Prevention and Control Practices for Safe Healthcare Delivery in All Settings* https://www.cdc.gov/infectioncontrol/guidelines/core-practices/index.html (2022).
100. National Health Service (NHS) England. *National Infection Prevention and Control Manual for England, V2.4* (NHS England, London, 2023).
101. National Health Service (NHS) National Services Scotland. *National Infection Prevention and Control Manual* (NHS Scotland, Edinburgh, 2022).
102. Schmid, S., Geffers, C., Wagenpfeil, G. & Simon, A. Preventive bundles to reduce catheter-associated bloodstream infections in neonatal intensive care. *GMS Hyg. Infect. Control* **13**, Doc10 (2018).
103. Pittiruti, M. et al. A GAVeCeLT bundle for central venous catheterization in neonates and children: a prospective clinical study on 729 cases. *J. Vasc. Access* **24**, 1477–1488 (2023).
104. Piersigilli, F. et al. Cyanoacrylate glue as part of a new bundle to decrease neonatal PICC-related complications. *Eur. J. Pediatr.* **182**, 5607–5613 (2023).
105. Gavin, N. C., Webster, J., Chan, R. J. & Rickard, C. M. Frequency of dressing changes for central venous access devices on catheter-related infections. *Cochrane Database Syst. Rev.* **2**, CD009213 (2016).
106. Broadhurst, D. et al. Management of central venous access device-associated skin impairment: an evidence-based algorithm. *J. Wound Ostomy Cont. Nurs.* **44**, 211–220 (2017).
107. Xu, H. et al. The effectiveness of dressings and securement devices to prevent central venous catheter-associated complications: a systematic review and meta-analysis. *Int. J. Nurs. Stud.* **149**, 104620 (2024).
108. Su, L. T. et al. The appropriate frequency of dressing for percutaneous central venous catheters in preventing catheter-related blood stream infection in NICU - a randomized controlled trial. *Pediatr. Neonatol.* **62**, 292–297 (2021).
109. Gilardi, E. et al. Reduction of bacterial colonization at the exit site of peripherally inserted central catheters: a comparison between chlorhexidine-releasing sponge dressings and cyano-acrylate. *J. Vasc. Access* **22**, 597–601 (2021).
110. Ullman, A. J. et al. Dressings and securement devices for central venous catheters (CVC). *Cochrane Database Syst. Rev.* **2015**, CD010367 (2015).
111. Prince, D. et al. Immobilization and death of bacteria by Flora Seal® Microbial Sealant. *Int. J. Pharm. Sci. Invent.* **6**, 45–49 (2017).
112. Prince, D., Solanki, Z., Varughese, R., Mastej, J. & Prince, D. Antibacterial effect and proposed mechanism of action of a topical surgical adhesive. *Am. J. Infect. Control* **46**, 26–29 (2018).
113. Wu, Y., Liu, Y., Wang, B. & Feng, B. Efficacy of antimicrobial peripherally inserted central catheters in line-associated bloodstream infections: a systematic review and meta-analysis. *Am. J. Infect. Control* **51**, 1425–1429 (2023).
114. van Rens, M. et al. Cyanoacrylate securement in neonatal PICC use: a 4-year observational study. *Adv. Neonatal Care* **22**, 270–279 (2022).
115. van Rens, M. F. et al. Octyl-butyl-cyanoacrylate glue for securement of peripheral intravenous catheters: a retrospective, observational study in the neonatal population. *J. Vasc. Access* **25**, 1229–1237 (2024).
116. D'Andrea, V. et al. Use of cyanoacrylate glue for the sutureless securement of epicutaneo-caval catheters in neonates. *J. Vasc. Access* **23**, 801–804 (2022).
117. National Institute for Health and Care Excellence (NICE). *SecurePort IV Tissue Adhesive for Use with Percutaneous Catheters. Medtech Innovation Briefing* (NICE, London, 2022).
118. D'Andrea, V. et al. Securement of umbilical venous catheter using cyanoacrylate glue: a randomized controlled trial. *J. Pediatr.* **260**, 113517 (2023).
119. Lund, C. H. & Osborne, J. W. Validity and reliability of the neonatal skin condition score. *J. Obstet. Gynecol. Neonatal Nurs.* **33**, 320–327 (2004).
120. Ashworth, C. J. & Briggs, L. Design and implementation of a neonatal tissue viability assessment tool on the newborn intensive care unit. *Infant* **7**, 191–194 (2011).
121. Kusari, A. et al. Evidence-based skin care in preterm infants. *Pediatr. Dermatol.* **36**, 16–23 (2019).
122. Lund, C. Medical adhesives in the NICU. *Newborn Inf. Nurs. Rev.* **14**, 160–165 (2014).
123. Fumarola, S. et al. Overlooked and underestimated: medical adhesive-related skin injuries. *J. Wound Care* **29**, S1–S24 (2020).
124. Broom, M., Dunk, A. M. & E Mohamed, A. L. Predicting neonatal skin injury: the first step to reducing skin injuries in neonates. Health Serv. Insights 12, 1178632919845630 (2019).
125. de Oliveira Marcatto, J. et al. Medical adhesive-related skin injuries in the neonatology department of a teaching hospital. *Nurs. Crit. Care* **27**, 583–588 (2022).
126. Doellman, D. & Rineair, S. The use of optical detection for continuous monitoring of pediatric IV sites. *J. Assoc. Vasc. Access* **24**, 44–47 (2019).
127. van Rens, M., Hugill, K. & Francia, A. V. A new approach for early recognition of peripheral intravenous (PIV) infiltration: a pilot appraisal of a sensor technology in a neonatal population. *Vasc. Access* **5**, 38–41 (2019).
128. van Rens, M. F. et al. Peripheral intravenous therapy infiltration/extravasation (PIVIE) risks and the potential for earlier notification of events using a novel sensor technology in a neonatal population. *J. Vasc. Access* **25**, 1801–1807 (2024).
129. Hoffman, L., & Bacon, O. Infusion Pumps. In: Hall, K. K. et al. *Making Healthcare Safer III: A Critical Analysis of Existing and Emerging Patient Safety Practices [Internet]* (Agency for Healthcare Research and Quality (US), Rockville, MD, 2020).
130. US Food and Drink Administration (FDA). Infusion pumps http://www.fda.gov/MedicalDevices/ProductsandMedical.Procedures/GeneralHospitalDevicesandSupplies/InfusionPumps/default.htm (2018).
131. US Food and Drink Administration (FDA). Syringe pump problems with fluid flow continuity at low infusion rates can result in serious clinical consequences: FDA safety communication. http://wayback.archive-it.org/7993/20171115052211/https:/www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm518049.htm (2016).
132. Schnock, K. O. et al. Intravenous medication administration safety with smart infusion pumps in the neonatal intensive care unit: an observational study. *Drug Saf.* **47**, 29–38 (2024).
133. Milstone, A. M. et al. Catheter dwell time and CLABSIs in neonates with PICCs: a multicenter cohort study. *Pediatrics* **132**, e1609–e1615 (2013).
134. Sanderson, E. et al. Dwell time and risk of central-line-associated bloodstream infection in neonates. *J. Hosp. Infect.* **97**, 267–274 (2017).
135. Hugill, K. et al. Safe and effective removal of cyanoacrylate vascular access catheter securement adhesive in neonates. *Front. Pediatr.* **11**, 1237648 (2023).
136. Atsma, F., Elwyn, G. & Westert, G. Understanding unwarranted variation in clinical practice: a focus on network effects, reflective medicine and learning health systems. *Int. J. Qual. Health Care* **32**, 271–274 (2020).
137. Sutherland, K. & Levesque, J. F. Unwarranted clinical variation in health care: definitions and proposal of an analytic framework. *J. Eval. Clin. Pract.* **26**, 687–696 (2020).
138. Harrison, R. et al. Addressing unwarranted clinical variation: a rapid review of current evidence. *J. Eval. Clin. Pract.* **25**, 53–65 (2019).
139. Adams, E., Harvey, K., & Sweeting, M. *Neonatology GIRFT Programme National Specialty Report* (NHS, London, 2022).
140. Tjomsland, O., Thoresen, C., Ingebrigtsen, T., Søreide, E. & Frich, J. C. Reducing unwarranted variation: can a 'clinical dashboard' be helpful for hospital executive boards and top-level leaders?. *BMJ Lead.* **8**, 186–190 (2024).
141. van Rens, M. R. & Hugill, K. *Vascular Access in Neonatal Nursing Practice: A Neuroprotective Approach* (Springer Nature, Cham, Switzerland, 2025).

ACKNOWLEDGEMENTS

The authors thank the families, patients, and colleagues who inspired the development of this framework. Additionally, we acknowledge colleagues from NEVAT, and particularly Dr. Isabel Geiger of EFCNI, for invaluable comments on earlier drafts of this manuscript. This initiative was formally endorsed by the ESPR Special Interest Group on IV access (SIG-IV).

AUTHOR CONTRIBUTIONS

M.F.P.T.v.R. conceptualized the first iteration of the 7-Rights-Framework, led the consensus development, drafted the initial manuscript, and revised the manuscript. K.H. helped with the conceptualization of the 7-Rights Framework, drafting of the initial manuscript, and further revised the manuscript. R.v.d.L., F.P., B.S., S.M., and A.v.d.H. contributed to the refinement of the framework, reviewed and revised drafts of the manuscript for important intellectual content. All authors approved the final manuscript.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41390-025-04521-z.

Correspondence and requests for materials should be addressed to Matheus F. P. T. van Rens.