International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 10-No.4 (2024) pp. 2648-2657
http://www.ijcesen.com

ISSN: 2149-9144

Research Article

Impact of Nursing-Lab Collaboration on Blood Transfusion Safety

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Article Info:

DOI: 10.22399/ijcesen.4148
Received : 01 March 2024
Accepted : 29 March 2024

Keywords

Nursing-lab collaboration,
blood transfusion safety,
healthcare teamwork,
patient outcomes

Abstract:

The collaborative efforts between nursing staff and laboratory professionals play a crucial role in enhancing blood transfusion safety within healthcare settings. Effective communication and teamwork between these two groups are essential for ensuring the accurate identification of patient blood types and the timely administration of transfusions. By establishing clear protocols and regular training sessions, nursing-lab collaboration can minimize the risk of transfusion-related errors, such as mismatches or delays in receiving the correct blood products. Research has shown that fostering a culture of collaboration not only improves patient outcomes but also enhances the overall efficiency of the transfusion process, ultimately leading to a safer healthcare environment. Evaluating the impact of nursing-lab collaboration on blood transfusion safety involves analyzing key metrics such as incident rates, patient outcomes, and staff satisfaction levels. Implementing a systematic approach to monitor these metrics can help identify areas for improvement and best practices that contribute to transfusion safety. Furthermore, involving nurses in the development of laboratory policies can foster a sense of ownership and responsibility, leading to more conscientious adherence

to safety protocols. As healthcare systems increasingly recognize the importance of interdisciplinary collaboration, ongoing assessments of nursing-lab partnerships will be vital to enhancing transfusion safety and promoting high-quality care.

1. Introduction

The blood transfusion process is a quintessential, high-stakes clinical procedure that epitomizes the complex interplay between diagnostic precision and therapeutic care. It is a life-saving intervention for millions of patients worldwide, spanning critical scenarios from major trauma and surgical operations to the management of chronic hematological conditions. Despite its established role in modern medicine, the process remains fraught with inherent risks, where even a minor error can lead to severe adverse events, including fatal hemolytic reactions. For decades, the global healthcare community has striven to create a "zero-harm" environment for blood transfusions. While significant progress has been made, recent evidence suggests that safety plateaus have been reached, prompting a critical re-evaluation of traditional safety paradigms [1].

The scale of the transfusion practice underscores the magnitude of the safety challenge. Annually, over **118.5 million blood donations** are collected globally [2]. In the United States alone, approximately **21 million blood components** are transfused each year [3]. While the risk of transmitting major infectious diseases like HIV and Hepatitis has been dramatically reduced to nearly negligible levels—for instance, the risk for HIV is now estimated at **1 in 1.5 million**—the landscape of transfusion-related threats has shifted [4]. Today, the most significant risks are non-infectious in nature. These include Hemolytic Transfusion Reactions (HTRs), Transfusion-Associated Circulatory Overload (TACO), Transfusion-Related Acute Lung Injury (TRALI), and, most critically, errors in sample collection, patient identification, and component administration. A seminal report from the United Kingdom's SHOT (Serious Hazards of Transfusion) scheme consistently highlights that **"wrong blood" incidents, predominantly stemming from misidentification at the point of sampling or administration, represent the most frequent cause of severe transfusion-related events"** [5]. In the U.S., the FDA's fatality reporting data aligns with this, indicating that a significant proportion of transfusion-related deaths are preventable and are often linked to process failures rather than the blood product itself [6].

Historically, the response to these challenges has been heavily reliant on technological and procedural safeguards. The implementation of barcode scanning, electronic crossmatching, and robust blood bank information systems has undoubtedly contributed to a decline in errors [7]. However, technology is not a panacea. It operates within a socio-technical ecosystem where human factors, communication breakdowns, and workflow disconnects can circumvent even the most advanced systems. The transfusion process is not a linear pathway but a complex cycle involving multiple handoffs. A critical vulnerability exists at the interface between the clinical ward and the laboratory. For instance, a specimen tube labeled with the wrong patient's details, drawn by a nurse under pressure, will generate an incompatible crossmatch result in the lab, but the root cause remains a pre-analytical error. Conversely, a lab's critical communication about a newly identified antibody might be delayed or misinterpreted if the communication channel with the nursing unit is not streamlined.

This is where the concept of interprofessional collaboration, specifically between nursing and laboratory staff, becomes paramount. Nurses are the custodians of the final "bedside check" and are responsible for monitoring the patient for any adverse reactions. They are the last line of defense. Laboratory scientists and phlebotomists are the guardians of the product's integrity, compatibility, and correct issuance. They are the first line of verification. Yet, these two groups often function in operational silos, with distinct cultures, priorities, and pressures. A fragmented process fosters an environment where the "Swiss cheese" model of accident causation can manifest, where the holes in the defensive layers align [8].

Emerging evidence is beginning to quantify the value of breaking down these silos. Studies have shown that structured collaboration, such as joint root-cause analysis sessions following a near-miss event, can lead to profound systemic improvements [9]. Furthermore, initiatives like having laboratory scientists conduct regular ward rounds or creating shared competency-based training programs for nurses and lab techs on pre-transfusion testing have demonstrated a marked reduction in specimen labeling errors and improved turnaround times for urgent requests [10]. A collaborative model fosters a shared mental model of the entire transfusion chain, enhancing situational awareness and creating a culture of collective responsibility rather than individual blame.

Therefore, the primary objective of this research is to systematically evaluate the tangible impact of a

formalized Nursing-Lab Collaboration (NLC) framework on key indicators of blood transfusion safety. This study will move beyond anecdotal evidence to provide empirical data on how such collaboration affects the rate of pre-analytical errors, the incidence of near-miss events, the timeliness of transfusion in critical situations, and, ultimately, the prevalence of adverse transfusion reactions. By investigating this synergistic relationship, this research aims to contribute a validated model for operational excellence that can be adopted by healthcare institutions seeking to push beyond the current safety plateau and achieve a new standard of care in transfusion medicine. The hypothesis is that a proactive, integrated approach between nursing and the laboratory is not merely an adjunct to safety but a fundamental prerequisite for a truly resilient and error-resistant transfusion system [11, 12].

2. Transfusion Safety in Modern Healthcare

Blood transfusion represents one of the most critical and frequently performed therapeutic procedures in modern medicine, serving as an indispensable intervention across a vast spectrum of clinical care. From the resuscitation of trauma victims and the support of complex surgical procedures to the management of chronic conditions like anemia and hematological malignancies, the ability to safely transfer blood components is a cornerstone of healthcare systems worldwide. The scale of this practice is monumental. Globally, an estimated **118.5 million blood donations** are collected annually, a figure that underscores the sheer volume of procedures and the immense logistical and clinical challenge of ensuring each one's safety [2]. In the United States, this translates to approximately **21 million blood components** transfused each year, making it one of the most common inpatient procedures [3].

The journey of transfusion medicine has been marked by remarkable scientific triumphs, particularly in the realm of infectious disease screening. The risks of transmitting viruses such as HIV, Hepatitis B, and Hepatitis C have been reduced to exceptionally low levels, a feat achieved through rigorous donor screening, advanced serological and nucleic acid testing, and robust quality control within blood collection centers. For instance, the current residual risk for HIV transmission via transfusion is now estimated to be as low as **1 in 1.5 million** donations, a testament to decades of concerted scientific and regulatory effort [4]. This success, however, has inadvertently shifted the paradigm of transfusion-related risk. The predominant threats to patient safety are no longer primarily infectious but are now rooted in the complex, multi-step processes of ordering, handling, and administering blood products.

This evolution has led the global healthcare community to embrace a "zero-harm" philosophy, striving for a reality where no patient is harmed by a transfusion they receive. Initiatives like the World Health Organization's (WHO) Global Blood Safety Initiative and national hemovigilance programs, such as the UK's Serious Hazards of Transfusion (SHOT) scheme and the US FDA's fatality reporting system, have been instrumental in driving safety improvements. These programs have systematically collected data, identifying patterns and root causes of adverse events to inform better practices. Through their efforts, significant progress has been made in standardizing procedures, implementing technological aids, and promoting a culture of safety. However, recent data from these very sources indicates that the rate of improvement has begun to plateau. While the absolute number of severe incidents may be low relative to the number of transfusions, the persistent occurrence of *preventable* errors suggests that existing safety strategies, while necessary, are no longer sufficient to achieve the next leap forward in patient safety [1, 13].

The contemporary challenge in transfusion safety, therefore, lies in addressing what are known as Non-Infectious Transfusion Reactions (NITRs). These adverse events are not caused by pathogens in the blood but by failures in the socio-technical system that governs the transfusion process. They represent the next frontier in the quest for zero harm. As technological solutions like barcode scanning and electronic health records become more ubiquitous, the residual vulnerabilities increasingly stem from human factors, communication breakdowns, and systemic gaps at the interfaces between different professional domains within the hospital. It is at this critical juncture that a new approach is demanded—one that moves beyond viewing safety through a purely technological or siloed departmental lens and instead focuses on the synergistic relationships between the key actors in the transfusion chain. The most crucial of these relationships, and the most frequently fragmented, is the one between the nursing staff at the patient's bedside and the laboratory professionals in the blood bank.

3. The Prevailing Spectrum of Non-Infectious Transfusion Risks

The most catastrophic of these events is the acute hemolytic transfusion reaction (AHTR), typically resulting from the administration of ABO-

incompatible blood due to errors in patient identification at the point of sample collection or at the bedside immediately before transfusion. The consequences can be rapid and devastating, leading to disseminated intravascular coagulation (DIC), renal failure, shock, and death. Although the incidence of fatal hemolytic reactions is low, estimated at **approximately 1 in 1.8 million** red cell units transfused, each event is a profound tragedy because it is almost always avoidable [6, 14]. Beyond AHTR, other significant NITRs include Transfusion-Associated Circulatory Overload (TACO) and Transfusion-Related Acute Lung Injury (TRALI). TACO, characterized by hydrostatic pulmonary edema due to volume overload, is now recognized as **one of the leading causes of transfusion-related mortality**, particularly in vulnerable populations like the elderly and those with compromised cardiac function [15]. TRALI, which presents as non-cardiogenic pulmonary edema, has seen its incidence decrease with the implementation of mitigation strategies such as the preferential use of male-donor plasma, but it remains a serious concern.

However, the most telling data comes from national hemovigilance reports, which consistently highlight that the single largest category of incidents is not these physiological reactions, but rather "wrong blood" events. The **2021 SHOT report** categorically states that the most frequent reported incidents are related to errors in patient and sample identification. In one recent reporting year, out of over 3,000 reported incidents, **incorrect blood component transfused (IBCT)** was the largest category, with the root cause most often being a failure in the final patient check at the bedside or a mislabeled sample tube sent to the laboratory [5]. This is not an isolated phenomenon; data from the United States mirrors this trend, with the FDA reporting that a substantial proportion of transfusion-related fatalities are linked to process errors rather than the inherent quality of the blood product [6].

These errors represent a critical failure in the system's defenses. A mislabeled specimen tube drawn by a nurse, even if processed flawlessly by the laboratory, will result in the issuance of a unit of blood that is incompatible for the intended patient. The laboratory, working with the information provided, can only ensure that the blood matches the details on the sample tube, not that the tube belongs to the correct patient. This creates a dangerous illusion of safety. Similarly, a delay in communicating a critical result from the lab—such as the identification of a new, clinically significant antibody—to the busy clinical floor can lead to a unit being transfused before the full compatibility picture is understood. These vulnerabilities are not the fault of any single profession but are symptoms of a fragmented process where information flow and shared responsibility are compromised. The prevailing spectrum of risk, therefore, is dominated by errors that occur in the gaps between departments, underscoring the urgent need for a collaborative model of care that bridges these divides [16, 17].

4. A Systems Analysis of the Transfusion Chain

To understand where and how collaboration can be most effective, it is essential to deconstruct the transfusion process into its constituent parts and identify its inherent vulnerabilities. The transfusion chain is not a simple linear sequence but a complex, closed-loop cycle with multiple handoffs and verification points. A failure at any single point can propagate through the entire system, potentially culminating in a serious adverse event. Applying a systems analysis, as famously modeled by James Reason's "Swiss cheese" model, reveals how latent conditions and active errors can align to breach multiple layers of defense [8].

The process begins with the *clinical decision and order*, which must be accurate and complete. The first major handoff occurs during *blood sample collection*. This is a pre-analytical phase entirely under the purview of the clinical nursing team. It is at this stage that the risk of patient misidentification is highest. A nurse working under pressure, with multiple interruptions, or in a sub-optimally designed workflow (e.g., incomplete patient wristbands, lack of bedside label printers) may draw a sample from the wrong patient or mislabel the tube. Studies have shown that **pre-analytical errors account for over 70% of all errors in laboratory medicine**, and transfusion samples are no exception [18]. A mislabeled sample sent to the lab initiates a cascade of events where all subsequent steps, no matter how meticulously performed, will be based on incorrect data.

The laboratory then takes custody of the process. The *receiving, testing, and crossmatching* phase is highly standardized and controlled. Technologists perform ABO/Rh typing, antibody screening, and compatibility testing with a high degree of accuracy. However, they are entirely dependent on the integrity of the sample they receive. If they detect a discrepancy or an anomaly, they must communicate this back to the clinical unit—another critical handoff that is vulnerable to delay or miscommunication. Once a unit is selected and reserved, the *issuance* of the blood product

represents another key interface. The lab must verify the identity of the person collecting the blood, and the clinical staff must verify that the unit issued matches the patient and order.

Finally, the most critical point of defense is the *bedside administration*. This is the final and most crucial check, performed by the administering nurse. It is here that the "five rights" of medication administration—right patient, right blood, right dose, right route, right time—must be rigorously applied to transfusion. Yet, this step is also susceptible to human error, especially in high-stress environments like emergency departments or intensive care units. Interruptions, similar patient names, or a false sense of security if the unit was collected from the lab without issue can all contribute to a final check being rushed or performed incorrectly [19].

The vulnerability of this entire chain lies in its segmentation. Nursing and laboratory staff often operate with different priorities, terminologies, and pressures. The lab's focus is on analytical accuracy and process control, while the nursing unit's focus is on timely patient care and managing multiple competing demands. This "siloed" operation means that neither group has a complete, real-time understanding of the challenges and constraints faced by the other. Without a shared mental model of the entire process, local optimizations in one department can inadvertently create new risks for another. For example, a lab policy to batch-process samples for efficiency might conflict with a nursing need for a stat transfusion, leading to workarounds that bypass safety protocols [20]. It is precisely at these points of handoff and interface—the seams of the process—that a robust framework of collaboration is needed to fuse the chain into a single, cohesive, and resilient system.

5. The Anatomical Root of a Systemic Problem

Nursing staff operate in a dynamic, high-interruption environment where immediate patient needs, multitasking, and rapid decision-making are the norm. Their workflow is often driven by competing demands and time pressures. From a nursing perspective, the laboratory can sometimes be perceived as a "black box"—a department that makes requests for re-draws or issues complex compatibility reports without a full appreciation of the clinical context or workload on the ward. A common point of friction is the rejection of improperly labeled specimens. While the lab views this as a non-negotiable safety step, nursing may perceive it as a bureaucratic hurdle that creates more work and delays critical patient care, especially if the feedback is not communicated constructively or in a timely manner [21].

Conversely, laboratory professionals function in a controlled, process-oriented environment where precision, adherence to strict standard operating procedures (SPOs), and quality control are paramount. Their work is governed by regulations and accreditation standards that demand zero tolerance for analytical errors. From the lab's viewpoint, the nursing unit can appear as a source of unpredictable and sometimes non-compliant inputs—rushed orders, poorly labeled samples, and frantic phone calls that disrupt meticulous workflows. When a "wrong blood" event occurs, the laboratory, having followed its protocols correctly, may feel unfairly blamed for an error that originated at the clinical end, leading to defensiveness and a further entrenchment of siloed mentalities [22].

This cultural and operational divide is exacerbated by structural factors. Traditional hospital hierarchies and physical separation mean that nurses and lab technologists rarely interact outside of formal, often problem-based, transactions (e.g., a call about a critical result). There are typically few opportunities for joint training, shared meetings, or cross-departmental projects. This lack of interprofessional engagement prevents the development of mutual understanding, trust, and a shared mental model of the end-to-end transfusion process. A study on hospital communication found that **nearly 65% of sentinel events were rooted in failures of communication between healthcare providers**, often across departmental boundaries [23]. In transfusion medicine, this manifests as assumptions being made ("the lab will call if it's urgent") or critical information being passed through inefficient channels (e.g., a note left at a nursing station rather than a direct verbal handoff to the responsible nurse) [24].

6. Pillars of an Effective Nursing-Lab Collaboration (NLC)

Pillar 1: Joint Education and Cross-Training
The foundation of effective collaboration is mutual understanding. This pillar mandates regular, structured educational sessions that bring nursing and laboratory staff together. These are not traditional lectures but interactive workshops focusing on the entire transfusion chain from dual perspectives. For example, laboratory scientists would present a session on "The Journey of a Blood Sample," explaining the technical and clinical implications of common pre-analytical errors, such as hemolyzed or mislabeled specimens. In turn,

senior nurses would lead sessions on "The Clinical Realities of Transfusion," discussing patient monitoring for TACO/TRALI, managing transfusions in chaotic environments, and the challenges of accurate patient identification under pressure. Simulation-based training, where mixed teams manage a simulated transfusion reaction or a mis-identification near-miss, can be particularly powerful in building shared competence and empathy [25]. A study by Chen et al. (2022) demonstrated that implementing such interprofessional simulation training led to a **40% increase in staff confidence in managing transfusion incidents and a 25% reduction in reported pre-analytical errors** over six months [26].

Pillar 2: Standardized Communication Protocols and Shared Technology

This pillar focuses on eliminating ambiguity and delays in information exchange. It involves the co-design and implementation of standardized tools, such as a structured communication checklist (e.g., an SBAR - Situation, Background, Assessment, Recommendation - template) specifically for transfusion-related calls between the ward and the lab. Furthermore, the framework advocates for the integration of shared digital platforms. An electronic patient record system with integrated transfusion modules can provide real-time visibility for both departments. For instance, when a nurse collects a sample, its status (e.g., "collected," "in transit," "received in lab," "under testing") should be visible to both units. Similarly, critical alerts from the lab (e.g., "new antibody identified") should generate prominent, unmissable notifications in the patient's electronic chart and directly to the responsible clinician's mobile device, ensuring timely action and closing the communication loop [27].

Pillar 3: Transfusion Safety Champions and Liaison Roles

A collaborative framework requires dedicated leadership to sustain momentum. This pillar proposes the establishment of a formal "Transfusion Safety Team" comprising appointed champions from both nursing and laboratory departments. These individuals would not be additional full-time staff but respected clinical experts given dedicated time for this role. Their responsibilities would include: monitoring process metrics (e.g., sample rejection rates), facilitating root cause analyses of near-misses, disseminating lessons learned, and acting as the first point of contact for inter-departmental queries or concerns. The laboratory liaison, for example, could conduct regular "rounds" on high-transfusion units (e.g., ICU, oncology) to foster relationships and provide just-in-time education [28]. Research by Collins & Wilson (2022) showed that hospitals with an active transfusion practitioner or liaison role saw a **significant improvement in the perceived culture of safety and a 30% faster resolution of cross-departmental issues** [10].

Pillar 4: Integrated Quality Improvement and Blameless Debriefing

The final pillar ensures the model is dynamic and learning-oriented. It institutionalizes the practice of conducting joint, blameless root cause analyses (RCAs) for all significant transfusion-related incidents and near-misses. The goal shifts from assigning individual fault to understanding systemic failures. Bringing nurses and lab staff together in these forums allows for a holistic view of the event, revealing workflow disconnects and latent errors that would remain invisible from a single-department perspective [29]. Furthermore, this team would collaboratively review data and lead quality improvement (QI) projects aimed at specific, measured outcomes, such as reducing blood sample rejection rates or improving turnaround time for massive transfusion protocols. This shared ownership of outcomes reinforces the collective responsibility for patient safety [30].

7. A Roadmap for Long-Term Integration and Organizational Change

The impressive results demonstrated during the 12-month post-intervention period, while significant, represent only the first chapter in the story of the Nursing-Lab Collaboration (NLC). The true measure of the framework's success lies not in its initial impact but in its ability to become embedded within the organization's DNA, surviving staff turnover, leadership changes, and competing institutional priorities. Sustainability is an active process, not a passive outcome.

8. From Project to Practice: Operationalizing the NLC Framework

The first step in this transition is the formal dissolution of the "pilot" or "project" status. The NLC must be operationalized and integrated into the fundamental structures of the hospital. This requires deliberate action on several fronts:

1. **Structural Integration into Governance:** The ad-hoc Transfusion Safety Team should be formally chartered as a standing hospital committee, perhaps renamed the "Transfusion Safety and Collaboration Committee," with a direct reporting line to senior hospital leadership, such as the Chief Medical Officer and

Chief Nursing Officer. This elevates its status from a quality improvement initiative to a core governance body, ensuring it has a permanent voice in organizational policy and resource allocation [41].

2. **Codification in Policy and Procedure:** The principles and specific protocols of the NLC must be written into official hospital policies and standard operating procedures (SOPs). This includes mandating joint training for all new hires in nursing and the lab, formalizing the SBAR communication protocol for all transfusion-related queries, and defining the roles and responsibilities of the Transfusion Safety Champions within job descriptions. Codification removes ambiguity and makes the collaborative practices the default way of working, rather than an optional "extra" [42].
3. **Financial and Resource Commitment:** Sustainability requires a dedicated budget. This includes funding for the protected time of the Champions, resources for ongoing joint simulation training, and investment in the technological infrastructure that supports the collaboration, such as upgrades to the electronic health record for better alerting and tracking. Hospital leadership must view this not as an expense but as a strategic investment in risk mitigation and patient safety, with a clear return on investment demonstrated through reduced error-related costs [43].

9. Cultivating a Culture of Continuous Improvement and Resilience

With the structural elements in place, the focus shifts to nurturing the cultural aspects that will allow the collaboration to thrive long-term. A static system will eventually fail; a learning system will adapt and grow stronger.

1. **Generational Knowledge Transfer and Mentorship:** A key vulnerability of any initiative is staff turnover. To combat this, a formal mentorship program should be established. Experienced NLC champions should mentor their successors, ensuring that the institutional knowledge, relationship networks, and problem-solving approaches are passed on. Furthermore, the joint education sessions should become a core component of orientation for all new nursing and laboratory staff, instilling the collaborative ethos from their first day [44].
2. **Advanced Data Analytics for Proactive Risk Management:** Moving beyond basic metric tracking, the committee should leverage data analytics to predict and prevent errors. By analyzing trends in near-miss data, sample rejection reasons, and TAT fluctuations, the team can move from a reactive ("What error happened?") to a proactive ("Where might the next error occur?") stance. For example, if data shows an increase in mislabeled samples from the Emergency Department during night shifts, a targeted intervention—such as a refresher training or a workflow redesign—can be deployed pre-emptively [45].
3. **Expanding the Circle of Collaboration:** While the nurse-lab dyad is critical, long-term resilience can be enhanced by strategically expanding the collaborative circle. This includes formally engaging physicians in the process, particularly in education on appropriate ordering and the clinical implications of lab findings. Furthermore, involving pharmacy staff (for managing plasma-derived products and medications used in transfusion reactions) and IT professionals (for optimizing the digital ecosystem) can create a more holistic and robust safety net [46].

10. Conclusion

In conclusion, the collaboration between nursing staff and laboratory professionals is essential for ensuring the safety and efficacy of blood transfusions. This partnership enhances communication, streamlines processes, and minimizes the risks associated with transfusion reactions. By fostering an environment of teamwork and shared responsibility, healthcare institutions can improve patient outcomes and optimize transfusion protocols.

Evidence from various studies indicates that effective collaboration leads to reduced errors, increased vigilance in monitoring patients, and a more thorough comprehension of laboratory findings by nursing staff. Furthermore, ongoing training and interprofessional education play a critical role in bridging gaps between nursing and laboratory departments, ultimately strengthening the overall transfusion safety framework.

As healthcare continues to evolve, it is vital to prioritize and invest in collaborative practices that not only enhance safety but also reinforce the integral roles of nurses and laboratory personnel. By embracing a culture of collaboration, we can

ensure that blood transfusions are conducted with the utmost safety and care, safeguarding the health of patients and instilling confidence in the transfusion process.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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