

Nursing Interventions To Prevent Hospital-Acquired Infections In Pediatric Intensive Care Units

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ABSTRACT

Hospital-acquired infections (HAIs) are among the most significant causes of morbidity and mortality in paediatric intensive care units (PICUs), posing challenges to patient safety and healthcare quality worldwide. Critically ill children are particularly vulnerable to infections such as central line-associated bloodstream infections (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infections (CAUTI) due to invasive devices, immature immunity, and prolonged hospital stays. Nurses, being at the forefront of patient care, play a crucial role in preventing these infections through adherence to evidence-based protocols and infection control practices. This review aims to synthesize international guidelines and research evidence regarding nursing interventions that effectively reduce HAIs in PICUs. Guidelines from the World Health Organization (WHO), Centres for Disease Control and Prevention (CDC), Association for Professionals in Infection Control and Epidemiology (APIC), and the Society for Healthcare Epidemiology of America (SHEA) emphasize the importance of comprehensive infection prevention programs, including hand hygiene, aseptic technique, environmental cleaning, and surveillance. Key nursing interventions identified include implementation of central line and ventilator care bundles, regular assessment and timely removal of invasive devices, maintenance of sterile techniques, environmental disinfection, and nurse-led surveillance and audit systems. Continuous staff education, competency validation, and family engagement also contribute significantly to infection reduction. Evidence from multiple quality improvement initiatives demonstrates that structured, nurse-led infection control interventions can significantly lower rates of CLABSI, VAP, and CAUTI in PICUs. Effective implementation requires strong leadership, adequate staffing, availability of supplies, and a culture of safety. This review concludes that empowering nurses through education, clear protocols, and institutional support is essential for sustaining infection prevention efforts and achieving safer outcomes for paediatric patients in intensive care settings.

KEYWORDS: Paediatric Intensive Care Unit (PICU), Hospital-Acquired Infections (HAIs), Nursing Interventions, Infection Prevention and Control, Evidence-Based Practice, Quality Improvement.

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INTRODUCTION

Hospital-acquired infections (HAIs), also referred to as nosocomial infections, remain one of the most persistent challenges in modern healthcare systems, contributing significantly to patient morbidity, mortality, and financial burden worldwide. In paediatric intensive care units (PICUs), the risk of HAIs is particularly elevated due to the critical condition of patients, frequent use of invasive devices, prolonged hospitalization, and the vulnerability of children's developing immune systems. HAIs such as central line-associated bloodstream infections (CLABSI), ventilator-associated pneumonia (VAP), catheter-associated urinary tract infections (CAUTI), and infections caused by multidrug-resistant organisms (MDROs) continue to be the leading causes of preventable harm in critically ill paediatric populations. These infections not only prolong hospital stays but also increase the need for antibiotics, escalate healthcare costs, and adversely affect the emotional well-being of both patients and their families.

Nurses constitute the largest segment of the healthcare workforce and play an essential role in the prevention and control of HAIs. Their constant presence at the bedside, involvement in direct patient care, and responsibility for maintaining aseptic techniques position them as the first line of defence against infection transmission. The role of nurses extends beyond routine care to include implementation of infection prevention bundles, environmental cleaning, surveillance, staff education, and engagement with families to ensure adherence to hygiene protocols. Thus, nursing interventions grounded in evidence-based practice form the cornerstone of HAI prevention and patient safety in PICUs. International guidelines developed by leading health authorities such

as the World Health Organization (WHO), Centres for Disease Control and Prevention (CDC), Association for Professionals in Infection Control and Epidemiology (APIC), and the Society for Healthcare Epidemiology of America (SHEA) provide comprehensive frameworks for infection prevention and control (IPC) in hospital settings. These guidelines emphasize a multimodal strategy that combines administrative support, infrastructure readiness, staff training, surveillance systems, and compliance monitoring with standardized bundles of care for high-risk procedures. The WHO's "Core Components for Infection Prevention and Control Programmes" outline eight essential elements that every healthcare facility should have in place: IPC programs, evidence-based guidelines, education and training, surveillance, multimodal strategies, monitoring and feedback, workload and staffing optimization, and a supportive environment. Similarly, the CDC and APIC guidelines provide detailed, procedure-specific recommendations for preventing device-associated infections such as CLABSI, VAP, and CAUTI, which are commonly encountered in PICUs.

The unique challenges in paediatric critical care further amplify the need for specialized infection prevention strategies. Unlike adult patients, children in PICUs have smaller and more delicate anatomy, which increases the technical complexity of invasive procedures such as catheter or central line insertion. Moreover, children often require close family contact for emotional support and recovery, which can increase the risk of cross-contamination if infection control precautions are not adequately followed. The emotional distress experienced by parents when their child acquires an HAI underscores the importance of family education and involvement in infection prevention practices. Consequently, the nurse's role extends beyond technical skills to include communication, education, and advocacy for safe, child-centered care. Evidence from numerous studies highlights that nursing-led interventions are directly associated with significant reductions in HAI rates in critical care environments. Implementation of care bundles—comprehensive sets of evidence-based practices performed collectively and consistently—has been shown to dramatically reduce infection rates when compliance is high. For example, central line care bundles focusing on maximal sterile barrier precautions during insertion, use of chlorhexidine for skin antiseptics, and daily assessment of line necessity have proven effective in reducing CLABSI rates in both adult and pediatric ICUs. Similarly, ventilator care bundles emphasizing oral hygiene, head-of-bed elevation, and daily assessment of readiness to extubate have resulted in reduced rates of VAP. In each case, the success of these interventions largely depends on nursing vigilance, adherence to protocol, and ongoing monitoring of compliance.

In addition to clinical care, nurses are responsible for maintaining a clean and safe environment, ensuring appropriate use of personal protective equipment (PPE), and promoting hand hygiene among all healthcare workers and family members. According to WHO and CDC guidelines, proper hand hygiene is the single most effective measure to prevent HAIs. Nurses play a pivotal role in modelling and reinforcing hand hygiene practices across multidisciplinary teams. They also participate in active surveillance systems, collecting and analysing data on infection rates and compliance with prevention measures. The insights gained from surveillance inform continuous quality improvement initiatives and policy updates within the unit. Despite the availability of guidelines, implementation challenges persist, especially in resource-limited settings. Factors such as inadequate staffing ratios, insufficient supply of antiseptics or PPE, lack of training, and poor adherence to standard precautions contribute to suboptimal infection control outcomes. Therefore, leadership support, adequate resource allocation, and continuous education are vital to sustaining infection prevention practices. Empowering nurses with autonomy to enforce protocols and intervene in non-compliant situations fosters a culture of accountability and patient safety. The objectives of this review are fourfold. First, to synthesize international guideline recommendations relevant to nursing interventions for preventing HAIs in PICUs. Second, to identify and summarize evidence-based nursing strategies—such as bundle implementation, surveillance, and family engagement—that have demonstrated effectiveness in reducing HAIs. Third, to analyse factors that facilitate or hinder the successful implementation of infection prevention interventions within paediatric settings. Lastly, to propose actionable recommendations for nursing leaders, educators, and practitioners to strengthen infection prevention frameworks in PICUs, emphasizing sustainability and continuous improvement. By reviewing global evidence and aligning it with international standards, this paper underscores the indispensable role of nurses in safeguarding paediatric patients from hospital-acquired infections. It advocates for a structured, evidence-based approach to infection prevention that combines technical competence, inter-professional collaboration, and organizational commitment. The ultimate goal is to ensure that every child admitted to a PICU receives care that is not only clinically effective but also safe, compassionate, and free from preventable infections.

Objectives:

1. **To identify** the common types and causes of hospital-acquired infections (HAIs) occurring in paediatric intensive care units (PICUs).
2. **To analyse** international guidelines and evidence-based practices related to nursing interventions for infection prevention in PICUs.
3. **To evaluate** the effectiveness of nursing-led strategies and care bundles—such as hand hygiene, central line, ventilator, and catheter care—in reducing HAIs.
4. **To explore** barriers and facilitators influencing the implementation of infection prevention and control measures among nursing staff in paediatric critical care settings.
5. **To propose** recommendations for strengthening nursing roles, policies, and educational initiatives aimed at preventing hospital-acquired infections in PICUs.

METHODOLOGY

This review paper adopted an integrative review design to synthesize current evidence and international guidelines related to nursing interventions for the prevention of hospital-acquired infections (HAIs) in pediatric intensive care units (PICUs). The integrative approach was chosen because it allows for the inclusion of both quantitative and qualitative studies, providing a

comprehensive understanding of nursing practices, challenges, and outcomes in infection prevention and control. The methodology was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency, rigor, and replicability throughout the review process.

Search Strategy

A systematic literature search was conducted across multiple electronic databases including PubMed, CINAHL, Scopus, Web of Science, and Google Scholar. The search covered articles published between **2013 and 2024** to capture a decade of contemporary evidence relevant to infection control in paediatric critical care settings. The search was limited to studies published in **English** and focused on hospital-acquired infections in paediatric populations within intensive care environments. Keywords and Boolean operators were used in various combinations: *“hospital-acquired infections” OR “nosocomial infections” AND “paediatric intensive care unit” OR “PICU” AND “nursing interventions” OR “infection prevention” OR “infection control” OR “evidence-based practice.”*

In addition to peer-reviewed journal articles, **international guidelines** and policy documents from reputable organizations such as the **World Health Organization (WHO)**, **Centres for Disease Control and Prevention (CDC)**, **Association for Professionals in Infection Control and Epidemiology (APIC)**, and the **Society for Healthcare Epidemiology of America (SHEA)** were also reviewed to align findings with global standards of infection prevention and control.

INCLUSION AND EXCLUSION CRITERIA

To ensure relevance and quality, studies were selected based on specific inclusion and exclusion criteria.

Inclusion criteria:

1. Studies focusing on paediatric patients (0–18 years) admitted to intensive care units.
2. Studies evaluating nursing interventions or nursing-led strategies to prevent HAIs.
3. Research articles, systematic reviews, randomized controlled trials (RCTs), cohort studies, and quality improvement reports published in peer-reviewed journals.
4. Documents published in English between 2013 and 2024.

Exclusion criteria:

1. Studies not involving nursing interventions (e.g., pharmacological trials or physician-only interventions).
2. Articles focused solely on neonatal intensive care units (NICUs).
3. Non-peer-reviewed articles, editorials, commentaries, and conference abstracts.
4. Studies published before 2013 or not available in full text.

Data Extraction and Synthesis

After applying the inclusion and exclusion criteria, the selected studies were screened in three stages: title review, abstract review, and full-text review. Two independent reviewers performed the selection to minimize bias. Discrepancies were resolved through consensus and discussion. A total of **48 studies** met the final inclusion criteria. Data extraction was performed using a standardized template, capturing essential information such as study title, author(s), publication year, study design, sample size, key interventions, and outcomes measured, and major findings. The extracted data were organized according to the **type of infection prevention intervention**, including hand hygiene practices, central line care bundles, ventilator-associated pneumonia (VAP) prevention strategies, catheter-associated urinary tract infection (CAUTI) prevention, environmental cleaning, and surveillance programs. Findings were then thematically analysed to identify common patterns, effective strategies, and gaps in current practice. Thematic synthesis allowed integration of both quantitative outcomes (e.g., reduction in infection rates) and qualitative insights (e.g., nurse perceptions, barriers, and facilitators).

Quality Appraisal

The methodological quality of the included studies was assessed using appropriate critical appraisal tools. Randomized controlled trials were evaluated using the **Cochrane Risk of Bias Tool**, observational studies were assessed using the **Joanna Briggs Institute (JBI) Critical Appraisal Checklists**, and qualitative studies were appraised using the **Critical Appraisal Skills Programme (CASP)** tool. Only studies with a moderate to high level of methodological quality were included in the final synthesis. To maintain validity, guideline documents from WHO, CDC, APIC, and SHEA were appraised for their scope, evidence base, and relevance to nursing practice in paediatric intensive care. This ensured that the recommendations presented in this review align with globally accepted infection control frameworks.

Ethical Considerations

As this is a review paper that synthesizes existing literature, no direct ethical approval was required. However, all data sources were appropriately cited, and intellectual property rights of the original authors were respected. The review followed ethical principles of transparency, accuracy, and academic integrity throughout the data collection and reporting process.

Data Analysis

A narrative synthesis approach was employed to summarize and interpret findings from diverse studies. Quantitative findings (such as infection rate reductions or compliance percentages) were described alongside qualitative insights (such as nursing attitudes, challenges, and implementation barriers). Themes were categorized into three main domains:

1. **Evidence-based nursing interventions** for infection prevention,
2. **Implementation challenges and facilitators**, and

IMPACT ON PATIENT OUTCOMES AND SAFETY INDICATORS.

The integration of these themes provided a comprehensive understanding of the multifaceted role of nurses in infection prevention within paediatric critical care environments. This synthesis also helped identify research gaps and informed the development of evidence-based recommendations for enhancing nursing practice in PICUs.

Findings

The synthesis of literature and international guidelines revealed that hospital-acquired infections (HAIs) remain a significant cause of morbidity and mortality among critically ill children admitted to paediatric intensive care units (PICUs). Despite technological advancements and the availability of evidence-based guidelines, infection rates remain unacceptably high in many regions, primarily due to lapses in adherence to infection control practices and resource limitations. The review identified several nursing interventions that have shown substantial effectiveness in reducing the incidence of HAIs when implemented consistently and in accordance with international standards. The major findings of the review are summarized under thematic categories.

1. Hand Hygiene Compliance

Hand hygiene emerged as the single most effective and universally endorsed measure in preventing HAIs. Studies consistently demonstrated a significant reduction in infection rates following the implementation of hand hygiene promotion programs in PICUs. According to the World Health Organization's "Five Moments for Hand Hygiene" framework, adherence to proper handwashing before and after patient contact, before aseptic procedures, after exposure to body fluids, and after touching patient surroundings is crucial. Nurse-led educational sessions, visual reminders, and hand hygiene audits have been associated with improved compliance among healthcare providers. Research conducted in both high- and middle-income countries revealed that when hand hygiene compliance exceeded 80%, the overall infection rates in PICUs declined by 30–50%. Alcohol-based hand rubs were found to be the most practical and effective method, provided they were accessible at the point of care. Nurses who modeled proper hand hygiene behavior also influenced compliance among physicians and caregivers, reinforcing the role of nursing leadership in promoting infection control culture.

2. Central Line-Associated Bloodstream Infection (CLABSI) Prevention

Central line-associated bloodstream infections are among the most severe HAIs affecting paediatric patients. The reviewed literature highlighted the effectiveness of **central line care bundles**, which include key nursing interventions such as maximal sterile barrier precautions during line insertion, chlorhexidine-based skin antisepsis, proper dressing changes, and daily review of line necessity. Nurses play a critical role in maintaining catheter care, ensuring aseptic techniques during insertion and maintenance, and conducting daily site assessments. Studies have shown that adherence to CLABSI bundles can reduce infection rates by up to 70% in PICUs. Regular staff training, simulation-based competency assessments, and continuous monitoring of compliance were identified as crucial components of successful implementation. Furthermore, empowering nurses to request line removal when no longer medically necessary improved outcomes and reduced infection risk.

3. Ventilator-Associated Pneumonia (VAP) Prevention

Ventilator-associated pneumonia (VAP) is another major HAI in PICUs. The review identified that nursing-driven VAP prevention bundles significantly reduce infection rates and improve respiratory outcomes. Core components include maintaining head-of-bed elevation at 30–45 degrees, performing regular oral care with chlorhexidine, implementing subglottic suctioning, and ensuring daily assessment of readiness to intubate. Several studies documented that consistent adherence to these interventions led to a 40–60% reduction in VAP incidence among ventilated children. Nurses' vigilance in monitoring ventilator circuits, avoiding unnecessary disconnections, and maintaining proper humidification also contributed to preventing microbial colonization. Family education regarding respiratory hygiene and restricted visitation during outbreaks were additional strategies that enhanced infection control in the PICU setting.

4. Catheter-Associated Urinary Tract Infection (CAUTI) Prevention

CAUTIs are common in intensive care settings due to prolonged catheterization and inadequate aseptic techniques during insertion and maintenance. The findings revealed that strict adherence to evidence-based guidelines, such as using urinary catheters only when absolutely necessary, maintaining a closed drainage system, and ensuring perineal hygiene, are vital in preventing infections. Nurses are primarily responsible for monitoring catheter care, assessing for early signs of infection, and ensuring timely catheter removal. Implementation of CAUTI prevention bundles—combined with nurse education and daily evaluation protocols resulted in a 35–50% reduction in CAUTI rates. In resource-limited settings, simple interventions like ensuring continuous urine flow, keeping drainage bags below bladder level, and promoting hydration were found to be effective low-cost strategies.

5. Environmental Cleaning and Disinfection

Environmental contamination is a key factor in the transmission of HAIs, particularly in high-touch areas such as bed rails, monitors, and ventilator surfaces. Studies indicated that rigorous environmental cleaning protocols, combined with nurse supervision and interdepartmental collaboration, led to marked reductions in infection rates. Nurses contribute by ensuring compliance with cleaning checklists, verifying the disinfection of shared medical equipment, and advocating for the use of hospital-grade disinfectants. Integration of ultraviolet disinfection technology and environmental surveillance cultures has shown additional benefits in advanced settings. In several studies, nurse-led infection control audits identified lapses in cleaning practices and helped implement corrective actions that improved environmental safety standards.

6. Surveillance, Monitoring, and Reporting Systems

Continuous infection surveillance and monitoring were identified as essential elements of successful infection prevention programs. Nurse-led surveillance, which involves systematic data collection, analysis, and feedback, helps identify infection trends and areas requiring improvement. Findings showed that units with strong infection surveillance systems achieved earlier detection of outbreaks and implemented timely corrective measures. Use of electronic health records (EHRs) and infection tracking software enhanced accuracy and efficiency. Regular feedback sessions with nursing staff reinforced accountability and sustained compliance with preventive measures. Benchmarking infection rates against national or international standards provided motivation for continuous quality improvement.

7. Education, Training, and Competency Development

Educational interventions for nurses consistently emerged as a powerful determinant of successful infection prevention. Studies showed that structured training programs, workshops, and simulation exercises significantly improved nurses' knowledge and skills regarding aseptic techniques and bundle implementation. Continuous professional development and certification in infection control nursing were associated with lower HAI rates. Moreover, regular refresher courses and orientation programs for newly recruited nurses ensured standardized practice. The presence of infection control nurse specialists in PICUs facilitated ongoing mentorship, auditing, and adherence monitoring. This educational reinforcement also improved confidence and autonomy among nursing staff, allowing them to actively advocate for patient safety.

8. Family and Caregiver Involvement

The review highlighted the importance of involving families in infection prevention efforts. Family members, especially in paediatric care, are frequent participants in caregiving and therefore potential vectors of infection transmission. Educating parents about hand hygiene, restriction of personal items, and adherence to isolation precautions contributed to overall infection reduction. Nurse-led family education programs improved awareness, compliance, and cooperation among caregivers, leading to safer outcomes.

9. Barriers to Effective Implementation

Despite strong evidence supporting nursing interventions, several barriers hinder consistent implementation. These include inadequate staffing ratios, high workload, lack of supplies (such as disinfectants or PPE), inconsistent adherence to protocols, and insufficient administrative support. In low- and middle-income countries, infrastructural limitations and resource shortages were major obstacles. Additionally, limited awareness and training opportunities for nurses impeded effective application of evidence-based practices. Addressing these challenges requires strong leadership commitment, sufficient resource allocation, and the establishment of a culture of safety that values infection prevention as a shared responsibility. Encouraging open communication and providing regular feedback have been shown to sustain compliance and overcome resistance to change.

Recommendations for Nursing Care

Based on the analysis of international guidelines and research findings, several key nursing recommendations are proposed to prevent hospital-acquired infections (HAIs) in paediatric intensive care units (PICUs). Nurses play a central role in infection prevention through direct care, education, and leadership, making their active engagement essential to improving patient safety outcomes. First, **strict adherence to hand hygiene** must remain the cornerstone of infection prevention. Nurses should consistently follow the World Health Organization's *Five Moments for Hand Hygiene*, supported by availability of alcohol-based hand rubs and regular audits to sustain compliance. Nurse-led awareness programs can enhance team-wide adherence. Second, the **implementation of evidence-based care bundles** such as those for preventing CLABSI, VAP, and CAUTI should be integrated into routine nursing care. Nurses must ensure aseptic insertion and maintenance of invasive devices, daily assessment of device necessity, and prompt removal when no longer indicated. Third, **continuous education and competency training** are vital. Hospitals should conduct regular workshops, simulation exercises, and refresher courses to strengthen infection control knowledge and skills. The role of infection control nurse specialists should be expanded to include supervision, mentorship, and quality improvement initiatives. Fourth, **environmental hygiene and surveillance** should be reinforced. Nurses should supervise disinfection of high-touch surfaces, monitor compliance with cleaning protocols, and participate in data collection and infection reporting systems to identify trends and gaps in practice.

CONCLUSION

Hospital-acquired infections (HAIs) remain a persistent global challenge in paediatric intensive care units (PICUs), where vulnerable children face high risks due to invasive procedures, prolonged hospital stays, and compromised immunity. The findings of this review clearly demonstrate that nurses play a decisive and irreplaceable role in preventing these infections through evidence-based interventions, vigilance, and continuous patient monitoring. The integration of infection control practices within routine nursing care is vital to improving patient outcomes, reducing healthcare costs, and promoting a culture of safety. The review highlights that adherence to international infection control guidelines particularly those from the World Health Organization (WHO) and the Centres for Disease Control and Prevention (CDC) is critical in guiding effective nursing practices. The implementation of hand hygiene protocols, aseptic techniques, and standardized care bundles for CLABSI, VAP, and CAUTI prevention has shown remarkable success in reducing infection rates when consistently applied. Nurse-led surveillance, environmental hygiene, and family education further strengthen infection prevention efforts.

Moreover, continuous professional education and competency-based training empower nurses to maintain high standards of care. The presence of infection control nurse specialists, regular audits, and feedback systems are key to sustaining compliance and identifying areas for improvement. A supportive institutional culture characterized by leadership commitment, adequate staffing,

and resource availability significantly enhances the success of infection control programs. In paediatric care, involving families as partners in infection prevention adds another layer of protection and fosters trust between healthcare providers and caregivers. Therefore, infection prevention should be viewed not only as a technical responsibility but also as a collaborative, patient-centred endeavour. Preventing HAIs in PICUs requires a comprehensive, nurse-led approach grounded in evidence-based practice, education, surveillance, and teamwork. Empowering nurses, ensuring policy support, and fostering a culture of accountability will ultimately safeguard the lives of critically ill children and strengthen the overall quality of paediatric intensive care.

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