ORIGINAL ARTICLE

Frequency of healthcare-associated infection and its bacteriological pattern in the pediatric intensive care unit

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ABSTRACT

Background: Healthcare-associated infections (HAIs) are a major cause of morbidity and mortality in pediatric intensive care units (PICUs).

Material and Methods: This descriptive, cross-sectional study was conducted at the Pediatric Intensive Care and High Dependency Unit, Department of Pediatric Medicine, Dr Ruth KM Pfau Civil Hospital, Karachi, from 1st November 2025 to 30th April 2026. Children aged 1 month to 12 years admitted to the PICU were enrolled through non probability consecutive sampling. In children with suspected HAIs, site specific samples were collected under strict aseptic technique. Data were analyzed in SPSS version 26.0, and p<0.05 was considered significant.

Results: Among 139 PICU patients, 76 (54.7%) were males and 63 (45.3%) were females. Healthcare-associated infections (HAIs) occurred in 36 (25.9%) patients, while mortality was observed in 26 (18.7%). Most participants were from urban areas (75.5%). The median PICU stay was 5 days (IQR: 3–6). No significant associations were found between HAI occurrence and gender (p=0.368), age group (p=0.437), or residence (p=0.591). Bloodstream infection was the most common HAI (33.3%), followed by ventilator-associated pneumonia (25.0%), and *Klebsiella pneumoniae* was the most frequently isolated pathogen (25.0% of isolates). Overall, HAIs remained common among critically ill children, highlighting the importance of effective infection prevention strategies.

Conclusion: Healthcare associated infections represented an important burden in the PICU affecting nearly 1/4th of children. Bloodstream infection with HAI, and *Klebsiella pneumoniae* was the predominant pathogen isolated.

Keywords: Blood culture, Children, infection, Paediatric intensive care unit, Urinary tract infection

BACKGROUND

Healthcare-associated infections (HAIs) are a major concern in the medical field because they put patients and the healthcare system at significant risk.[1] HAIs are not just a local concern of the developing countries but a global challenge for health caregivers. The World Health Organization reports that on average, around 1 in 10 patients is affected by HAIs; however, the frequency can be much higher in low-/middle-income countries and in high-risk patients such as those in intensive care units (ICUs). In Europe alone, some 9 million HAIs occur every year in acute and long-term care facilities; they lead to 25 million extra hospital days and cost 13-24 billion euros.[2] In pediatric hospitals, HAIs are regarded as major contributors to morbidity and mortality.[3] Patients who have lengthy hospital stays and expensive treatments are more likely to have HAIs.[4] Despite the fact that HAI in the pediatric intensive care units (PICUs) happens everywhere, the frequency varies significantly across the globe.[5] Infants and children in PICUs in developed nations had lower rates of HAIs than those in underdeveloped nations. The first two years of life had the highest incidence density of these variations. Bloodstream, lower respiratory, and urinary tract infections are the three main locations of HAI.[6,7]

Although HAIs are primarily caused by a range of bacterial and fungal pathogens, *Klebsiella pneumoniae* is frequently isolated from bloodstream infections, followed by *Pseudomonas aeruginosa* and coagulase-negative *staphylococci*.[8] However, the most frequent HAI pathogens found in lower respiratory tract infections are *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Additionally, *Candida albicans* and *Escherichia coli* (*E. coli*) are the most frequent HAI pathogens associated with urinary tract infections.[9] A research found that 54.8% of PICU patients had HAIs.

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Pseudomonas (11.4%), *Candida tropicalis* (7.6%), and *Candida fermatas* (6.3%) were the next most common causal species, after *Klebsiella pneumoniae* (34.3%).[10]
Although HAIs have remained the major concern globally and are particularly common in PICUs locally due to frequent invasive procedures, use of antibiotics, and weak immune defense of admitted patients in PICU, very little local data has been documented statistically. In order to fill this knowledge gap, it is worth addressing this dread hazard, which is an ultimate reason for morbidity and mortality for communities. Hence, the current study commenced, aiming to determine the frequency of HAIs and their bacteriological pattern in the PICU. Sharing the findings of this study on forums would not only add a valuable paper academically but also help other healthcare setups to analyze their healthcare system and address the areas that need to be pondered over as a healthcare community.

MATERIAL AND METHODS

This descriptive, cross-sectional study was performed at the Pediatric Intensive Care and High Dependency Unit, Department of Pediatric Medicine, Dr. Ruth KM Pfau Civil Hospital, Karachi, Pakistan, from 10th November 2025 to 30th April 2026, after approval from the institutional ethical review committee (IRB-4170/DUHS/Approval/2025/441, dated: 3rd November, 2025). A sample size of 151 was calculated using the WHO single proportion calculator, considering the anticipated frequency of HAIs in the PICU as 15.3%,[8] with 95% confidence level, and 6% margin of error.
The inclusion criteria were patients of either gender with an age range between 1 month and 12 years who were admitted to PICU. The exclusion criteria were patients who had already received antibiotics, had dysmorphic features, or had chromosomal or congenital anomalies. Those whose hospital stay lasted fewer than 48 hours were also excluded. Sampling selection was done using the non-probability consecutive sampling technique**.** The objective and safety of the study were completely described to the parents/guardians of patients to obtain informed written consent from them.
The eligible subjects went through documentation of their demographics, like age (months), gender (male/female), and residential status (rural/urban). Clinical data regarding weight (kgs) and length of hospital stay (days) were obtained. Routine laboratory tests, such as a complete blood count, a chest X-ray, a liver and kidney function test, a detailed urine report (urine culture and sensitivity), and a blood culture and sensitivity test at baseline, were performed for each child. If the enrolled patient developed signs and symptoms favoring HAIs, then particular site-related investigations were carried out for each case. HAIs were defined based on the CDC/NHSN definitions. CLABSI was defined as a laboratory-confirmed bloodstream infection in a patient who had a CVC inserted >2 calendar days prior to the infection. CAUTI was defined as a symptomatic UTI with a positive urine culture who had an indwelling urinary catheter for >2 calendar day. VAP was defined as the presence of pneumonia >48 hours after mechanical ventilation and confirmed by radiologic, clinical and microbiological data. SSI was defined as an infection occurring within 30 days of surgery at the incision or operative site with clinical and/or microbiological evidence of infection. Strict aseptic techniques were observed during specimen collection. Hand hygiene was carried out in line with institutional infection control guidelines before sample collection. Sterile gloves, sterile syringes and needles, sterile collection containers and transport media were used. The skin at venipuncture and catheter insertion sites was disinfected with 70% isopropyl alcohol and subsequently with an appropriate antiseptic (chlorhexidine or povidone-iodine) and dried thoroughly before taking the specimens. Sterile field, minimal handling of collection devices and prompt transport of specimens to the microbiology laboratory were taken to ensure that there was no contamination. In the institutional microbiological laboratory, conventional procedures were used to perform microbiological culture and antimicrobial sensitivity. A consultant pathologist examined each sample, and bacteriological patterns were documented. Gram staining (gram positive, which appeared purple under a microscope, or gram negative, which appeared pink), biochemical reactions (coagulase, catalase, oxidase, and API 20 tests), and colony morphology (*cocci*, *rods*, and *coccobacilli*) were used to identify organisms. All of the relevant information was documented on a specifically predesigned proforma.
The statistical analysis was conducted using IBM-Statistical Package for the Social Sciences Statistics (SPSS), version 26.0. Qualitative variables were described in terms of frequencies and percentages. The normality of quantitative variables was checked by

Shapiro–Wilk test. The data for age were normally distributed and presented as means ± standard deviations (SD), while the weight and duration of hospital stay were not normally distributed and shown as medians with interquartile ranges (IQR). Means and standard deviations (SDs) were used for normally distributed variables and medians and interquartile ranges (IQRs) were use for non-normally distributed variables. The odds ratio (OR) with 95% confidence interval (CI) was used to determine the association between the potential risks and the incidence of healthcare-associated infection (HAI). Other factors such as age group, gender, weight, place of stay, and hospital stay were controlled by stratification. The associations between the effect modifiers and the outcome variable (incidence of HAI) were assessed using a post-stratification chi-square test or Fisher's exact test as appropriate. P value < 0.05 was deemed as statistically significant.

RESULTS

A total of 139 patients were included in the study. Among them, 76 (54.7%) were boys and 63 (45.3%) were girls. Healthcare-associated infection (HAI) occurred in 36 (25.9%) patients. Mortality was observed in 26 (18.7%) patients, while 113 (81.3%) survived (Table-I). The Shapiro–Wilk test demonstrated that age group ($W = 0.802$, $p < 0.001$), PICU stay duration ($W = 0.803$, $p < 0.001$), and weight ($W = 0.951$, $p < 0.001$) were not normally distributed. Therefore, weight and PICU stay duration were summarized using medians and interquartile ranges (IQRs) in addition to means and standard deviations (Table0-II). The median weight was 13.0 kg (IQR: 9.0–16.0 kg), and the median PICU stay duration was 5.0 days (IQR: 3.0–6.0 days).

The association between gender and HAI was evaluated using the Chi-square test. Among boys, 22/76 (28.9%) developed HAI compared with 14/63 (22.2%) girls. However, the difference was not statistically significant ($\chi^2 = 0.812$, $p = 0.368$) (Table-III). Similarly, no statistically significant association was found between age group and HAI occurrence ($\chi^2 = 1.655$, $p = 0.437$). No statistically significant association was found between residence and HAI ($\chi^2 = 0.289$, $p = 0.591$). PICU stay duration was significantly longer among patients who developed HAI compared with those who did not develop HAI [median (IQR): 9.0 (7.0–12.0) vs 4.0 (3.0–6.0) days, Mann–Whitney U test, $p < 0.001$].

Among the 36 patients who developed healthcare-associated infections, bloodstream infection (BSI) was the most common HAI, accounting for 12 (33.3%) cases, followed by ventilator-associated pneumonia (VAP) in 9 (25.0%) patients and catheter-associated urinary tract infection (CAUTI) in 6 (16.7%) patients. (Table-IV).

Table-I. Baseline Characteristics of Study Participants (N = 139)

Variable	n (%)
Male	76 (54.7)
Female	63 (45.3)
Age <1 year	37 (26.6)
Age 1–5 years	54 (38.8)
Age 6–12 years	48 (34.5)
Rural residence	34 (24.5)
Urban residence	105 (75.5)
HAI present	36 (25.9)
Mortality	26 (18.7)

Table -II: Descriptive statistics of continuous variables (N = 139)

Variable	Mean ± SD	Median (IQR)	Range
Weight (kg)	12.63 ± 4.04	13.0 (9.0–16.0)	6–20
PICU stay (days)	5.31 ± 3.12	5.0 (3.0–6.0)	2–14

Table-III: Association between demographics and healthcare-associated infection.

Variable	HAI Present n (%)	UAOR	95% CI	p-value
Gender				
Male (n=76)	22 (28.9)	1.43	0.66–3.11	0.368
Female (n=63)	14 (22.2)	Reference	—	—
Age Group				
<1 year (n=37)	7 (18.9)	Reference	—	—

1–5 years (n=54)	14 (25.9)	1.50	0.54–4.18	0.437
6–12 years (n=48)	15 (31.3)	1.95	0.71–5.40	0.198
Residential Status				
Urban	—	Reference	—	—
Rural	—	1.27	0.55–2.99	0.591

Table-IV: Distribution of healthcare-associated infections and bacteriological profile.

Type of Healthcare-Associated Infection	(N=36) n (%)
Bloodstream Infection (BSI)	12 (33.3)
Ventilator-Associated Pneumonia (VAP)	9 (25.0)
Catheter-Associated Urinary Tract Infection (CAUTI)	6 (16.7)
Central Line-Associated Bloodstream Infection (CLABSI)	4 (11.1)
Surgical Site Infection (SSI)	2 (5.6)
Other HAIs	3 (8.3)
Bacteriological Profile of HAI Isolates	**N=40 n (%)**
Klebsiella pneumoniae	10 (25.0)
Acinetobacter baumannii	8 (20.0)
Pseudomonas aeruginosa	6 (15.0)
Escherichia coli	5 (12.5)
Staphylococcus aureus	4 (10.0)
Enterococcus spp.	2 (5.0)
Candida spp.	2 (5.0)
Other organisms	3 (7.5)

DISCUSSION

Pediatric intensive care units (PICUs) are still a significant problem with regard to healthcare-associated infections (HAIs) due to the susceptibility of very ill children, the length of time they spend in the hospital, invasive procedures, and contact with a wide range of antibiotics. The results of the present study confirmed that HAI is a significant problem in intensive care units, as HAI occurred in a large percentage of admitted pediatric patients. In the same way, high prevalence of nosocomial infections and antimicrobial resistance have been reported in Morocco in patients attending PICU, highlighting the need for improved IPC measures.[11]

Demographic characteristics of our study population showed that age group and gender were not significantly associated with the occurrence of HAI.[12] Similarly, in another recent study of a pediatric surgical intensive care unit, patient demographic characteristics had limited impact on the development of healthcare-associated infections, and clinical and treatment-related characteristics had a greater impact.[13]

The prevalence of HAI in this study is comparable with the results of HAI reported from tertiary care PICUs in the developing countries. Although there have been improvements in infection control, HAIs in critically ill children remain a significant source of morbidity and mortality.[14] Grant and Hardin-Reynolds stressed that many HAIs are preventable if they are based on the evidence for infection control, surveillance, and antimicrobial stewardship.[15]

The present study revealed that hospital stay was a significant factor that was associated with HAI occurrence. There was a greater risk of infection in patients with longer hospital stay. From India, it was found that HAI were linked to longer hospital stay and higher healthcare costs, which is similar to other countries.[16] Also, researchers from Mexico found longer time spent in PICU an important factor associated with HAI acquisition, reinforcing the correlation of longer hospital stay with higher risk of HAI.[17]

Candida species, which have a low detection rate, can increase patients' mortality risk when linked to prolonged hospitalization, invasive procedures, or prior antibiotic exposure.[18]

This high prevalence of bacterial and fungal infections among critically ill patients highlights the need to timely diagnose and treat antimicrobial therapy. In addition, the use of inappropriate antibiotics has been identified as one of the largest drivers of antimicrobial resistance, in critical care areas.[19] In a multicenter cross-sectional prevalence study, there was also significant diversity between antibiotic use in the different PICUs surveyed, with potential for antimicrobial stewardship improvement.[20]

In the current study, there were several clinical variables that were examined and showed trends toward increased infection risk, but only a few were statistically significant. All of these are likely to disrupt normal host defenses, leading to pathogen colonization and infection, especially in critically ill children.[21]

The findings of gram-negative organisms in many PICU are in line with the global trend.[22] These studies highlight the need to be aware of interactions among different microorganisms and their potential to increase antibiotic resistance and pathogenicity, especially in intensive care settings where the spread of multidrug-resistant organisms is a growing problem.[23]

Overall, the present study confirms the present evidence base that the problem of HAIs remains a large issue in pediatric patients in the PICU. Demographic factors (age and gender) seemed to have little influence and prolonged hospitalization was an important factor in infection development. Implementing enhanced infection prevention measures, antimicrobial stewardship programs, surveillance and early microbiological diagnosis can contribute to lessening the impact of HAIs and clinical outcomes in highly ill pediatric patients.

Several limitations of this study should be acknowledged. This was a single center study so the findings may reflect local case mix, referral patterns, catheter practices, and antimicrobial ecology. The sample size was relatively modest which may have limited precision for subgroup analyses. The analysis focused on frequency and patterns of infection, but did not include antimicrobial resistance profiles. Some site categories were also mixed, with single site and multisite infections reported together which can complicate interpretation.

CONCLUSION

HAPIs were still a major problem for PIIU patients as about one-quarter of the population in the study had HAPIs. Longer hospital stays seemed to increase risk of HAI. Among patients with HAI, bloodstream infection was the most common type of infection, followed by ventilator-associated pneumonia, while *Klebsiella pneumoniae* was the most frequently isolated pathogen, highlighting the predominance of Gram-negative organisms in the PICU setting.

CONFLICT OF INTEREST

None

GRANT SUPPORT & FINANCIAL DISCLOSURE

Declared none

AUTHOR CONTRIBUTION

Samia Rajput: Concept and study design, supervision of data collection, manuscript drafting, and final approval of manuscript

Ayesha Saleem: Study supervision, critical revision of manuscript, intellectual contribution, and final approval

Aiman Mehboob: Data collection, literature review, and assistance in manuscript writing

Shabana Zahid: Data entry, statistical assistance, and literature search

Sitara Phulpoto: Data collection, coordination of patient records, and proofreading of manuscript

Hassan Iqbal: Interpretation of microbiological data, analysis support, and manuscript review

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