

Original Article

Healthcare-associated infections in the first four years of a pediatric surgical intensive care unit

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Introduction: Healthcare-associated infections (HAIs) are a significant cause of morbidity and mortality, particularly among critical pediatric surgical patients. This study aimed to evaluate the incidence, distribution, types, and pathogens involved in HAIs, in a newly established pediatric surgery intensive care unit (PSICU).

Methodology: The Infection Control Team of Marmara University Pendik Training and Research Hospital identified and documented HAI cases according to the Centers for Disease Control and Prevention criteria over a four-year period following the unit's opening. Prospective, laboratory-based surveillance of HAIs was conducted within the PSICU from 1 January 2011 to 30 November 2014. Continuous monitoring and early detection of HAIs are crucial for implementing timely and effective infection control measures.

Results: A total of 599 patients were admitted to the PSICU, and 90 HAI cases were identified, resulting in an overall HAI rate of 15%. The incidence density was 14.7 per 1,000 patient-days. The most prevalent types were bloodstream infections (40%), pneumonia (23.4%), and urinary tract infections (17.8%). The primary pathogens were *Klebsiella* spp. (27.8%), *Acinetobacter baumannii* (13.9%), *Staphylococcus* spp. (13.9%), and *Candida* spp. (13.9%).

Conclusions: There is limited data on HAI rates in PSICUs, and this study showed that infection rates in the PSICU were not higher than in pediatric intensive care units and neonatal intensive care units. The incidence of HAIs in this study was not higher than reports from other PSICUs in developing countries like Mexico, Brazil, and Egypt; but was higher compared to the rates reported in developed countries such as the US.

Key words: infections; surgery; surveillance.

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Introduction

Healthcare-associated infections (HAIs) are one of the leading causes of morbidity and mortality in pediatric patients undergoing hospital care [1]. HAIs are more prevalent in intensive care units (ICUs) compared to other hospital departments [1,2]. The primary reasons for this increased risk include the more frequent use of medical devices, interventions by healthcare workers, and surgeries associated with prolonged hospitalizations. These surgeries typically involve procedures performed at the bedside, such as the insertion of central catheters, thoracostomy tubes, and dialysis catheters [3]. Among the HAIs in ICUs are catheter-related bloodstream infections, ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infections. VAP is the most frequently observed HAI in ICUs [4–6]. Studies on infections associated with surgery primarily focus on surgical site

infections (SSIs) [7], and the literature is predominantly centered on adult patients [8]. It has been reported that in developing countries the incidence of HAIs is higher compared to developed countries due to a larger patient load, insufficient staffing, and poor adherence to infection control measures [9]. Effective infection control programs, such as surveillance, can reduce infection rates. Surveillance involves routine and systematic collection of data based on standardized case definitions. This process provides routine analysis and feedback; which aids in identifying necessary healthcare services that require improvement, and preventive measures for hospitalized patients [10].

Turkey is a developing country, and has implemented a national HAI surveillance system since 2008. However, despite the presence of this system, there is a paucity of published data on infection rates, types of HAIs, pathogens, and antimicrobial resistance

Table 1. Rates of HAIs in the pediatric surgery intensive care unit over a four-year period following its opening.

	2011	2012	2013	2014	Total
Number of HAIs	7	36	30	17	90
Number of patients	112	157	179	151	599
Total patient days	797	1,834	2,007	1,460	6,098
Rate of HAIs (%)	6.2	22.9	16.7	11.2	15
Incidence density (per 1000 patient-days)	8.7	19.6	14.9	11.6	14.7

HAIs: healthcare-associated infections.

patterns. Furthermore, comorbidities and mortalities associated with HAI risk factors have not been adequately reported. The existing HAI literature largely focuses on adult patients. Although studies on neonatal and pediatric ICUs (NICU and PICU) have emerged in recent years, information on HAI incidence rates in these facilities remains limited. There are insufficient studies investigating HAIs and their risk factors in pediatric surgical intensive care units (PSICU). In this study, we aim to present observations on HAIs in a newly established PSICU.

Methodology

The study was conducted in accordance with the Declaration of Helsinki and received approval from the Ethics Committee of Marmara University, and the requirement for consent was waived for all participants (date: 9 September 2023; No: 09.2023.1107). The research was conducted in the PSICU of Marmara University Pendik Training and Research Hospital. The hospital began admitting patients in 2011 and has a capacity of 8 beds. The Infection Control Team performed active surveillance of HAIs. Laboratory-based HAI surveillance was carried out prospectively between 1 January 2011 and 30 November 2014.

The National Hospital Infections Surveillance Network (UHESA), which has been operating since 2008, was used for this surveillance. The data were collected prospectively according to the standard protocols of UHESA. HAIs were classified based on the standard definitions established by the Centers for Disease Control and Prevention (CDC) [11]. An HAI was defined as an infection occurring 48 hours after hospital admission, or upto 10 days after discharge.

Blood cultures were performed using BACTEC peds plus/F bottles (BD Diagnostics, Sparks Glencoe, USA). The identification of bacterial species was performed using the VITEK2 system (BioMérieux, Marcy l’Etoile, France). Susceptibility to non-β-lactam antibiotics was evaluated using the disk diffusion method according to the criteria set by the Clinical and Laboratory Standards Institute (CLSI) [12]. The HAI rate was calculated as the number of HAIs/total number of hospitalized patients x 100, and the incidence density was calculated as the number of HAIs/total patient-days × 1,000 for a given period.

Results

A total of 599 patients were admitted to the PSICU of Marmara University Pendik Training and Research Hospital, and 90 cases of HAIs were identified during the study period. This resulted in an overall HAI rate of 15% and an incidence density of 14.7 per 1,000 patient-days (Table 1).

The most frequently observed HAIs were bloodstream infections (BSIs), accounting for 40% of all cases. Pneumonia was identified in 23.4% of cases, and urinary tract infections (UTIs) were identified in 17.8% of cases. Other types of HAIs included skin and soft tissue infections (SSTIs); SSIs; gastrointestinal system infections (GISIs); cardiovascular system infections (CVSIs); and other infections such as those affecting the ear, nose, and throat (Table 2).

In terms of pathogen distribution, *Klebsiella pneumoniae* (*K. pneumoniae*) was the most commonly isolated microorganism, identified in 22 cases (27.8%). *Acinetobacter baumannii* (*A. baumannii*), *Staphylococcus* spp., and *Candida* spp. were isolated in

Table 2. Distribution of the HAI types from 2011–2014.

	2011	2012	2013	2014	Total (%)
BSI	3	15	13	5	36 (40%)
Pneumonia	2	6	7	6	21 (23.4%)
UTI	2	10	3	1	16 (17.8%)
SSTI	0	2	3	3	8 (8.9%)
SSI	0	2	1	1	4 (4.4%)
GISI	0	0	1	1	2 (2.2%)
CVSI	0	0	1	0	1 (1.1%)
CNSI	0	0	0	0	0 (0%)
OI	0	1	1	0	2 (2.2%)
Total	7	36	30	17	90 (100%)

BSI: bloodstream infection; UTI: urinary tract infection; SSTI: skin and soft tissue infection; SSI: surgical site infection; GISI: gastrointestinal system infection; CVSI: cardiovascular system infection; CNSI: central nervous system infection; OI: other infection (includes eye: ear: nose: throat infections).

11 cases each (13.9%). Other pathogens, including *Enterococcus* spp., *Escherichia coli*, and *Pseudomonas aeruginosa*, were identified less frequently; and a total of 79 distinct pathogens were isolated (Table 3).

Discussion

Despite significant advances recorded in ICUs in recent years, HAIs continue to cause serious morbidity and mortality [12]. Although specific data on PSICUs are limited, it is well-known that infectious agents observed in surgical ICUs are among the leading causes of morbidity and mortality [13]. HAI rates are the highest in ICUs and surgical departments, while they are the lowest in other medical units. Active surveillance of HAIs in PICUs and PSICUs plays a critical role in infection control, and can contribute to reducing morbidity and mortality. While comprehensive data on the epidemiology of HAIs are available from developed countries, data from developing countries like Turkey are limited [12,13].

Difficulties in vascular access, frequent medication administration, and the need for more intensive nursing care in PICUs place children at a higher risk for HAIs compared to adults. Studies report that HAI rates in PICUs worldwide range from 3.6% to 20% [14]. In Turkey, these rates vary between 2.9% and 43.9% in PICUs, and between 3.2% and 42.3% in NICUs [15,16]. In our study, the HAI rate was found to be 15.02% during the first 4 years. The incidence of HAIs in the PSICU (14.76 per 1,000 patient-days) observed in this study was not higher than reports from other PSICUs in developing countries like Mexico, Brazil, and Egypt; but was higher compared to rates reported in developed countries like the United States [17]. In an incidence study conducted in 17 European cities, the HAI rate in PICUs was reported to be 23.6% [18]. In a study conducted in Spain, this rate was 29.8%, while a

national point prevalence study involving 50 PICUs in Turkey recorded a general HAI rate of 37% [9]. The notably lower infection rate in this study compared to the PICU and NICU in the same center may be related to the fact that most of the patients admitted to the PSICU were followed up for surgical reasons. Indeed, a large proportion of the patients treated in NICUs and PICUs are followed due to critical conditions like pneumonia and sepsis caused by infectious agents. Additionally, it should be noted that the immune systems of patients in these units are either not fully developed or compromised.

The types of HAIs can vary from country to country, hospital to hospital, and even between different units within the same hospital; as observed in this study and previous studies in the same institution [9,12,19]. A study by Orsi *et al.* identified 100 different infections in 76 patients, of which 36% were BSIs [20]. In a study conducted in North Korea, it was found that the most common infections in 489 neonates were pneumonia (28%) and BSIs (26%) [21]. A study by Madden *et al.* reported 13 SSIs and 9 BSIs among 133 neonates in a surgical NICU [22]. Shankar *et al.* found that BSIs and SSIs were the most common infections in a surgical NICU, accounting for 70% of all infections [23]. In a study conducted in Turkey, the most frequent HAI type was VAP (61.5%), followed by BSIs (26.2%) [24]. In another study conducted by Güler *et al.* in Turkey in 2019, HAIs were identified in 73 of 216 neonates (33.7%) in a surgical NICU; and after excluding 48 patients who did not meet the criteria for HAIs, the infection rate was 27.6% [25]. Shankar *et al.* reported an HAI rate of 14.9% in their study of 167 patients [23]. These variations in infection rates can be attributed to differences in treatment methods, postoperative follow-up processes, and the underdeveloped immune systems of neonates.

Table 3. Distribution of the HAI pathogens from 2011 to 2014.

	2011	2012	2013	2014	Total (%)
<i>Klebsiella pneumoniae</i>	2	9	5	6	22 (27.8%)
<i>Acinetobacter baumannii</i>	0	4	5	2	11 (13.9%)
<i>Staphylococcus</i> spp.	1	1	3	6	11 (13.9%)
Coagulase negative <i>Staphylococcus</i>	1	0	3	6	10
<i>Staphylococcus aureus</i>	0	1	0	0	1
<i>Candida</i> spp.	1	7	3	0	11 (13.9%)
<i>Candida albicans</i>	1	3	2	0	6
<i>Candida parapsilosis</i>	0	4	1	0	5
<i>Enterococcus</i> spp.	1	3	0	2	6 (7.6%)
<i>Enterococcus faecium</i>	1	2	0	0	3
<i>Enterococcus faecalis</i>	0	1	0	2	3
<i>Escherichia Coli</i>	0	1	0	3	4 (5.2%)
<i>Pseudomonas aeruginosa</i>	0	2	1	0	3 (3.8%)
Others	0	6	2	3	11 (13.9%)
Total	5	33	19	22	79 (100%)

HAI: healthcare-associated infection. Others, includes *Serratia* spp, *Citrobacter* spp, *Stenotrophomonas maltophilia*, *Proteus mirabilis*, *Morganella morganii*, *Moraxella catarrhalis*, and streptococci.

In our study, BSIs were the most common type of infection identified between 2011 and 2014. A total of 36 BSI cases (40%) were recorded; and pneumonia was the second most frequent infection, with 21 cases (23.4%). Urinary tract infections (UTIs) ranked third, with a total of 16 cases (17.8%). SSIs, given that this study was conducted in a surgical unit, were recorded in 4 cases (4.4%), which is lower than the rates of SSIs reported in the literature.

It is estimated that 2 million new cases of HAIs occur annually in the United States, resulting in 90,000 deaths. The annual cost of these infections is estimated to be between 4.5 and 5.7 billion USD [26]. Studies on the economic burden of HAIs in our country are limited. In a study conducted in the United States, the most common HAI was BSI (41.3%), followed by VAP (22.7%) [27]. Maoulainine *et al.* reported that 79.6% of HAIs were caused by extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria (GNB), with *K. pneumoniae* being the most common pathogen (39.7%) [28]. Another study reported that 79.8% of the isolated microorganisms were GNB, and *K. pneumoniae* was the most frequent pathogen (29.3%) [29]. In a study conducted in a pediatric cardiovascular surgery intensive care unit (PCVS-ICU) in Turkey, 73.6% of the 76 isolates identified during the first 5 years were GNB, and *K. pneumoniae* (26%) was the most common pathogen, followed by *Candida* spp. (26.3%). In the next 5 years, 69% of the 94 isolates were GNB, while *Candida* spp. was found at a rate of 31% [15]. In our study, the most common pathogen was *K. pneumoniae*, isolated in 22 cases (27.8%). This was followed by *A. baumannii*, *Staphylococcus* spp., and *Candida* spp.; each identified in 11 cases (13.9%).

National infection control efforts and training programs since the early 2000s have made progress in Turkey. The UHESA was implemented in Turkey in 2008. Similarly, the National Nosocomial Infections Surveillance System, established in the United States in the 1970s, has led to a 30–40% reduction in HAI rates. After implementing the Krankenhaus Infektions Surveillance System in Germany, the incidence of VAP decreased by 24% within 3 years [30].

Our PSICU is a newly established unit. Despite new facilities, equipment, and infrastructure, the high HAI rates observed during the first year indicate non-compliance with infection control measures among healthcare workers. Low compliance with hand hygiene (HH) was one of the primary causes of these high HAI rates. Other contributing factors include staff shortages, insufficient training, and lack of feedback. We investigated HH compliance among physicians and

nurses in our NICUs and PICUs, and found that that compliance was 31.9% among physicians and 41.4% among nurses [19]. This low compliance emerged as one of the primary causes of the high HAI rates. New facilities and equipment do not affect the frequency of HAIs. Invasive procedures and major surgeries should be minimized to reduce infection rates and improve patient safety in PSICUs. While our local HAI rate is higher compared to studies conducted in developed countries, it is comparable to the results from developing countries.

This study had a number of limitations. First, this study was a single-center study which might limit the generalizability of the results. Second, we could not present the antibiotic susceptibility patterns of the pathogens. Another limitation of the study is that it does not include device-associated infection data. Despite these limitations, the strengths of the study are that it is one of the limited number of studies presenting HAI data in a PSICU; and, that prospective, laboratory-based surveillance data, which plays a critical role in HAI control, were analyzed. Active surveillance of HAIs has become a fundamental component of quality and risk management in ICU patients. Surveillance of HAIs in surgical care units also plays a crucial role in infection control. Well-organized surgical care and improved technical equipment, along with effective infection control programs, should be effective in reducing HAI rates in PSICUs.

Conclusions

There is limited data on the rates of HAIs in PSICUs, and this study showed that infection rates in the PSICU were not higher than PICU and NICU infection rates. The incidence of HAIs in this study was not higher than reports from other PSICUs in developing countries, but was higher compared to rates reported in developed countries. HAIs are a widespread issue in both developed and developing countries, and are a critical indicator of healthcare quality. These infections pose a significant threat by increasing morbidity and mortality rates in patients, while also contributing to the rising costs of healthcare services. In order to reduce the frequency of HAIs, factors such as patient age, underlying health conditions, invasive procedures and medical treatments administered during hospitalization, attitudes of healthcare personnel providing patient care, and environmental factors should be carefully examined. Surveillance studies should be conducted with precision within this context.

Authors' contributions

KKC, GK, AS, methodology and data collection, data analysis; SA, SK, writing original draft; SA, SK, AS, review and editing.

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Conflict of interests

No conflict of interests is declared.

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