Original Article

Healthcare-associated infections in a newly opened pediatric intensive care unit in Turkey: Results of four-year surveillance

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Abstract

Introduction: Healthcare-associated infections (HAIs) are important causes of morbidity and mortality, especially in critically ill patients in intensive care units. The aim of this study was to assess the rate and distribution of HAIs, pathogens, and antimicrobial susceptibility patterns in a newly opened pediatric intensive care unit (PICU).

Methodology: The infection control team detected and recorded HAI cases according to the Centers for Disease Control and Prevention's criteria in the PICU of Marmara University Pendik Training and Research Hospital over a four-year period following its opening. Laboratory-based HAIs surveillance was performed prospectively from 1 January 2011 to 30 November 2014.

Results: During the study period, 1,007 patients hospitalized in the PICU and 224 HAIs were identified. The overall HAI rate was 22.24%, and the incidence density was 20.71 per 1,000 patient-days. The most commonly observed HAIs were bloodstream infection (35.7%), pneumonia (21.4%), and urinary tract infection (20.5%), and the three most common HAI pathogens were *Klebsiella* spp. (19.4%), *Pseudomonas aeruginosa* (13.8%), and *Acinetobacter baumanii* (12%). Methicillin resistance was detected in 78% of coagulase-negative *Staphylococcus*. Presence of extended-spectrum beta-lactamases was determined in 45% and 54% of *Klebsiella* spp. strains and *Escherichia coli* isolates, respectively.

Conclusions: Our rate of HAIs is higher than the mean rates reported in PICU studies from developed countries. Active surveillance studies of HAIs is an essential component of infection control, which may contribute to improving preventive strategies in developing countries.

Introduction

Healthcare-associated infections (HAIs) continue to be an important cause of morbidity and mortality. They prolong hospital stay, increase antibiotic usage, and have a considerable impact on healthcare cost. HAIs are a major public health problem worldwide, but particularly in developing countries [1,2]. Incidence of HAIs varies according to age, hospital ward, underlying disease, and other risk factors. HAIs are more common in intensive care units than in other hospital wards. The main causes of this increased risk include more frequent medical device use and healthcare worker manipulations. Most of the current HAI literature focuses on adults, and data regarding pediatric intensive care unit (PICU)-acquired HAIs and related risk factors are limited [1]. Turkey is a developing country, and although its national HAI surveillance system has been in place since 2008, few published data regarding infection rates, HAI types, pathogens, and antimicrobial susceptibility rates are available. Moreover, HAI risk factors and related co-morbidities and mortalities have not been reported. There are not enough studies available investigating HAIs and risk factors in PICU patients [1].

In developing countries, the incidence of HAIs has been reported to be higher than in developed nations because of the high number of patients, limited number of staff, and insufficient compliance with infection control measures [2,3]. Effective infection control programs, such as surveillance, can reduce the infection rate. Surveillance is the routine and orderly collection of data based on standard definitions of cases. It

provides data for routine analysis and feedback of information. It also helps to determine specific health care for hospitalized patients and provides data on necessary precautions [4]. For many years, it has been emphasised that active surveillance of HAIs is essential to improve the safety of patients, especially in intensive care units.

The aim of this study was to assess HAI rates, distribution of HAI types, pathogens, and changes in antimicrobial susceptibility in newly opened 14-bed PICU over a four-year period.

Methodology

This study was performed in the PICU at Marmara University Pendik Training and Research Hospital in Istanbul, Turkey. The hospital started admitting patients in 2011. The 14-bed PICU consists of five rooms, including two single rooms where a total of six nurses and five doctors work during the day. Each nurse has to care for three patients. Active surveillance of HAIs was performed by the infection control team. Laboratory-based HAI surveillance was performed prospectively from 1 January 2011 to 30 November 2014.

The National Hospital Infections Surveillance Network (UHESA) has been in place since 2008 [1,5]. Data were prospectively collected according to standard protocols of the UHESA. Criteria specified by the Centers for Disease Control and Prevention were used

as standard definitions for HAIs [6]. HAI was described as infection occurring 48 hours after admission or 10 days after discharge. Depending on symptoms, urine, cerebrospinal fluid, endotracheal aspirate, sputum, or wound specimens were obtained.

Blood cultures were performed using BACTEC peds plus/F bottles (BD Diagnostics, Sparks Glencoe, USA). Identifications were done using VITEK2 (BioMérieux, Marcy l'Etoile, France). Extended-spectrum β-lactamases (ESBLs) were detected using the E-test, according to the manufacturer's instructions (AB Biodisk, Solna, Sweden). Susceptibility to non-β-lactam antibiotics was evaluated by a disk diffusion method according to the criteria of the Clinical and Laboratory Standards Institute (CLSI) [7]. E-test strips of vancomycin and teicoplanin were used to confirm resistance to glycopeptides according to the manufacturer's instructions (AB Biodisk). For the interpretation of susceptibility results, the breakpoints of resistance set by the CLSI were used [7]. All information and culture results of patients with HAIs were collected by an infection control nurse. The rate of an HAI was calculated as the number of HAIs/number of all hospitalized patients x100, and incidence density was calculated as the number of HAIs/total patient-days x1,000 in a given period.

Table 1. Rates of healthcare-associated infections (HAIs) in the pediatric intensive care unit of Marmara University Pendik Training and Research Hospital over a four-year period following its opening.

	2011	2012	2013	2014	Total
Number of HAIs	60	63	56	45	224
Number of patients	86	299	319	303	1,007
Total patient-days	1,068	2,618	3,462	3,668	10,816
Rate of HAIs (%)	69.7	21.07	17.55	14.85	22.24
Incidence density (per 1,000 patient-days)	56.17	24.06	16.18	12.27	20.71

Table 2. Distribution of healthcare-associated infection (HAI) types between 2011 and 2014.

Types of HAIs	Years				
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	Total n (%)
BSI	20 (33.3)	32 (50.8)	16 (28.6)	12 (26.7)	80 (35.7)
Pneumonia	14 (23.3)	9 (14.3)	14 (25)	11 (24.4)	48 (21.4)
UTI	16 (26.7)	10 (15.8)	10 (17.9)	10 (22.3)	46 (20.6)
SSTI	7 (11.7)	6 (9.5)	4 (7.1)	6 (13.3)	23 (10.3)
GISI	3 (5)	1 (1.6)	7 (12.5))	4 (8.9)	15 (6.7)
SSI	0 (0)	1 (1.6)	1 (1.8)	1 (2,2)	3 (1,3)
CVSI	0 (0)	0 (0)	1 (1.8)	0 (0)	1 (0.4)
CNSI	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
OI	0 (0)	4 (6.4)	3 (5.3)	1 (2.2)	8 (3.6)
Total	**60 (100)**	**63 (100)**	**56 (100)**	**45 (100)**	**224 (100)**

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

Results

In the four-year period of the study, 224 HAIs were detected from 1,007 patients. Based on the surveillance data, annual HAI rates for each year between 2011 and 2014 were 69.7%, 21.1%, 17.5%, and 14.8%, respectively. The overall HAI rate was 22.24 per 100 admissions, and the incidence density was 20.71 per 1,000 patient-days. The rates of HAIs by year are summarized in Table 1.

Regardless of the year of surveillance, the three most commonly detected HAI types were bloodstream infection (BSI) (35.7%), pneumonia (21.4%), and urinary tract infection (UTI) (20.6%). BSI was the most common HAI type every year. Pneumonia was the second-most common HAI type in 2013 and 2014, and UTI was the second-most common HAI type in 2011 and 2012. The distributions of the HAIs types for each year are shown in Table 2.

Table 3. Distribution of healthcare-associated infection (HAI) pathogens between 2011 and 2014

Pathogens of HAIs	Years				
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	Total n (%)
Klebsiella **spp.**	**9 (21.4)**	**8 (17)**	**16 (34)**	**9 (11.1)**	**42 (19.4)**
Klebsiella pneumoniae	7 (16.6)	7 (14.9)	16 (34)	9 (11.1)	39 (17.9)
Klebsiella oxitoca	0 (0)	1 (2.1)	0 (0)	0 (0)	1 (0.5)
Other *Klebsiella* spp.	2 (4.8)	0 (0)	0 (0)	0 (0)	2 (1)
Pseudomonas aeruginosa	**3 (7.2)**	**5 (10.7)**	**6 (12.8)**	**16 (19.8)**	**30 (13.8)**
Acinetobacter baumanii	**8 (19)**	**4 (8.4)**	**2 (4.2)**	**12 (14.8)**	**26 (12)**
***Candida* spp.**	**9 (21.4)**	**3 (6.4)**	**4 (8.4)**	**9 (11.1)**	**25 (11.5)**
Candida albicans	4 (9.5)	2 (4.2)	2 (4.2)	9 (11.1)	17 (7.8)
Candida parapsilosis	1 (2.4)	1 (2.1)	1 (2.1)	0 (0)	3 (1.4)
Other *Candida* spp.	4 (9.5)	0 (0)	1 (2.1)	0 (0)	5 (2.3)
***Staphylococcus* spp.**	**4 (9.5)**	**6 (12.8)**	**1 (2.1)**	**8 (9.8)**	**19 (8.7)**
CoNS	3 (7.1)	6 (12.8)	1 (2.1)	8 (9.8)	18 (8.2)
S. aureus	1 (2.4)	0 (0)	0 (0)	0 (0)	1 (0.5)
Escherichia coli	**2 (4.8)**	**4 (8.4)**	**1 (2.1)**	**6 (7.4)**	**13 (6)**
***Enterococcus* spp.**	**2 (4.8)**	**4 (8.4)**	**2 (4.2)**	**0 (0)**	**8 (3,7)**
Enterococcus faecium	1 (2.4)	2 (4.2)	1 (2.1)	0 (0)	4 (1.7)
Enterococcus faecalis	0 (0)	1 (2.1)	1 (2.1)	0 (0)	2 (1)
Other *Enterococcus* spp.	1 (2.4)	1 (2.1)	0 (0)	0 (0)	2 (1)
Others*	**5 (11.9)**	**13 (27.7)**	**15 (32)**	**21 (25.9)**	**54 (24.9)**
Total	**42 (100)**	**47 (100)**	**47 (100)**	**81 (100)**	**217 (100)**

CoNS: coagulase-negative *Staphylococcus*; *Others includes *Serratia* spp., *Citrobacter* spp., *Stenotrophomonas maltophilia*, *Proteus mirabilis*, *Morganella morganii*, *Moraxella catarrhalis*, and *Streptococci.*

Table 4. Distribution of the pathogens' antibiotic susceptibility patterns between 2011 and 2014.

Antibiotic susceptibility patterns of pathogens	Years				
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	Total n (%)
***Klebsiella* spp.**	**9 (21.4)**	**8 (19.1)**	**16 (38.1)**	**9 (21.4)**	**42 (100)**
Presence of an ESBL	2 (22)	3 (37)	7 (44)	7 (78)	19 (45)
Absence of an ESBL	7 (78)	5 (63)	9 (56)	2 (22)	23 (55)
Escherichia coli	**2 (15.3)**	**4 (30.8)**	**1 (7.7)**	**6 (46.2)**	**13 (100)**
Presence of an ESBL	1 (50)	2 (50)	0 (0)	4 (67)	7 (54)
Absence of an ESBL	1 (50)	2 (50)	1 (100)	2 (33)	6 (46)
CoNS	**3 (16.7)**	**6 (33.4)**	**1 (5.5)**	**8 (44.4)**	**18 (100)**
Methicillin sensitive	0 (0)	2 (33)	0 (0)	2 (33)	4 (22)
Methicillin resistance	3 (100)	4 (67)	1 (100)	6 (67)	14 (78)
Staphylococcus aureus	**1 (100)**	**0 (0)**	**0 (0)**	**0 (0)**	**1 (100)**
Methicillin sensitive	1 (100)	0 (0)	0 (0)	0 (0)	1 (100)
Methicillin resistance	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
***Enterococcus* spp.**	**2 (25)**	**4 (50)**	**2 (25)**	**0 (0)**	**8 (100)**
Ampicillin resistance	2 (100)	3 (75)	1 (50)	0 (0)	6 (75)
Vancomycin resistance	1 (50)	2 (50)	0 (0)	0 (0)	3 (38)

CoNS: coagulase-negative *Staphylococcus*; ESBL: extended-spectrum beta-lactamase.

Klebsiella species accounted for 19.4% of all isolates and were the most common cause of HAIs, followed by *Escherichia coli* (13.8%) and *Acinetobacter baumanii* (12%). *Candida* species were found to be the fourth-most common agent causing HAIs. They were isolated from 11.5% of the infected patients. *Candida albicans* and non-*albicans Candida* strains accounted for 7.8% and 3.7% of HAIs, respectively (Table 3).

Reagarding the antibiotic susceptibility patterns among pathogens isolated from HAIs, methicillin resistance was detected in 78% of coagulase-negative *Staphylococcus*. Nineteen (45%) *Klebsiella* spp. isolates and seven (54%) *Escherichia coli* isolates produced ESBLs. Vancomycin and ampicillin resistance were detected in 38% and 75% of *Enterococcus* spp. strains, respectively (Table 4). Carbapenem susceptibility was detected in 63% and 31% in *Pseudomonas aeruginosa* and *Acinetobacter baumanii* isolates, respectively.

Discussion

Despite the recent advances in pediatric intensive care, HAIs still cause considerable morbidity and mortality. HAIs are highest in intensive care units and surgical wards, and lowest in medical units [8]. Active surveillance of HAIs play a substantial role in infection control in the PICU, which may contribute to improving patient care. Although there are many data on the epidemiology of HAIs in PICU from industrialized countries, data from developing countries like Turkey are limited.

Although our HAI incidence was not higher in the PICU (22.2 per 100 admissions or 20.7 per 1,000 patient-days) compared to other reports from PICUs in developing countries such as Mexico, Brazil, and Egypt, it was higher than that reported from developed countries such as the United States [9-11]. In a multicenter study, the HAI rates were 6.1 per 100 patients and 14.1 per 1,000 patient-days in 61 PICUs during 1992–1997 in American hospitals [12]. In another American study, the HAI rate was 11.9 per 100 admissions in 35 PICUs [13]. A prevalence study from 17 European centers reported a PICU HAI rate as 23.6% [14]. Our prevalence is lower than that reported (29.8%) in a Spanish PICU study [15]. A national point-prevalence survey study of 50 PICUs in Turkey reported the overall HAI rate as 37% [1].

Nationwide infection control studies and infection control training program reports have improved since the early 2000s in Turkey. UHESA was implemented in Turkey in 2008 [5]. A similar network, the National Nosocomial Infections Surveillance System (NNIS), has been operational since the 1970s in the United States, where it has led to a 30%–40% decrease in HAI rates [12,16]. Following the introduction of the Krankenhaus Infektions Surveillance System (KISS), the incidence of ventilator-associated pneumonia was reduced by 24% over three years in Germany [17].

Although our PICU was newly opened, the HAI rates were higher in the first years after opening. We observed that HAI rates gradually decreased over the years in this study. High HAI rates in the first year despite the new facility, equipment, and infrastructure suggests that healthcare workers had not complied with infection control measures. Poor compliance with hand hygiene (HH) was one of the causes of this high rate of HAIs. Other reasons were lack of staff and training and not enough feedback and delay awareness. We investigated the compliance with HH among the doctors and nurses in our neonatal and pediatric intensive care units. Overall compliance with HH in doctors and nurses was low, at 31.9% and 41.4%, respectively [18], which was the major causes of high HAI rates. We gave feedback to the hospital infection control committee and all PICU staff about HH compliance. HH training was given more frequently. Infection control committee members and PICU employees must exert more effort to decrease HAI rates.

The two most important infection control measures are HH compliance and active surveillance. We want to emphasize once again the importance of active surveillance and HH compliance for monitoring and controlling HAIs. Therefore, we believe that delayed awareness and implementation of infection control measures and prevention methods and the late adoption of HAI surveillance has contributed to the high HAI rates in Turkey.

The most common HAI type was BSI (35.7%) in this study (Table 2). In the United States, BSIs (28%), pneumonia (21%), and UTIs (15%) are the most common HAIs in PICUs [12]. Kepenekli *et al.* reported that the most common HAIs are pneumonia (55%), BSIs (27%), and UTIs (7%) in a national point-prevalence study that included 50 PICUs in Turkey [1]. The order of frequency of HAI types may vary according to the department, hospital population, and settings.

Klebsiella spp. was the most frequently isolated microrganism from all HAIs in our study. About 50% of *Klebsiella* spp. strains and *Escherichia coli* isolates were ESBL positive in the current study, similar to the rates in 2008–2010 at the old hospital building [2]. An

international, multicenter study that included Turkey reported that the 78% of *Klebsiella pneumoniae* isolates produce ESBLs [19]. *Pseudomonas aeruginosa* and *Acinetobacter baumanii* are other frequently isolated pathogens and important agents in PICUs with the increase in antimicrobial resistance. *Pseudomonas aeruginosa* was the second-most common causative agent in our study. It has been reported to be the most common pathogen of nosocomial pneumonia in European and Canadian studies as well [14,20]. The overall carbapenem susceptibility rate was 63% among *Pseudomonas aeruginosa* isolates in this study. The carbapenem susceptibility rate has been reported to be between 48% and 71% in previous national studies [1,2,21,22]. *Acinetobacter* infection rates in PICUs are also increasing due to resistance to commonly used broad-spectrum antibiotics. *Acinetobacter baumannii* represented the third-most common causative agent in our study. Among 26 *Acinetobacter baumannii* isolates tested, 18 (69%) were resistant to carbapenems. All the *Acinetobacter baumannii* isolates were susceptible to colistin.

The susceptibility patterns in *Pseudomonas aeruginosa* and *Acinetobacter baumannii* change over different areas of the hospital and over time [2]. We considered the consistently high rates of resistance to be caused by insufficient compliance with infection control measures and inappropriate and long-term use of broad-spectrum antibiotics in critically ill children in the PICU. Owing to active surveillance, clinicians may estimate the antibiograms patterns, which may help clinicians with the empirical antibiotic treatment. These pathogens are inherently resistant to the commonly used antibiotics. They are associated with contaminated water supply, are able to colonize the mucosa of patients and surfaces of various devices in the PICU, and are particularly common in hospital settings. In the PICU, water and water-related devices could be monitered, which can help infection control measures.

Conclusions

This study reported the HAI rates in the PICU are higher compared to those in developed countries. The high rate of HAIs with resistant bacteria reported in our study may be caused by the lack of infrastructure, delayed awareness regarding infection control measures, the inability to implement infection control measures such as HH, and the late adoption of HAI surveillance. This report emphasized once again that active surveillance of HAIs and HH compliance are fundamental components of infection control in

developing countries such as Turkey, and may contribute improved patient care and survival in PICUs.

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