An Evaluation of Pediatric Intensive Care Unit Infection Rates and Various Risk Factors

Ayşe Ulus[1], **Soner Sertan Kara**[2], **Elif Çelik**[3]

[1] Infection Control Nurse, Aydın Adnan Menderes University Medical Faculty, Aydın, Turkey

[2] Pediatric Infectious Diseases Department, Aydın Adnan Menderes University Medical Faculty, Aydın, Turkey

[3] Pediatric Intensive Care Unit, Aydın Adnan Menderes University Medical Faculty, Aydın, Turkey

10.5222/TP.2020.66376

Cite as: Ulus A, Kara SS, Çelik E. An evaluation of pediatric intensive care unit infection rates and various risk factors. Trends in Pediatrics 2020;1(2):75-80.

Received: 30 November 2020
Accepted: 07 December 2020
Publication date: 31 December 2020

Keywords: Pediatric intensive care unit, healthcare-associated infections, ventilator-associated pneumonia

Soner Sertan Kara
Pediatric Infectious Diseases Department, Aydın Adnan Menderes University Medical Faculty, Aydın, Turkey
ORCID: 0000-0002-8129-6063
drsoner@yahoo.com

A. Ulus 0000-0001-9569-9501
E. Çelik 0000-0002-0298-4088

ABSTRACT

Objective: *The pediatric intensive care unit (PICU) is a unit in which the general condition and vital signs of patients aged one month to 18 years are continuously monitored, and support treatments after advanced pediatric and surgical procedures are provided. Healthcare-associated infections (HAIs) can develop during some interventions and treatments. The purpose of this study was to investigate infection and handwashing rates for the previous five years in a hospital PICU providing tertiary intensive care and to examine HAI agent microorganisms and their resistance rates.*

Methods: *Data for patients followed-up at the Aydın Adnan Menderes University Hospital PICU between 1 January 2015, and 30 October 2020, were examined retrospectively. The study data were obtained from the hospital microbiology laboratory culture specimen results, radiology data, clinical visits, and information recorded on the National Healthcare-Associated Infections Surveillance System. HAIs rates, density, infectious agents and resistance rates, and hand hygiene compliance rates were calculated from these data.*

Results: *Two hundred and thirty-three patients were included in the study. The mean annual number of patient days was 1742±322. The mean annual total number of infections was 9.0±3.9, the mean infection rate was 4.2±2.8, and the mean infection density was 5.0±1.5. Bloodstream infections constituted the most common infections, followed by ventilator-associated pneumonia (VAP). Carbapenem resistance at a rate of 50% was determined for both Acinetobacter spp. and Pseudomonas aeruginosa. A strong correlation was determined between VAP and patient days (p=0.05, r=0.80). Hand hygiene observations revealed compliance rates of 48.1±14.3 in nurses, 33.9±28.2 in patient carers, 31.8±12.5 in physicians, and 30.9±26.2 in cleaning personnel.*

Conclusion: *Mean annual infection numbers in this study were similar to those of previous studies from other centers. The most common infection was bloodstream infections. Nurses had the highest handwashing rates, with physicians in the third place. Higher VAP was correlated with increased patient days.*

INTRODUCTION

The pediatric intensive care unit (PICU) is a unit in which patients aged from one month to 18 years are observed, basic vital signs can be monitored, support treatments such as fluid and blood transfusion, hemodialysis, resuscitation, and mechanical ventilation, can be provided, and advanced pediatric, some surgical, and diagnostic procedures can be carried out. Complications in PICU include healthcare-associated infections (HAIs) which constitute infections that are not present or incubating during admission to the health institution but develop after the third day of hospitalization.[1]

The general rate of HAI development in intensive care units is 20-40 percent, the most commonly reported being bloodstream infections (BSIs), ventilator-associated pneumonia (VAP), urinary tract infections (URTIs), and surgical site infections (SSIs).[2] The HAI rate in pediatric intensive care units (PICUs) is 6-12 percent. The microorganisms identified vary

depending on the type of infection. The most commonly isolated microorganisms include *Staphylococcus aureus*, coagulase-negative *staphylococci, enterococci* and *Candida* spp in BSIs, gram-negative bacteria, particularly *Pseudomonas aeruginosa,* in VAP, and *Escherichia coli, Klebsiella pneumoniae, Enterobacter* and *Candida* spp in URTIs. Rotavirus and respiratory syncytial virus are also infectious agents frequently seen in children. Treatment for microorganisms with high antibiotic resistance is limited, and mortality rates are high. Resistant microorganisms seen with increasing frequency, particularly in HAIs, include methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-resistant coagulase-negative *staphylococci* (MRCNS), vancomycin-resistant *enterococci* (VRE), extended-spectrum beta-lactamases (ESBL)-positive *Klebsiella* and *E. coli*, and carbapenem-resistant *Pseudomonas* and *Acinetobacter*.[3] Risk factors for HAIs developing with these microorganisms include chronic diseases, sedative medication use, surgery, invasive interventions and procedures such as fluid and blood transfusions, intravenous nutrition, presence of nasogastric, central/urinary catheters, and mechanical ventilation.[2] Other risk factors are premature birth, low birth weight, congenital anomalies, and immunosuppression.[3]

Hand hygiene is the most important precaution against transmission of microorganisms in hospital. This low-cost and simple precaution has been described as capable of preventing half of nosocomial infections.[19] Low compliance with hand hygiene leads to the emergence of new and different microorganisms by affecting the hospital flora, and to an increase in nosocomial infections.[14] International guidelines recommend ensuring hand hygiene with frequent washing with soap and water and rubbing the hands with alcohol-based hand disinfectant. When hand hygiene is at a high level, the incidence of HAI is known to be low, and there is a decreased risk of microorganism transmission. However, research into epidemics has noted that compliance is low.[5]

The purpose of the present study was to examine infection and handwashing rates over the previous five years in a PICU providing tertiary intensive care service in our hospital, together with microorganism HAI agents and resistance rates.

MATERIAL and METHOD

Data for patients followed-up in the Aydın Adnan Menderes University Hospital PICU, Turkey, between 1 January, 2015, and 30 October, 2020, were evaluated retrospectively. The PICU operates continuously and without interruption as a third level, six-bed capacity, intensive care unit. The study data were collected through active and continuous surveillance by an infection control nurse (ECN). Patients' clinical manifestations, culture specimen results, radiology data, and clinical visits have been monitored in surveillance studies. Bacterial growth in patients' specimens and sensitivity results were monitored on a daily basis through transfer of data from the hospital microbiology laboratory to the hospital data management system. Data described in line with the diagnostic criteria set out in the National Health Service-Associated Infections Surveillance System, and recorded onto the system by ECN used in the present study.[1]

Handwashing observations were performed by ECN based on criteria specified in the World Alliance for Patient Safety Guideline for Observers at three-monthly periods for all physicians, nurses, patient carers, and cleaning personnel working in the unit.[1] Observation data were also obtained from information recorded in the National Health Service-Associated Infections Surveillance System hand hygiene section.

HAIs constitute infections that are not present or incubating during admission to the health institution and that develop after the third day of hospitalization and in association with health services.[1] Health-care worker occupation-related infections and those producing symptoms after discharge are also included in this class.

- Infection rate is calculated as number of infections/number of hospitalized patients x 100.
- Infection density is calculated as number of infections/patient days x 1000.
- The term patient days is defined as the length of the patient's stay in the unit in days.

Statistical analyses were performed on SPSS (Statistical package for the Social Sciences) version 17.0 software. Normality of distribution of variables was evaluated using the Kolmogorov-Smirnov / Shapiro-Wilk tests. Descriptive statistics were expressed as mean±standard deviation for normally distributed variables and as median (minimum-maximum) for non-normally distributed variables. Categorical variables were expressed as percentages (%). Correlation analyses were performed using Pearson's correlation test.

RESULTS

Two hundred thirty-three patients were included in the study. The mean annual number of patient days was 1742±322 days. Annual mean infection numbers, rates, and densities are shown in Table 1. Bloodstream infections were the most frequently detected HAI, followed by VAP.

The most frequently identified agent in the study was *Enterobacteriaceae* family, and infection numbers decreased over time (Table 2). Other agents identified were *Acinetobacter* spp. and *Pseudomonas aeruginosa*. Carbapenem resistance was determined in 50% of these pathogens . The highest handwashing rates during the study period were identified in nurses, followed by patient carers, and then by doctors (Table 3).

Table 1. Infection numbers, rates, and densities

	Infection number	Infection rate	Infection density
Bloodstream infection	4.6±2.3	2.1±1.4	2.6±1.1
Ventilator-associated pneumonia	2.5±1.8	1.2±1.0	1.3±0.9
Surgical site infection	0.67±0.81	0.30±0.33	0.37±0.44
Urinary tract infection	1.0±1.2	0.5±0.7	0.5±0.7
Meningitis	0.1±0.4	0.1±0.2	0.2±0.08
Total	9.0±3.9	4.2±2.8	5.0±1.5

Data are expressed as mean±standard deviation

Table 2. Infectious agents in the study and resistance rates, n (%)

	2015	2016	2017	2018	2019	2020	Total
Acinetobacter spp.	3	0	0	3	0	0	6
Carbapenem-resistant strain	1 (33%)			2 (66%)			3 (50%)
Pseudomonas aeruginosa	0	2	2	1	0	1	6
Carbapenem-resistant strain		2 (100%)	0 (0%)	0 (0%)		1 (100%)	3 (50%)
Enterobacteriaceae	10	3	7	3	2	1	26
ESBL-producing strain	1 (10%)	1 (33%)	3 (43%)	3 (100%)	1 (50%)	0 (0%)	9 (34%)
Staphylococcus aureus	2	0	1	1	0	0	4
MRSA	1 (50%)		0 (0%)	1 (100%)			2 (50%)

ESBL; extended spectrum beta lactamases

Table 3. Health personnel handwashing percentages

Doctors	31.8±12.5
Nurse	48.1±14.3
Cleaning personnel	30.9±26.2
Patient caregivers	33.9±28.2
GENERAL	42.4±15.8

Data expressed as mean±standard deviation

Table 4. Correlations between infection parameters

	Total infection number	Total infection rate	Total infection density	Patient days
Bloodstream infection rate	p=0.03 r=0.85	p=0.03 r=0.84	p=0.02 r=0.87	-
Ventilator-associated *pneumonia* numbers	p=0.03 r=0.83	p=0.04 r=0.82	-	p=0.05 r=0.80

Correlations between infection parameters are shown in Table 4. A strong correlation was determined between BSI rate and total number of infections (p=0.03, r=0.85), infection rate (p=0.03, r=0.84) and infection density (p=0.02, r=0.87). VAP was strongly correlated with total number of infections (p=0.03, r=0.83), total infection rate (p=0.04, r=0.82), and patient days (p=0.05, r=0.80). No correlation was determined between handwashing rates and infection numbers, rates, or densities.

DISCUSSION

The frequency of hospital infections, their distributions, and factors affecting increases or decreases in their incidence rates are determined through surveillance studies conducted by infection control committees. Problems are identified based on the data obtained, and the appropriate activity for identifying a solution is then carried out.[6] In the present study, the rate of HAI was 4.2%±2.8 and the density was 5.0±1.5. Previous studies from Turkey have reported various infection rates and densities. In Istanbul University Faculty of Medicine between 1 January and 30 June, 2010, reported infection rates and densities were 9.6% and 10.88%, while Adana Numune Education and Research Hospital between 1 January, 2012, and 31 December, 2016 the corresponding rates were 2.36% and 2.89%, respectively.[3,7]. The lower rates in the present study relative to the study from Istanbul suggested the involvement of various factors. Indeed, the neonatal and pediatric wards were being included in the study, bone marrow transplantation is not performed on pediatric patients in our hospital, diagnosis is not difficult to make through viral infection tests being performed when necessary, and rapid transfer of inpatients to the ward is realized once the indication for intensive care has disappeared. The higher rates obtained in our study than those from Adana may be associated with low compliance with hygiene among physicians, insufficient maximum barrier precautions being taken during catheter placement, catheters remaining in place for long periods, and a possession of sufficient data for diagnosis of nosocomial infections following active surveillance.

Consistent with other studies in the literature, the most common nosocomial infections in this study were BSIs and VAP.[8,9] In contrast to other, previous studies, the most frequent infectious agent in the PICU in the present study was the *Enterobacteriaceae* group, while *Candida* spp. reported in other studies were not among the first three.[7,8,10-12] Carbapenem resistance seen in *Acinetobacter* spp. and *Pseudomonas aeruginosa* strains was lower than relevant data reported by Kayseri Education and Research Hospital and Adana Numune Education and Research Hospital.[7,12] This is very likely related to a lower frequency of antibiotic use and to narrower spectrum antibiotics being employed.

Consistent with some previous studies, hand hygiene compliance rates in the present study were higher among nurses than among doctors.[13,14] However, Karahan et al.[15] reported no difference in compliance among the occupational groups. The higher hand hygiene compliance among nurses compared to doctors and other health personnel in the present research was attributed to their comparatively greater involvement in patient care, greater observation of the measures adopted by them, and to their being warned in the event of incorrect practices. Karaoğlu et al.[16] cited the difficulties inherent in being a doctor and male gender as risk factors for low compliance in physicians. In the present study, we thought that the low compliance rate might have derived from doctors feeling themselves to be clean, to their thinking that hand hygiene is more important in surgical procedures,

and to an absence of large numbers of role models among their own colleagues. Examination of the general literature shows that hand hygiene is correlated with infection rates.[4] However, no correlation was determined in the present study between handwashing rates, rates, and densities of infection, and the number of infections.

Prolonged stay in the ICU, mechanical ventilation exceeding 48 hours, intubation, immunosuppression, genetic diseases, underlying respiratory diseases, a history of broad-spectrum antibiotic use, and enteral nutrition have been cited as risk factors for the development of VAP.[17,18] A strong correlation was similarly observed in the present study between VAP and duration of hospitalization. We think that shortening lengths of hospital stay may be the most important factor in reducing VAP rates in the future. Although this study produced significant findings making a significant contribution to the existing literature, it also has a number of limitations. Our hospital's pediatric infectious diseases specialist only commenced work in 2018, for which reason, although the same guidelines were employed, various difficulties and deficiencies were experienced in terms of diagnosing HAI in the earlier period. Although catheter-associated infections have recently been described separately, BSI numbers, rates, and densities in the present study included both catheter-related and -unrelated cases which were evaluated in combination. Finally, although each HAI has its own variable specific risk factors, due to deficiencies in retrospective data, these parameters could not be assessed individually. Nonetheless, this study is the first on the subject from the relevant department of our hospital, and will be a useful guide for future more extensive and multi-perspective studies.

In conclusion, the annual total infection numbers, infection rates, and infection densities in the present study were similar to those in previous studies obtained from other centers. BSIs were the most common HAI. The most frequently identified HAI agent was the *Enterobacteriaceae* family. Other frequently identified agents, *Acinetobacter* spp. and *Pseudomonas aeruginosa*, exhibited carbapenem resistance rates of 50%. The highest rates of handwashing throughout the study period were observed among nurses, followed by patient carers, and then doctors. A strong correlation was determined between VAP and patient days.

Ethics Committee Approval: Local Ethical Committee at Aydin Adnan Menderes University.
Conflict of Interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
Funding: The authors received no financial support for the research, authorship, and/or publication of this article.
Informed Consent: Parents of the patient provided informed consent to publish the report.

REFERENCES

1. Türkiye Cumhuriyeti Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğü Bulaşıcı Hastalıklar Daire Başkanlığı. Ulusal Sağlık Hizmeti İlişkili Enfeksiyonlar Sürveyans Rehberi, Ankara, 1. Baskı, 2017: 2.
2. Tayran N. Çocuk Yoğun Bakım Ünitesinde Sıfır Enfeksiyon, 5. Ulusal Sağlık Bakımı İlişkili Enfeksiyonlar Simpozyumu, İstanbul, 5-6 Mayıs 2017: 4.
3. Maraş H. İstanbul Tıp Fakültesi, Çocuk Sağlığı ve Hastalıkları Anabilim Dalı Servislerinde 2010 yılı ilk yarısı hastane enfeksiyonu sürveyansı, Uzmanlık Tezi, İstanbul Üniversitesi İstanbul Tıp Fakültesi, İstanbul, 2011:5-15.
4. Günaydın M. Hastane enfeksiyonları ile mücadelede el hijyeni, 20. DAS Eğitim Semineri, Mart 2012, Giresun: 24.
5. Türk Hastane İnfeksiyonları ve Kontrolü Derneği. El Hijyeni Kılavuzu. Hastane İnfeksiyonları Dergisi. 2008;1(Ek 1).
6. Erol S. Hastane enfeksiyonları sürveyansı, hastane enfeksiyonları: Korunma ve kontrol sempozyum dizisi. 2008;43-51.
7. Celiloğlu C, Tolunay O, Çelik T, Sucu A, Yurtçu E, Çelik Ü. Çocuk yoğun bakım ünitesindeki hastane enfeksiyonlarının değerlendirilmesi. J Pediatr Inf. 2017;11(3):129-34. https://doi.org/10.5578/ced.64028
8. Anıl A, Anıl M, Özdemir N, et al. Çocuk yoğun bakım ünitesinde hastane enfeksiyonları risk faktörleri. J Pediatr Emerg Intens Care Med. 2014;1:9-16.
9. Yeğin L. Yenidoğan yoğun bakım ünitesi ve çocuk yoğun bakım ünitesinde yatan hastalarda sağlık bakımı ilişkili enfeksiyonlar: Dört yıllık sürveyans çalışması, Uzmanlık Tezi. Uludağ Üniversitesi Tıp Fakültesi. Bursa; 2015:41.
10. Kılıç F, Çoban Y, Davutoğlu M, Dalkıran T. Çocuk yoğun bakım ünitesinde izlenen hastaların geriye dönük analizi ve mortaliteyi etkileyen faktörlerin incelenmesi. J Pediatr Emerg Intensive Care Med. 2016;3:140-5. https://doi.org/10.4274/cayd.02996
11. Solmaz A, Güzelçiçek A. Çocuk yoğun bakım ünitesinde izlenen sepsis olgularının geriye dönük analizi. Harran Üniversitesi Tıp Fakültesi Dergisi. 2019;16:24-8.
12. Ergül A, Işık H, Altıntop Y, Torun Y. Bir çocuk yoğun

bakım biriminde kan kültürlerinin geriye dönük değerlendirilmesi: Üç yıllık sonuçlar. Turk Pediatri Ars. 2017;52(3):154-61.
13. Şen S, Sönmezoğlu M, Akbal E, Uğur E, Afacan S. Bir üniversite hastanesinde sağlık personelinin el hijyeninde beş indikasyona uyumu. Klimik Dergisi. 2013;26:17-20. https://doi.org/10.5152/kd.2013.05
14. Oğuz B, Kurutkan M. Hastane kaynaklı enfeksiyonları azaltmanın altın kuralı el hijyeni: Kamu ve özel hastane karşılaştırması. Konuralp Tıp Dergisi. 2013;5(2):36-42.
15. Karahan E, Doğan Ş, Çelik S. Sağlık çalışanlarında el hijyeni inancı ve uygulamalarının değerlendirilmesi. Sağlık Akademisi Kastamonu (SAK). 2020;5:91-103. https://doi.org/10.25279/sak.616961
16. Karaoğlu M, Akın S. Hastane enfeksiyonlarının önlenmesinde el hijyenine uyum ve el hijyeni uyumunun geliştirilmesi, Sağlık ve Toplum. 2018:1;3-10.
17. Kaya S. Çocuklarda ventilatör ilişkili pnömoni sıklığı, etkenleri, risk faktörleri, morbitide ve mortalite üzerine etkileri, uzmanlık tezi. Anlara Üniversitesi Tıp Fakültesi, Ankara. 2011;7-8.
18. Akbaş H. Ventilatör ilişkili pnömoni tanısı konulan çocukların retrospektif değerlendirilmesi. Uzmanlık tezi, Hacettepe Üniversitesi Tıp Fakültesi. Ankara; 2015:9-10.
19. Güçlü E, Tuna N, Yahyaoğlu M, et al. Eğitimin ve alkol bazlı el antiseptiklerinin hastanede yaygınlaştırılmasının el hijyeni uyumunaetkisi, FLORA Dergisi 2012;17:118-25.