



# Risk Factors for Nosocomial Infections in Children

## Çocuklarda Nozokomiyal Enfeksiyonlar İçin Risk Faktörleri

Tülin Çataklı<sup>1</sup>, Aysel Yöney<sup>2</sup>

<sup>1</sup>Lokman Hekim Hospital, Division of Pediatrics, Ankara, Turkey

<sup>2</sup>Dr. Sami Ulus Children's Hospital, Ankara, Turkey

### Abstract

**Aim:** To determine the frequency of healthcare associated infections (HCAIs) developed within a year in patients admitted to a tertiary pediatric hospital.

**Material and Method:** Between February 1996 January 1997 the patients hospitalized at Dr Sami Ulus Children's Hospital and diagnosed as HCAI during their follow up were included in the study. The diagnosis of 'nosocomial infection' was made on the basis of Center for Disease Control (CDC) diagnostic criteria. Clinical, laboratory and imaging findings were recorded.

**Results:** HCAIs were detected in 311 (9.1%) of the 3420 hospitalized patients. Some of these patients experienced more than 1 episode, and thus, the total HCAI episodes were 353. Of the patients with HCAI; 77.8% were younger than 1 year old, 60.5% (n= 188) were male. HCAI was detected to occur after 10.9±10 days of hospitalization. The most frequent HCAIs were acute gastroenteritis, sepsis, urinary tract infections and lower respiratory system infections. Gram-negative organisms were the most frequently isolated agents. Of the 311 patients with HCAIs, 38 (12.2%) died.

**Conclusion:** HCAI is an important cause for mortality and morbidity in pediatrics clinics. HCAI surveillance, detection of the problems and taking precautions for infection control are important steps.

**Keywords:** Health care-associated infections, child, risk factors

### Öz

**Amaç:** Üçüncü basamak bir çocuk hastanesine yatırılan hastalarda bir yıllık süre içinde gelişen sağlık bakımı ile ilişkili enfeksiyon (SBİE) sıklığının belirlenmesidir.

**Gereç ve Yöntem:** Şubat 1996 – Ocak 1997 tarihleri arasında Dr. Sami Ulus Çocuk Hastanesine yatırılan ve izlemlerinde SBİE tanısı alan hastalar çalışmaya alındı. SBİE tanısı, CDC (Center for Disease Control and Prevention) tanı kriterleri esas alınarak konuldu. Klinik kayıtlar, laboratuvar ve görüntüleme bulguları kaydedildi.

**Bulgular:** Hastaneye yatırılan 3420 hastada 311 (%9,1) SBİE saptandı. Bu hastalardan bazılarında 1'den fazla enfeksiyon epizodu saptandı. Toplam SBİE epizodları 353 idi. Olguların %77,8'i bir yaş altında, %60,5 (n=188) erkek idi. SBİE yatıştan sonraki 10,9±10 günlerde ortaya çıktığı saptandı. En sık görülen SBİE; akut gastroenterit, sepsis, üriner sistem enfeksiyonu ve alt solunum yolu enfeksiyonları idi. Gram negatif organizmalar en sık izole edilen ajanlardı. SBİE tanısı alan 311 hastanın 38'i kaybedildi (%12,2).

**Sonuç:** SBİE çocuk servislerinde önemli mortalite ve morbidite nedenidir. SBİE surveyansı sorunların saptanması ve enfeksiyon kontrolü için önlemler alınması çok önemli basamaktır.

**Anahtar Kelimeler:** Sağlık bakımı ilişkili enfeksiyon, çocuk, risk faktörler



## INTRODUCTION

Hospital-acquired infections (HCAI), also known as healthcare-associated infections (HCAI), are nosocomially acquired infections that are typically not present or might be incubating at the time of admission. These infections are usually acquired after hospitalization and manifest 48 hours after admission to the hospital. HCAs can happen in any health care facility, including hospitals, ambulatory surgical centers, end-stage renal disease facilities, and long-term care facilities. Bacteria, fungi, viruses, or other, less common pathogens can cause HCAs. HCAs are a significant cause of illness and death — and they can have serious emotional, financial, and medical consequences.<sup>[1,2]</sup> Patients hospitalized in pediatric services and pediatric intensive care units (PICUs) have a higher risk of HCAs. Prolonged hospitalization, invasive interventions, congenital malformations, and total parenteral nutrition are significant factors that increase the risk of nosocomial infections in pediatric patients. Prolonged hospitalization, invasive interventions, congenital malformations, and total parenteral nutrition are significant factors that increase the risk of HCAI in pediatric patients. The incidence, prevalence, morbidity and mortality rates of HCAs varies depending on factors such as the type of the hospital, age of the patient, diagnosis at hospitalization, hospitalization service, diagnosis and treatment interventions.<sup>[3]</sup> HCAs are a frequent problem, particularly in Intensive Care Units (PICU). In Europe, incidence of nosocomial infections was reported as 1-2.5% in general pediatric services and as 6.1-15.1% in pediatric intensive care units (PICU).<sup>[4,5]</sup> In developing countries, HCAI rates of PICUs were reported - much higher 13.6-15.4%.<sup>[7,8]</sup>

Healthcare-associated infection is to be a significant cause of morbidity and mortality worldwide and in Turkey. HCAI frequency is reported as 3.02% to 9.3% in the pediatric age group in Turkey.<sup>[3,9]</sup> Since 2005 every hospital has “National Nosocomial Infections Surveillance and Control Unit”.<sup>[10]</sup> Since then there has been significant decrease in HCAI rates, where the particular decrease in year 2007 should be noted.<sup>[3]</sup>

The aim of this research is to find out the frequency of nosocomial infections in one year period in Dr. Sami Ulus Pediatric Hospital and to compare the changes in surveillance studies of nosocomial infections in children in different years with the derived data.

## MATERIAL AND METHOD

In the present study, the data of healthcare-associated infections detected at Dr. Sami Ulus Children's Training and Research Hospital -a tertiary hospital-, were collected in the period January 1996- December 1996. The pediatric hematology-oncology service was excluded from the study. The diagnosis of Healthcare-associated infections (HCAI) have been assessed according to the Centers for Disease Control and Prevention (CDC) criteria. For HCAs, questionnaires included information on the type of infection, onset of infection, any device relationship (e.g. whether a urinary catheter had

been fitted before onset of infection), and other details. Information on whether the nosocomial infection had already been present on admission or had been acquired during the current hospital stay, and the pathogen that had caused the infection, were also recorded. Culture samples obtained from patients were studied in the microbiology laboratory using traditional manual methods. Infection sites, responsible microorganisms and their effect on prognosis were studied. For prophylactic antibiotic use, the type of antibiotic, route of administration, indication, and whether the indication was listed in the patient's medical record were recorded. The Statistical Package for the Social Sciences (SPSS) for Windows version 10.1 was used for the statistical analysis. The study was approved by the Ethics Committee of Dr.Sami Ulus Maternity and Children's Training and Research Hospital, Ankara, Turkey (Date: 17.01.2020, No:73799008).

## RESULTS

In the 1-year period, 3420 patients were hospitalized. HCAs were detected in 311 (9.1%) of the patients. Thirty-eight (13.5%) of these patients experienced more than 1 episode, and thus, the total number of HCAI episodes was 353. 39.5% (n=123) of the patients were female and 60.5% (n= 188) of them were male. The relationship between gender and HCAI was found statistically significant ( $p<0.05$ ). 77.8% of the patients were younger than 1 year of age. HCAI frequency was higher in the 0–1-year-old age group than the other age groups. This difference was found statistically significant ( $p<0.05$ ) (**Table 1**).

**Table 1.** Distribution of HCAI by age groups n (%)

Diagnosis / age	0-12 months	1-4 age	5-9 age	10-14 age	Total n (%)
Gastroenteritis	79 (88.7)	9 (10.1)	1 (1.2)		89 (28.6)
Sepsis	67 (84.8)	9 (11.3)	2 (2.5)	1 (1.2)	79 (25.4)
Urinary tract infection	61 (83.6)	12 (16.4)			73 (23.4)
Pneumonia	20 (51.2)	9 (23.0)	7 (17.9)	3 (7.7)	39 (12.5)
Peritonitis			3 (30.0)	7 (70.0)	10 (3.2)
Omphalitis	9 (100.0)				9 (2.8)
Skin infection	3 (42.8)	4 (57.1)			7 (2.2)
Conjunctivitis	3 (60.0)	2 (40.0)			5 (1.6)
Total, n (%)	242 (77.8)	44 (14.1)	13 (4.1)	12 (3.8)	311 (100.0)

HCAI distribution in terms of diagnosis was as follows: 28.6% (n=89) of them were GE, 25.4% (n=79) were sepsis, 23.4% (n=73) were UTI, 12.5% (n=39) were pneumonia, 3.2% (n=10) were peritonitis, 2.8% (n=9) were omphalitis, 2.2% (n=7) were skin infection and 1.6% (n=5) were conjunctivitis. HCAI-GE was high because of the *Salmonella* Gastroenteritis epidemic during May-June period.

Patients were diagnosed with HCAI on the average of  $10.9 \pm 10^{\text{th}}$  (383<sup>rd</sup>) day of their hospitalization - in HCAI-Sepsis it was  $16.1 \pm 6.7$ , urinary tract infection  $19.2 \pm 13.1$ , pneumonia  $22.8 \pm 13.9$  and GE  $14.6 \pm 8.9$  days. Although the day of diagnosis for HCAs differed, this was not found statistically significant ( $p>0.05$ ).

**Table 2.** Distribution of the causative microorganisms of HCAI

	n	%
<i>Klebsiella</i> spp.	99	40.2
<i>Salmonella</i> spp.	58	23.5
<i>E. coli</i>	29	11.7
CoNS	14	5.6
<i>S. aureus</i>	8	3.2
<i>Pseudomonas</i> spp.	10	4.0
<i>Candida</i>	8	3.2
<i>Enterococcus</i> spp.	7	2.8
<i>Enterobacter</i> spp.	7	2.8
Group B <i>streptococcus</i>	6	2.4
Total	246	100

CoNS: Coagulase negative *staphylococcus*

The comorbid diseases were malnutrition 50.4% (n=178), congenital heart diseases 17.5% (n=62), Immunodeficiency 15.8% (n=56), chronic kidney disease (CKD) 2.8%(n=10) and neuromuscular disease 1.4% (n=5). Nine of HCAI-Peritonitis cases (n=10) were the patients who were applied continuous ambulatory peritoneal dialysis (CAPD) because of CKD. Existence of CAPD in Peritonitis cases was found to be statistically significant (p<0.05).

The HCAI diagnosis was established by clinical features in 107 (34.4%) patients whose cultures were negative or not available. Various organisms were isolated in 246 (69.6%) of the cultures in the 353 HCAIs episodes. Gram-negative organisms were more frequently isolated (58.9%) than Gram positive- organisms (41.0%). The most frequently isolated organisms were *Klebsiella* spp. 99 (40.2%), *Salmonella* spp. 58 (23.5%), *E. coli* 29 (11.7%), coagulase-negative *staphylococcus* (CoNS) 14 (5.6%), *Pseudomonas aeruginosa* 10 (4 %), *Candida* 8 (4.0%), *Enterococcus* spp. 7 (2.8%), *Enterobacter* spp. 7 (2.8%) and Group B *Streptococcus* 6 (2.4%).

When the distribution of detected organisms and infection site was examined, in HCAI-sepsis and UTI cases, the most frequently detected agent was *K. pneumoniae*. In HCAI-UTI cases, *E. coli* was the second most frequently detected agent. In all of the culture-positive HCAI-GE cases, *Salmonella* spp was detected as the agent (**Table 3**).

In vitro antibiotics susceptibility of the isolated microorganisms were as follows: *Klebsiella* spp; amikasin 45%, sulperazon 59%, *Escherichia* spp; sulperazone 45%, seftriakson 60%, *Salmonella* spp.; amikasin and netilmisin 45%, *P. aeruginosa*; sulperazone 56%, netilmicin sulfate 49%, *S. aureus*; vancomycin 80%, CoNS; ceftazidime 55%. Group B *Streptococcus* was found susceptible to Amoxicillin- Clavulanic Acid with the ratio of 80%. In all agents, imipenem susceptibility was 100%.

Thirty-eight of the 311 patients (12.2%) died. 32 of them were HCAI-sepsis and 6 of them were HCAI-pneumonia. 14 of the patients who died of sepsis were the premature newborns who had been hospitalized in neonatal intensive care unit (NICU). In NICU, premature newborn mortality was 28.5% (14/49) and term neonatal was 12.1% (5/41).

During the period that this research was conducted, in the services, there was 1 washbasin in every room and no isolation room in any of the services. During daytime working hours there was 1 nurse per 6-7 patients and 1 nurse per 15-20 patients during nighttime working hours.

## DISCUSSION

Healthcare-associated infections (HCAIs), or nosocomial infections, are a significant cause of morbidity and mortality. HCAI surveillance is important for effective infection control.<sup>[12,13]</sup> The frequency of HCAIs varies according to the type of hospital. The rates have been determined as 4.4% in primary care hospitals; 7.1% in tertiary care hospitals and 19.2% in intensive care units.<sup>[14]</sup> In our study, the HCAIs rate was found to be 9.1%. During the period of our study, in the studies of Campins et al.<sup>[15]</sup> from Spain, and Starling et al.<sup>[16]</sup> from Brasil, the frequency of nosocomial infection was reported as 9.7% and 10.2%, respectively. In 2009, Özçetin et al.<sup>[9]</sup> reported the frequency of HCAIs as 5,3% in the pediatric service of the university hospital (excluding the neonatal service) covering a one year period. In the study of Maraş et al.<sup>[17]</sup> published in 2015, the frequency of nosocomial infection was reported as 9.3%. Although studies have been conducted in different countries and in different years, the HCAI rate in pediatric services is similar.

**Table 3.** The distribution of the detected organisms according to the infection site

HCAI-microorganisms	The HCAI-Site								Total
	GE (n=89)	Sepsis (n=79)	Pneumonia (n=39)	UTI (n=73)	Peritonitis (n=10)	Omphalitis (n=9)	Skin infection (n=7)	Conjunctivitis (n=5)	
<i>Klebsiella</i> spp.		43		41	4	9		2	99
<i>E. coli</i>		1		28					29
<i>Salmonella</i> spp.	58								58
CoNS		4	1		4	3		2	14
<i>S. aureus</i>		2	2		2		2		8
<i>Pseudomonas</i> spp.		4		1			3	2	10
<i>Candida</i>				3					8
<i>Enterococcus</i> spp.		3		4					7
<i>Enterobacter</i> spp.		2		5					7
Group B <i>streptococcus</i>		2		4					6

GE: Gastroenteritis, UTI: Urinary tract infection, CoNS: Coagulase negative *staphylococcus*

The frequency of the HCAs in children is inversely correlated with age.<sup>[18]</sup> It was found in our study that approximately  $\frac{2}{3}$  of the HCAI cases were under twelve months. HCAI incidence in the pediatric intensive care unit (PICU) was high: long-term monitoring, invasive interventions, total parenteral nutrition, and the use of high-spectrum antibiotics are factors that increase the risk of infection among patients who are treated and monitored in pediatric clinics, especially in PICUs.<sup>[20]</sup> In our study, 28.9% of all HCAs were detected in the neonatal intensive care unit. In parallel with the findings of earlier studies, the frequency of nosocomial infections was highest in our study among PICU patients.<sup>[21]</sup>

In our study, the most frequently observed HCAs were bloodstream infections, urinary tract infections and pneumonia when *Salmonella* gastroenteritis in May and June is excluded.

HCAI microorganisms differ between the hospitals and in different units within the same hospital.<sup>[4,22]</sup> In our study, gram negative bacilli such as *Klebsiella* spp., *Salmonella* spp. and *E. coli* were detected as responsible in more than half of the HCAI cases. The results of our study are similar to those of studies conducted in following years in Turkey.<sup>[3,9,23,24]</sup> In our study, common HCAs-microorganisms were detected to have low susceptibility to aminoglycoside and third-generation cephalosporins. This situation was thought to be related to the frequent preference of these antibiotics in empirical treatment or to Extended-Spectrum Beta-Lactamases (ESLB) Producing *Escherichia coli* and *Klebsiella* spp. All of the microbiological agents were detected as highly susceptible to imipenem (100%). Since carbapenems (imipenem) were not widely used during the years of our study, it was thought that they were highly susceptible especially against ESLBs.

In our study, 12.2% of HCAs cases (n=311) died. All of these cases had risk factors that facilitated the development of infection (Age, male gender, congenital heart disease, Chronic Kidney Disease, malnutrition, prematurity). Kepenekli et al.<sup>[24]</sup> found that HCAs cause considerable morbidity and mortality in pediatric intensive care units (PIUCs). The research indicates that the mortality rate of HCAs in PICUs is 13%. Similar findings about mortality and morbidity were noted in our study.

The number of patients per nurse and nurse care are important in preventing HCAs.<sup>[25]</sup> Özçetin et al.<sup>[9]</sup> reported in their study that as the number of patients per nurse increased, the frequency of HCAI increased. In our hospital during daytime working hours there was 1 nurse per 6-7 patients and 1 nurse per 15-20 patients during nighttime working hours. The relationship between the number of patients per nurse and the state of HCAI development has not been evaluated.

It is not easy to determine the additional costs that HCAs bring to hospitals. Annually, approximately 2 million patients suffer with healthcare-associated infections (HCAs) in the USA, and nearly 90,000 are estimated to die. The overall direct cost of HCAs to hospitals ranges from US \$28 billion to 45 billion.<sup>[26]</sup> In our country, the studies conducted by Yalçın et

al.<sup>[27]</sup> had reported that the duration of hospital stay due to nosocomial infection increased by 20 days per patient and the cost per patient increased by 1582 dollars. Carbapenem antibiotics (imipenem) were generally used in our study due to low susceptibility to other antibiotics. In the one year period, the additional cost of the antibiotics alone was calculated as about 75000 USD.

## CONCLUSION

Healthcare-acquired infections (HCAs) are significant causes of mortality and morbidity, and may lead to prolonged hospitalization as well as increased costs throughout the world. The surveillance of HCAs may help in decreasing the incidence of infections and reducing costs.

## ETHICAL DECLARATIONS

**Ethics Committee Approval:** University of Health Sciences, Dr Sami Ulus Maternity and Children's Education and Research Hospital Evaluation Committee approval was obtained for this study (approval number: 73799008/ 17-01-2020)

**Informed Consent:** Because the study was designed retrospectively, no written informed consent form was obtained from patients.

**Referee Evaluation Process:** Externally peer-reviewed.

**Conflict of Interest Statement:** The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Financial Disclosure:** The authors declared that this study has received no financial support.

**Author Contributions:** All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

## REFERENCES

1. Boev C, Kiss E. Hospital-Acquired Infections: Current Trends and Prevention. Crit Care Nurs Clin North Am 2017;29(1):51-65.
2. The burden of health care-associated infection worldwide, World Health Organization Web site. Available at: [http://www.who.int/gpsc/country\\_work/burden\\_hcai/en](http://www.who.int/gpsc/country_work/burden_hcai/en). Accessed April 8, 2021.
3. Balaban I, Tanir G, Metin Timur O, et al. Nosocomial Infections in the General Pediatric Wards of a Hospital in Turkey. Jpn J Infect Dis 2012;65:318-21.
4. Raymond J, Aujard Y, and the European Study Group. Nosocomial infections in pediatric patients: a European, multicenter prospective study. Infect Control Hosp Epidemiol 2000;21:260-3.
5. Urrea M, Pons M, Serra M, Latorre C, Palomeque A. Prospective incidence study of nosocomial infections in a pediatric intensive care unit. Pediatr Infect Dis J 2003;22:490-3.
6. Grohskopf L, Sinkowitz-Cochran R, Garrett D et al. and the Pediatric Prevention Network. A national point-prevalence survey of pediatric intensive care unit-acquired infections in the United States. J Pediatr 2002;140:432-8.
7. Asembergiene J, Gurskis V, Kevalas R, Valinteliene R. Nosocomial infections in the pediatric intensive care units in Lithuania. Medicina (Kaunas) 2009;45(1):29-36.

8. Cavalcante SS, Mota E, Silva LR, Teixeira LF, Cavalcante LB. Risk factors for developing nosocomial infections among pediatric patients. *Pediatr Infect Dis J* 2006;25:438–45.
9. Özçetin M, Ulaş Saz E, Karapınar B, Özen S, Aydemir Ş, Vardar F. Hastane enfeksiyonları;sıklığı ve risk faktörleri. *Çocuk Enfeksiyon Derg* 2009;3:49-53.
10. Ulusal Hastane Enfeksiyonları Sürveyans Ağı (UHESA) Kasım 2016. Available at:www.tmc-online.org. Accessed April 21, 2021.
11. Horan TC, Andrus M, Dudeck MA. CDC/NHSN Surveillance definition of healthcare-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control* 2008;36(5):309-32.
12. Storr J, Twyman A, Zingg W et al. and WHO Guidelines Development Group. Core components for effective infection prevention and control programmes:new WHO evidence-based recommendations. *Antimicrob Resist Infect Control* 2017;6:6.
13. Revelas A. Healthcare - associated infections:A public health problem. *Niger Med J* 2012;53(2):59–64.
14. Suetens C, Latour K, Kärki T et al. Prevalence of healthcare-associated infections, estimated incidence and composite antimicrobial resistance index in acute care hospitals and long-term care facilities:results from two European point prevalence surveys, 2016 to 2017. *Euro Surveill* 2018;23(46):1800516.
15. Campins M, Vaque J, Rossello' J et al. and EPINE Working Group. Nosocomial infections in pediatric patients:A prevalence study in Spanish hospitals. *American Journal of Infection Control* 1993;21(3):58- 63.
16. Starling CF, Couto M, Pinheiro C. Applying the Centers for Disease control and Prevention and National Nosocomial Surveillance system methods in Brazilian hospitals. *Am J Infect Control* 1997;25:303-6.
17. Maraş H, Somer A, Sütçü M, Acar M, Salman N. Bir Üniversite Hastanesinde Pediyatrik Sağlık Bakımı ile İlişkili Enfeksiyon Sürveyansı:Altı Aylık Prospektif İzlem. *Çocuk Derg* 2015;15(2):65-73.
18. Gebremedhin D, Berhe H, Gebrekirstos K. Risk factors for neonatal sepsis in public hospitals of Mekelle City, North Ethiopia, 2015:unmatched case control study. *PLoS One* 2016;11:e0154798.
19. Klevens RM, Edwards JR, Richards CL et al. Estimating health care-associated infections and deaths. *Public Health Rep* 2007;122(2):160–6.
20. Dramowski A, Whitelaw A, Cotton MF. Burden, spectrum, and impact of healthcare-associated infection at a South African children's hospital. *J Hosp Infect* 2016;94(4):364-72.
21. Hacımustafoğlu M, Çelebi S, Tuncer E, Özkaya G, Çakır D, Bozdemir ŞE. Çocuk kliniği ve çocuk yoğun bakım ünitesi hastane enfeksiyonları sıklığı. *Çocuk Enfeksiyon Dergisi* 2009;3:112-7.
22. Abramczyk ML, Carvalho WB, Carvalho ES, Medeiros EAS. Nosocomial infection in a pediatric intensive care unit in a developing country *Braz J Infect Dis* 2003;7(6):375-80.
23. Bulut ME, Öncül A. Nosocomial Infection Agents of Şişli Hamidiye Etfal Training and Research Hospital:Comparison of 1995 and 2017 Data. *Sisli Etfal Hastan Tıp Bul* 2020;54(1):78-82.
24. Kepenekli E, Soysal A, Yalındag-Ozturk N et al. and Turkish PICU-HCAI Study Group. Healthcare-Associated Infections in Pediatric Intensive Care Units in Turkey:a National Point-Prevalence Survey. *Jpn J Infect Dis* 2015;68(5):381–6.
25. Shang J, Stone P, Larson E. Studies on Nurse staffing and Healthcare Associated Infection:Methodological Challenges and Potential Solutions. *Am J Infect Control* 2015;43(6):581–8.
26. Stone PW. Economic burden of healthcare-associated infections:An American perspective. *Expert Rev Pharmacoecon Outcomes Res* 2009;9(5):417-22.
27. Yalçın S, Akalın HA, Ünal S. Hacettepe Üniversitesi Hastane İnfeksiyonlarında Antibiyotik Tedavi İlkeleri. *Aktüel Tıp Derg* 1983;1:448.