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Short Communication

Nosocomial Infections in the General Pediatric Wards of a Hospital in Turkey

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SUMMARY: The aims of this study were to determine the prevalence, type, and clinical features of nosocomial infections (NIs), their etiological distribution, and the antibiotic resistance patterns of causative organisms in the general pediatric wards of a hospital in Turkey over a 3-year period. The Hospital Infection Control Committee NI surveillance reports were used as a database. NIs were detected in 171 (2.25%) of the 7,594 hospitalized patients. Some of these patients experienced more than 1 episode, and thus, the total NI episodes were 229. Patients' age varied from 1 to 144 months (mean ± standard deviation, 14.5 ± 23.6 months). The NI rate was 3.02%, and the NI density was 3.17/1,000 patient days. The most frequent NIs were lower respiratory system infections, blood stream infections, and urinary tract infections. Gram-negative organisms were the most frequently isolated agents. Of the 171 patients with NIs, 47 (27.5%) died.

Nosocomial infections (NIs) are the major causes of prolonged hospital stays, increased costs, the increased resistance of organisms to antimicrobials, and mortality in hospitalized adults and children. NIs in pediatric and adult patients differ with respect to the sites of infection and the types of pathogens. In addition, NIs differ by country, region, hospital, and type of units, such as wards or intensive care units (1). There exist many reports on epidemiology, risk factors, and preventive measures for adult NIs. However, studies that focus on the pediatric population, particularly in developing countries, are limited. For this reason, we investigated the epidemiological, microbiological, and clinical features of NIs in the general wards of a pediatric hospital that does not have a pediatric intensive care unit (PICU) facility.

Immunocompetent patients who were aged from 1 month to 18 years and had been admitted for miscellaneous diseases and developed a NI between January 2005 and January 2008 in a hospital in Turkey were retrospectively evaluated. The patients who had positive bacterial culture results or had negative culture results but clinical features of infection were included. A positive blood culture that was taken at least 72 h after the preceding positive blood culture was assessed as a new NI episode. The Hospital Infection Control Committee (HICC) NI surveillance reports were used as the database. NIs were defined on the basis of the Centers for Disease Control and Prevention (CDC) criteria (2). Crude NI rates were calculated with the following formula: NI rate = (infection number/admitted or discharged patient number) × 100, and NI density was caluculated with the following formula: density = (infection number/patient day) × 1,000 for each year and ward. The ventilator-associated pneumonia (VAP) rate was calculated with the following formula: VAP rate = (VAP number/mechanical ventilator day) × 1,000. The NIs of each patient were classified according to the infection sites. Standard methods were used for microbiologic, biochemical, and radiologic investigations. Antibiotic susceptibility tests were performed according to the Clinical Laboratory Standards Institute (CLSI) recommendations.

The Statistical Package for the Social Sciences (SPSS) for Windows version 11.5 was used for the statistical analysis. The descriptive statistics of intermittent and continuous numerable variables were expressed as mean ± standard deviation or median (minimum–maximum), and classifiable variables were expressed as the number of cases and percents. The test for the significance of differences between 2% was used to evaluate whether there was a statistically significant difference in the NI rates among the years.

In the 3-year period, 7,594 patients were hospitalized in the general pediatric wards. NIs were detected in 171 (2.25%) of the patients. Fifty-eight (34%) of these patients experienced more than 1 episode, and thus, the total number of NI episodes was 229. The mean age of the patients was 14.5 ± 23.6 months (1–144 months), and 88% of the patients were younger than 2 years of age. Ninety-nine of the patients were male, and 72 were female. The diagnoses upon admission were infectious diseases, which were most commonly community-acquired pneumonia and sepsis and which occurred in 106 (61.9%) of the patients. The comorbid diseases were malnutrition (55, 24%), congenital heart diseases (44, 19.2%), chronic lung diseases (4, 1.7%), neuromuscular

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Table 1. Crude nosocomial infection (NI) rates and NI densities by year

Year	No. of admitted patients	Total hospital day	No. of NI episodes	Crude NI rate (%)	NI density (/1,000 patient days)
2005	2,575	26,125	97	3.77	3.71
2006	2,468	23,839	94	3.81	3.94
2007	2,551	22,362	38	1.49	1.70
Total	7,594	72,326	229	3.02	3.17

disease (53, 23%), genetic syndrome (24, 10.5%), and metabolic disease (8, 3.5%). The durations of hospital stays were 2–197 days (34.43 ± 29 days). The overall NI rate was 3.02%, and the density was 3.17/1,000 patient days. There was no statistically significant difference in the NI rates between the years of 2005 and 2006 ($P = 0.938$), whereas a statistically significant decrease was seen in the NI rates in 2007 ($P < 0.001$ and $P < 0.001$) compared to those in 2005 and 2006, respectively. This may have been related to educational activities of the HICC, the development of isolation conditions, and adherence to prevention strategies, especially hand washing. The crude NI rates and NI densities by year are shown in Table 1.

The NI diagnosis was established by clinical features in 135 patients whose cultures were negative or not available. Most of them had clinical sepsis (27, 20%), nosocomial pneumonia (NP) (67, 49.6%), or VAP (29, 21.5%). The most frequent NIs were lower respiratory system infections (LRTIs) (116, 50.6%), bloodstream infections (BSIs) (51, 22.3%), and urinary tract infections (UTIs) (46, 20.1%). LRTIs consisted of NP (73, 63%) and VAP (43, 37%). The VAP rate was calculated as 35.5/1,000 ventilator days. BSI included clinical sepsis (27, 53%) and laboratory-confirmed BSI (24, 47%). Thirty-nine (84.8%) of the UTI patients had symptomatic UTI, and 7 (15.2%) patients had asymptomatic bacteriuria.

During the study period, 56 (32.7%) of the patients were mechanically ventilated, and there were 43/229 (18.8%) VAP episodes. A urinary catheter was used in 12 (7%) patients. Among the 46 UTI episodes, only 2 were related to urinary catheters. A central venous catheter was implemented in 8 (4.7%) patients. Three episodes of BSIs were associated with central venous catheters.

Various organisms were isolated in 94 (41%) of the cultures in the 229 NI episodes. Gram-negative organisms were more frequently isolated (79.8%) than Gram-positive organisms (20.2%). The most frequently isolated organisms were *Klebsiella* spp. (27, 28.7%), *Pseudomonas aeruginosa* (18, 19.1%), *Escherichia coli* (15, 15.9%), and coagulase-negative staphylococcus (CoNS) (9, 9.6%). For the BSIs, the most frequent organisms were *Klebsiella pneunomiae* and CoNS; for LRTIs, they were *P. aeruginosa*; and for UTIs, they were *Klebsiella* spp. Extended-spectrum β-lactamase (ESBL) production of *E. coli* and *Klebsiella* spp. occurred in 11 (73.4%) and 18 (66.6%), respectively. Inducible β-lactamase production was 100% with *Enterobacter cloacae* and 11.1% in *P. aeruginosa*. The distribution of detected organisms and antibiotic resistance patterns according to the infection site are demonstrated in Table 2.

Forty-seven of the 171 patients (27.5%) died. The median age of these patients was 9.2 months. LRTI episodes were most common in these patients (69.3%), and mechanical ventilation was applied in 72.3% of them. The most frequent NI was VAP (38.7% of all episodes that developed in these patients) and the most frequently isolated organism was *P. aeruginosa* (41.6%).

The NIs and the distribution of pathogens vary according to the patient characteristics (age, primary diagnosis, comorbidities, and procedures done), the healthcare setting (intensive care, ward, or surgical care), facility of infection control measures, and healthcare system (hospital, region, or country) (1). Surveillance is an essential element of programs for controlling hospital infections. The National NI Surveillance System has existed in Turkey since 2005. This study included the years 2005, 2006, and 2007, which were early in the systemic efforts of surveillance and control of NI in our hospital and country. Since then, NI rates have significantly decreased, especially in 2007.

We found that the NI rate was 3.02%, and the incidence density was 3.17/1,000 patient days. The NI rates range from 1% in Northern Europe to >40% in some parts of Asia, South America, and Africa (1). The higher rates are possibly related to the presence of risk factors and the absence of a PICU facility. It has been reported that the incidence of NIs was significantly higher in PICUs than in general wards in Western countries (3–5). In developing countries, NI rates of PICUs were reported as much higher (6–8). The distribution of infections by sites may vary with respect to various factors, such as age, properties of hospitals, the prevalence of invasive procedures, risk factors, and associated diseases of patients (3–5,8). LRTIs were the most common infection in our study, which was followed by BSIs and UTIs. We thought that this was related to a higher rate of mechanical ventilator utilization, but a lower rate of vascular and urinary catheter utilization. The VAP frequency was 35.5 cases per 1,000 ventilator days in our study. The incidence rate of VAP that was found in our study was higher than that of other studies (4,9–13). This was thought to be a result of the treatment of critically ill patients with mechanical ventilators in general pediatric wards without a sufficient number of medical staff and isolation conditions because of the absence of a PICU in the hospital. Additionally, nearly one-third of our patients with LRTIs had neuromuscular disease as a component of various genetic syndromes. A comparison of intubated patients with and without VAP demonstrated that there was an association between VAP and underlying illness, particularly genetic syndrome (13).

Gram-negative organisms were the most common pathogens in our study. The Gram-negative bacilli vary in the frequencies that they cause the 4 most common NIs: LRTI, surgical site infection (SSI), UTI, and BSI, in both adults and children. Data from the United States revealed that the percentage of SSIs that was associated with Gram-negative bacilli decreased significantly over the years, while the percentages of LRTIs and UTIs remained constant (14,15). CoNS is the organism that most frequently causes BSIs in most studies and is responsible for over 80% of catheter-related BSIs

Table 2. Distribution of detected organisms and resistance patterns to the infection site

	Total	BSI		LRTI		UTI		GE	Meningitis	CESI	Peritonitis	SSISI
		LCBSI	Clinical sepsis	NP	VAP	SUTI	ASB					
Nosocomial episodes	229	24	27	73	43	39	7	9	2	2	2	1
Positive culture results	94	24	0	6	14	38	7	0	2	0	2	1
Gram-negative pathogens	75 (79.8)											
E. coli												
ESBL −	4 (4.2)					3 (7.9)	1 (14.3)					
ESBL +	11 (11.7)					7 (18.4)	4 (57.1)					
K. pneumoniae												
ESBL −	6 (6.4)	2 (8.3)			1 (7.1)	3 (7.9)						
ESBL +	16 (17)	4 (16.7)				12 (31.6)						
K. oxytoca												
ESBL −	3 (3.2)	2 (8.3)										1 (100)
ESBL +	2 (2.1)					1 (2.6)	1 (14.3)					
P. aeruginosa												
IBL −	16 (17)	2 (8.3)		1 (16.7)	9 (64.3)	3 (7.9)					1 (50)	
IBL +	2 (2.1)				2 (14.2)							
Other pathogens	15 (15.9)	8 (33.3)			1 (7.1)	3 (7.9)	1 (14.3)		1 (50)		1 (50)	
Gram-positive pathogens	19 (20.2)											
CoNS	9 (9.6)	4 (16.7)		4 (66.6)	1 (7.1)							
S. aureus												
MSSA												
MRSA	2 (2.1)					1 (2.6)			1 (50)			
Enterococcus spp.	6 (6.4)	1 (4.2)				5 (13.2)						
S. viridans	2 (2.1)	1 (4.2)		1 (16.7)								

ESBL, extended-spectrum β-lactamase; IBL, inducible β-lactamase; CoNS, coagulase-negative staphylococcus; MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *S. aureus*; BSI, blood stream infection; LRTI, lower respiratory system infection; UTI, urinary tract infection; LCBSI, laboratory-confirmed blood stream infection; NP, nosocomial pneumonia; VAP, ventilator-associated pneumonia; SUTI: symptomatic urinary tract infection; ASB, asymptomatic bacteriuria; GE, gastroenteritis; CESI, catheter exit site infection; SSISI, superficial surgical incisional site infection.

(3,4,16–19). In our study, *K. pneumoniae* was more frequently isolated in BSIs than CoNS. This difference may be the result of a low rate of use of central line catheter in our hospital. The ESBL-producing *K. pneumoniae* rate was high in our study. Increasing ESBL production is an important problem in *K. pneumoniae* infections (3,20). Mechanical ventilation and hospitalization for more than 14 days have been reported to be the strongest independent predictors of ESBL-positive *K. pneumoniae* colonization in pediatric patients (21,22). In our study, *P. aeruginosa* was found to be the most common pathogen in patients with LRTIs, especially VAP; this was similar to the findings of other studies from Europe and the United States (3,13,23). *E. coli* is an important nosocomial pathogen that primarily causes UTIs. In our study, *E. coli* was the responsible organism in one-third of nosocomial UTIs, and the ESBL-production rate was high. The antibiotic resistance of *E. coli* is also an increasing problem (20,22).

Clinical sepsis and NP are well-known diagnoses that are not based on microbiological tests but are based on CDC criteria (2). The cultures of some VAP patients in our study were not confirmed. It was reported in a systematic review of literature from 1947 to 2010 that the diagnosis of VAP is problematic because the clinical, radiologic, and microbiologic criteria lack sensitivity and specificity relative to autopsy/histopathology and culture. The authors recommended that a more rigorous approach to diagnosis be conducted by using the CDC algorithm (24).

We found a high mortality rate (27.5%) with NIs. It has been reported from different studies that lower age, malnutrition, underlying diseases, *P. aeruginosa* infections, and VAP are related to the higher mortality rates of NIs (3,7,25–28). The presence of various risk factors in our study group, the predominance of VAP, and antibiotic-resistant Gram-negative pathogens, especially *P. aeruginosa*, as etiological agents were related to the high mortality rate.

In conclusion, in this study, we investigated the surveillance data of a tertiary care children's hospital that did not have a PICU facility. Surveillance of NIs plays a key role in infection control in hospitals because it discloses characteristics of healthcare units and patients, risk factors, and the responsible organisms for NI and serves as a guide for measures to reduce NI rates.

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Conflict of interest None to declare.

REFERENCES

1. McFee, R.B. (2009): Nosocomial or hospital-acquired infections: an overview. Dis. Mon., 55, 422–438.
2. Garner, J.S., Jarvis, W.R., Emori, T.G., et al. (1996): CDC Definitions of Nosocomial Infections. *In* Olmsted, R.N. (ed.), APIC Infection Control and Applied Epidemiology: Principles and Practice. Mosby, St. Louis. A1-A20.
3. Raymond, J. and Aujard, Y. (2000): Nosocomial infections in pediatric patients: a European, multicenter prospective study. Infect. Control Hosp. Epidemiol., 21, 260–263.
4. Richards, M.J., Edwards, J.R., Culver, D.H., et al. (1999): Nosocomial infections in pediatric intensive care units in the United States. National Nosocomial Infections Surveillance System. Pediatrics, 103, e39.
5. Singh-Naz, N., Sprague, B.M., Patel, K.M., et al. (1996): Risk factors for nosocomial infection in critically ill children: a prospective cohort study. Crit. Care Med., 24, 875–878.
6. Cavalcante, S.S., Mota, E., Silva, L.R., et al. (2006): Risk factors for developing nosocomial infections among pediatric patients. Pediatr. Infect. Dis. J., 25, 438–445.
7. Abramczyk, M.L., Carvalho, W.B., Carvalho, E.S., et al. (2003): Nosocomial infection in a pediatric intensive care unit in a developing country. Braz. J. Infect. Dis., 7, 375–380.
8. Asembergiene, J., Gurskis, V., Kevalas, R., et al. (2009): Nosocomial infections in the pediatric intensive care units in Lithuania. Medicina (Kaunas), 45, 29–36.
9. Myrianthefs, P.M., Kalafati, M., Samara, I., et al. (2004): Nosocomial pneumonia. Crit. Care Nurs. Q., 27, 241–257.
10. George, D.L., Falk, P.S., Wunderlink, R.G., et al. (1998): Epidemiology of ventilator-acquired pneumonia based on protected bronkoskopic sampling. Am. J. Respir. Crit. Care Med., 158, 1839–1847.
11. Rosenthal, V.D., Maki, D.G., Salomao, R., et al. (2006): International Nosocomial Infection Control Consortium. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. Ann. Intern. Med., 145, 582–591.
12. National Nosocomial Infections Surveillance System Report (2004): Data summary from January 1992 through June 2004, issued October 2004. Am. J. Infect. Control, 32, 470–485.
13. Elward, A.M., Warren, D.K. and Fraser, V.J. (2002): Ventilator-associated pneumonia in pediatric intensive care unit patients: risk factors and outcomes. Pediatrics, 109, 758–764.
14. Gaynes, R. and Edwards, J.R. (2005): Overview of nosocomial infections caused by gram negative bacilli. Clin. Infect. Dis., 41, 848–854
15. Woods, C.R. and Bryant, K.A. (2008): Healthcare acquired infections due to gram negative bacteria. Pediatr. Infect. Dis. J., 27, 453–454.
16. Suljagic, V., Cobeljic, M., Jankovic, S., et al. (2005): Nosocomial bloodstream infections in ICU and non-ICU patients. Am. J. Infect. Control, 33, 333–340.
17. Yogaraj, J.S., Elward, A.M. and Fraser, V.J. (2002): Rate, risk factors, and outcomes of nosocomial primary bloodstream infection in pediatric intensive care unit patients. Pediatrics, 110, 481–485.
18. Urrea, M., Pons, M., Serra, M., et al. (2003): Prospective incidence study of nosocomial infections in a pediatric intensive care unit. Pediatr. Infect. Dis. J., 22, 490–494.
19. Bryant, K.A. and Woods, C.R. (2008): Healthcare-acquired infections due to Gram-positive bacteria. Pediatr. Infect. Dis. J., 27, 455–456.
20. Blaschke, A.J., Korgenski E.K., Daly, J.A., et al. (2009): Extended-spectrum beta-lactamase producing pathogens in a children's hospital: a 5-year experience. Am. J. Infect. Control, 37, 435–441.
21. Demir, S., Soysal, A., Bakir, M., et al. (2008): Extended-spectrum beta-lactamase-producing *Klebsiella pneumoniae* in paediatric wards: a nested case-control study. J. Paediatr. Child Health, 44, 548–553.
22. Gür, D., Gülay, Z., Akan, O.A., et al. (2008): Resistance to newer beta-lactams and related ESBL types in gram-negative nosocomial isolates in Turkish hospitals: results of the multicentre HITIT study. Mikrobiyol. Bul., 42, 537–544.
23. National Nosocomial Infections Surveillance System Report (1999): Data summary from January 1990–May 1999, issued June 1999. Am. J. Infect. Control, 27, 520–532.
24. Venkatachalam, V., Hendley, J.O. and Willson, D.F. (2011): The diagnostic dilemma of ventilator-associated pneumonia in critically ill children. Pediatr. Crit. Care Med., 12, 286–296.
25. Januel, J.M., Harbarth, S., Allard, R., et al. (2010): Estimating attributible mortality due to nosocomial infections acquired in intensive care units. Infect. Control Hosp. Epidemiol., 31, 388–394.
26. Heyland, D.K., Cook, D.J., Griffith, L., et al. (1999): For the Canadian Critical Care Trial Group. The attributable morbidity and mortality of ventilator-associated pneumonia in the critically ill patient. Am. J. Respir. Crit. Care Med, 159, 1249–1256.
27. Parkins, M.D., Gregson, D.B., Pitout, J.D.D., et al. (2010): Population-based study of the epidemiology and the risk factors for *Pseudomonas aeruginosa* bloodstream infection. Infection, 38, 25–32.
28. Iversen, B.G., Brantsaeter, A.B. and Aavitsland, P. (2008): Nationwide study of invasive *Pseudomonas aeruginosa* infection in Norway: importance of underlying disease. J. Infect., 57, 139–146.