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Original Article

Four years of surveillance data on healthcare-associated infections in high-risk newborns

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ABSTRACT

Objective: Healthcare-associated infections (HAIs) are a major issue in neonatal intensive care units (NICUs). The characteristics of HAIs and the distribution of pathogens might also vary. HAI surveillance is important for infection control to determine HAI rates and pathogen characteristics. The purpose of this study was to assess the rates of HAIs, distribution of HAI types, characteristics of the pathogens, and antibiotic susceptibility in the first four years of a newly opened NICU.

Method: In the NICU of Marmara University Pendik Training and Research Hospital, the infection control team identified HAIs and recorded the National Hospital Infection Surveillance Network in accordance with the standards of the Centers for Disease Control and Prevention throughout the period of four years after the unit's opening. All patients in the first four years of the NICU were included in the study. The capacity of the NICU is 16 incubators and the average nurse/neonate ratio was 1/3 in this period.

Results: During the 4-year study period, 1301 patients were hospitalized in the NICU and 378 HAIs were detected. The overall HAI rate was 29.1% and the density was 21.8 per 1000 patient days. Neonatal groups with birth weights of 750 grams and 751–1000 grams had the highest rates and incidence density of HAIs. The most common HAI pathogens were *Klebsiella* spp. (27.8%), *Staphylococcus* spp. (26.2%), *Acinetobacter baumannii* (5.8%), and *Escherichia coli* (5.8%).

Conclusion: The risk of HAIs was found to be higher in neonates with a birth weight <1000 grams. In places where HAI rates are high such as NICUs, analyzing the characteristics of HAIs with active surveillance data is an essential component of infection control. This could enhance patient care and increase the survival of preterm infants with low birth weight.

Keywords: Healthcare-associated infections, neonate, surveillance, Türkiye

INTRODUCTION

Healthcare-associated infections (HAIs) are common in neonatal intensive care units (NICUs), but the patterns of infection and distribution of pathogens may vary. Neonates are especially vulnerable to HAIs due to the immature host immune defense, invasive devices that penetrate skin and mucosal surfaces, frequent use of antibiotics that disrupt the microbiome, and the necessity for prolonged hospitalization.[1] HAIs are one of the major causes of mortality and morbidity in newborns with a birth

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weight of less than 1500 grams in neonatal intensive care units (NICUs). The incidence of HAIs in NICUs is higher than in other hospital wards and it has been reported to increase up to 30% in preterm infants.[2,3] Moreover, HAIs are also associated with high mortality, increased length of stay, high healthcare costs, and adverse neurodevelopmental outcomes.[2,3] Monitoring HAI rates is considered crucial to the quality of care in the NICU. The infection rate can be reduced through effective infection control measures. The routine and orderly data collection based on defined case criteria is known as surveillance. It provides information for important precautions of infection control.[4] The necessity of active HAI surveillance has been stressed in recent years to increase patient safety, particularly for critically ill patients in intensive care units.

The purpose of this study was to assess the rates of HAIs, distribution of HAI types, characteristics of the pathogens, and antibiotic susceptibility in the first four years of a newly opened NICU.

MATERIALS AND METHODS

The retrospective surveillance study was conducted in the NICU at Marmara University Hospital for four years following its opening. The Level III severely ill newborns, extremely low birth weight premature infants, neonates requiring pre- or postoperative management, and newborns with congenital anomalies requiring multidisciplinary follow-up are all treated in the NICU, which has 16 incubators and a 100% occupancy rate. During the study period, the average nurse-to-baby ratio was one-third. The nurse in charge of infection control performed active surveillance information of HAIs. Laboratory and medical records-based HAI surveillance was conducted prospectively from 1 January 2011 to 31 November 2014.

UHESA, the National Hospital Infections Surveillance Network, was established in 2008.[5] HAI-related information was collected prospectively according to the standard protocols of the UHESA. HAIs were defined using the criteria of the Centers for Disease Control and Prevention (CDC-2008) for children <1 year of age.[6] HAI was described as an infection that occurred 48 hours after admission or ten days after hospital discharge. HAIs were analyzed according to the birth weight of the neonates. Cerebrospinal fluid (CSF), urine, sputum, endotracheal aspirate, or wound specimens were collected based on symptoms. The Clinical and Laboratory Standards Institute (CLSI) criteria's breakpoints of resistance were utilized for the evaluation of the susceptibility results.[7]

The following formulas were used to calculate healthcare-associated infection rates[8]:

HAI rate: Number of healthcare-associated infections/number of hospitalized patients) ×100

HAI incidence density: Number of healthcare-associated infections/patient days) ×1000

The extra length of stay was the difference between the length of stay of patients with HAIs and the length of stay of patients hospitalized in the NICU during that period who did not acquire a device-associated (DA)-HAI.[9, 10] All information was recorded by a certified infection control nurse after clinical findings and culture results were discussed with the consultant neonatologist and pediatric infectious disease specialist. The Marmara University Clinical Research Ethics Committee approved the study (Date: 09.08.2023, No: 09.2023-1107).

RESULTS

The total number of inpatients during the study period was 1301, while 6401 live births and 378 HAIs were identified. Based on the surveillance data, the annual HAI rates for 2011-2014 were 23.7%, 36.2%, 24.9%, and 29.6%, respectively. The incidence density for HAIs was 21.8 per 1000 patient days, and the overall HAI rate was 29.1 per 100 admissions (Table 1). The incidence density and infection rate of neonatal HAIs were highest in the < 750 g group and the 751-1000 g group by birth weight. The distribution of the neonates with HAI based on birth weight is shown in Table 2.

Regardless of the surveillance year, bloodstream infections (BSIs), pneumonia (24.4%), and urinary tract infections (UTIs) (12.7%) were the three most common HAI types. In the first three years, BSI was the most prevalent type of HAI. In 2014, pneumonia was the most prevalent HAI type, while it was the second most common HAI type in 2012 and 2013. The distribution of the HAI types for each year is shown in Table 3. A total of 39 DA-HAIs were detected in the first three years. The overall rate of DA-HAIs was calculated to be 3.6 per 1000 ICU days and 5.3 per 1000 device days. The total number of urinary catheter, ventilator, and central line days was 405, 2407, and 4509, respectively. The average rates of ventilator-associated pneumonia (VAP), catheter-associated urinary tract infection (CAUTI), and central line-associated bloodstream infection (CLABSI) were 13.7, 7.4, and 0.6 per 1000 device days, respectively.

Table 1. The HAIs characteristics by year

	2011	2012	2013	2014	Total
Number of HAIs	68	151	97	62	378
Number of patients	286	417	389	209	1301
Total patient days	2763	5131	5489	3985	17368
Rate of HAIs(%)	23.7	36.2	24.9	29.6	29.1
Incidence Density (per 1000 patient-days)	24.6	29.4	17.7	15.6	21.8

Table 2. The HAIs characteristics by birth weight

	Number of HAIs	Number of patients	Total patient days	Rate of HAIs (%)	Incidence Density (per 1000 patient-days)
<750 g	65	46	2069	141.3	31.4
751-1000 g	56	38	2370	147.3	23.6
1001-1500 g	79	97	3414	81.4	23.1
1501-2500 g	83	273	3796	30.4	21.9
>2500 g	95	847	5719	11.2	16.6
Total	378	1301	17368	29,1	21.8

Table 3. The distribution of HAIs types

Types of HAIs	Years				
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	Total n (%)
BSI*	24 (35.3)	48 (31.8)	43 (44.3)	10 (16.2)	125 (33.1)
Pneumonia	12 (17.6)	40 (26.5)	15 (15.5)	25 (40.3)	92 (24.4)
UTI†	14 (20.6)	13 (8.6)	8 (8.2)	13 (21)	48 (12.7)
GISI‡	5 (7.4)	14 (9.3)	7 (7.2)	1 (1.6)	27 (7.2)
SSTI§	5 (7.4)	11 (7.3)	4 (4.1)	2 (3.2)	22 (5.8)
CNSI||	1 (1.4)	7 (4.6)	4 (4.1)	4 (6.4)	16 (4.2)
SSI¶	0 (0)	0 (0)	1 (1)	0 (0)	1 (0.2)
CVSI**	0 (0)	0 (0)	1 (1)	0 (0)	1 (0.2)
OI††	7 (10.3)	18 (11.9)	14 (14.4)	7 (11.3)	46 (12.2)
Total	68 (100)	151 (100)	97 (100)	62 (100)	378 (100)

*BSI: Bloodstream infection, †UTI: Urinary tract infection, ‡GISI: Gastrointestinal system infection, §SSTI: Skin and soft tissue infections, ||CNSI: Central nervous system infections, ¶SSI: surgical site infection, **CVSI: Cardiovascular system infection, ††OI: Other infection.

One hundred seventy-two pathogens were isolated from 378 HAIs. *Klebsiella spp.* accounted for 27.8% of all strains and were the most common cause of HAIs, followed by *Staphylococci* (26.2%), *Acinetobacter baumannii* (5.8%), and *Escherichia coli* (5.8%) (Table 4). When we analyzed the antibiotic susceptibility of isolated pathogens we found that the methicillin resistance rates were 29.4% and 25% for *Coagulase-negative staphylococci* and *Staphylococcus aureus*, respectively. Thirty-two (66.6%) isolates of *Klebsiella* spp. and six (60%) *Escherichia coli* strains produced ESBL. Ampicillin and vancomycin resistance were calculated at 37.5% and 37.5% of *enterococci,* respectively. Carbapenem resistance rates were 70% and 62.5% for *Acinetobacter baumannii* and *Pseudomonas aeruginosa* strains, respectively (Table 5).

Table 4. The distribution of pathogens

Pathogens of HAIs	Years				
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	Total n (%)
Klebsiella spp.	6 (23.1)	17 (28.3)	7 (17.1)	18 (40)	48 (27.8)
Klebsiella pneumoniae	5 (19.3)	15 (25)	6 (14.7)	18 (40)	44 (25.6)
Klebsiella oxitoca	0 (0)	2 (3.3)	1 (2.4)	0 (0)	3 (1.6)
Other Klebsiella spp.	1 (3.8)	0 (0)	0 (0)	0 (0)	1 (0.6)
Staphylococcus spp.	10 (38.5)	12 (20)	11 (26.8)	12 (26.7)	45 (26.2)
CoNS	9 (34.7)	12 (20)	9 (22)	11 (24.5)	41 (23.9)
S. aureus	1 (3.8)	0 (0)	2 (4.8)	1 (2.2)	4 (2.3)
Acinetobacter baumannii	1 (3.8)	2 (3.3)	5 (12.2)	2 (4.4)	10 (5.8)
Escherichia coli	2 (7.7)	6 (10)	0 (0)	2 (4.4)	10 (5.8)
Pseudomonas aeruginosa	0 (0)	1 (1.7)	4 (9.8)	3 (6.7	8 (4.7)
Enterococcus spp.	1 (3.8)	3 (5)	1 (2.4)	3 (6.7)	8 (4.7)
Enterococcus faecium	1 (3.8)	1 (1.7)	0 (0)	0 (0)	2 (1.2)
Enterococcus feacalis	0 (0)	2 (3.3)	1 (2.4)	3 (6.7)	6 (3.5)
Other Enterococcus spp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Others	6 (23.1)	19 (31.7)	13(31.7)	5 (11.1)	43 (25)
Total	26 (100)	60 (100)	41 (100)	45 (100)	172(100)

Table 5. The distribution of the antibiotic susceptibility patterns

Pathogens of HAIs	Years				
	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	Total n (%)
Klebsiella spp.	6 (12.5)	17 (35.4)	7 (14.6)	18 (37.5)	48 (100)
Presence of an ESBL†	4 (8.3)	11 (22.9)	5 (10.4)	12 (25)	32 (66.6)
Absence of an ESBL	2 (4.2)	6 (12.5)	2 (4.2)	6 (12.5)	16 (33.4)
*CoNS**	9 (22)	12 (29.2)	9 (22)	11 (26.8)	41 (100)
Methicillin sensitive	4 (9.7)	11 (26.8)	8 (19.5)	6 (14.6)	29 (70.6)
Methicillin resistance	5 (12.2)	1 (2.5)	1 (2.5)	5 (12.2)	12 (29.4)
Staphylococcus aureus	1 (25)	0 (0)	2 (50)	1 (25)	4 (100)
Methicillin sensitive	1 (25)	0 (0)	1 (25)	1 (25)	3 (75)
Methicillin resistance	0 (0)	0 (0)	1 (25)	0 (0)	1 (25)
Acinetobacter baumanii	1 (10)	2 (20)	5 (50)	2 (20)	10 (100)
Carbapenem resistance	0 (0)	2 (20)	4 (40)	1 (10)	7 (70)
Escherichia coli	2 (20)	6 (60)	0 (0)	2 (20)	10 (100)
Presence of an ESBL	2 (20)	3 (30)	0 (0)	1 (10)	6 (60)
Absence of an ESBL	0 (0)	3 (30)	0 (0)	1 (10)	4 (40)
Pseudomonas aeruginosa	1 (12.5)	1 (12.5)	4 (50)	2 (25)	8 (100)
Carbapenem resistance	0 (0)	0 (0)	3 (75)	2 (100)	5 (62.5)
Enterococcus spp.	1 (12.5)	3 (37.5)	1 (12.5)	3 (37.5)	8 (100)
Ampiciline resistance	1 (100)	1 (33.3)	0 (0)	1 (33.3)	3 (37.5)
Vancomycin resistance	1 (100)	1 (33.3)	0 (0)	1 (33.3)	3 (37.5)

*CoNS: Coagulase negative staphylococcus, †ESBL: Extended-spectrum beta-lactamases

DISCUSSION

HAIs continue to have a significant negative impact on healthcare costs, prolonged hospital stays, increased antibiotic use, and cause morbidity and mortality. HAIs are a global public health issue, especially in developing countries.[11,12] HAIs have been reported to occur more frequently in developing countries than in developed countries.[12]

Most of the current HAI literature focuses on adults, and data on NICU-acquired HAIs are limited, especially in developing countries. Although Turkey's national HAI surveillance system has been in effect since 2008, there is a scarcity of published data on infection rates, types of HAI, pathogen distribution, and antibiotic susceptibility rates.[5] We believe that clinicians can find current data, messages, and suggestions about HAIs and HAI control in this study. The other important aspect of this study is that it was conducted in a newly opened NICU. To our knowledge, there is limited data on a newly opened NICU.

The incidence of HAIs in the NICU has been reported to range between 9-50.7%.[3,13-18] The rates of HAIs reported in the literature show a wide range, which may be due to differences in study methods or surveillance, and the conditions of the country. In Türkiye, the National Hospital Infections Surveillance Network (UHESA), was established in 2008.[5] Since its establishment in the 1970s, the National Nosocomial Infections Surveillance System (NNIS) in the USA has helped to reduce the incidence of HAIs by 30–40%.[19,20] In Germany, the incidence of ventilator-associated pneumonia decreased by 24% over three years when the Krankenhaus Infektions Surveillance System (KISS) was implemented.[21] In Europe, surveillance systems for HAIs in NICUs are active in Germany (Germany's Neonatal-Krankenhaus Infektions Surveillance System, NEO-KISS) and England.[22–24] Therefore, HAI surveillance studies, ideally prospective active surveillance, are important for effective infection control. Active surveillance studies can help characterize the epidemiology of HAIs.

In all NICUs, infection prevention must be a major concern. Clinical practices and the patient care environment must be closely monitored to reduce the risk of HAIs.[25] Although the NICU was recently opened, HAI characteristics have varied over the years. The HAI rate was at its lowest in the first year and at its highest in the second year. Although the average HAI rate in Türkiye was higher than the rates in certain industrialized countries, such as the United States, Italy, and China, it was still lower than previous reports from several developing countries, such as Brazil and Indonesia.[13,16,18,26,27] The overall HAI rate was reported to be 23.5%, according to a national point-prevalence survey study conducted in 38 NICUs in Türkiye.[28] The HAI rate in neonatal care has been reported to be between 8.3-23.5 % in Türkiye.[28-32]

The incidence density for HAIs in this series was 21.8 per 1000 patient days, and the overall HAI rate was 29.1%. Our rates were higher than the mean of the recently reported rates in Türkiye.[28-32] The high incidence of HAIs despite modern infrastructure, equipment, and facilities implies that healthcare staff have not followed infection control procedures. One of the reasons for the high rate of HAIs was low HH compliance Other reasons may include staff shortages, poor training, inadequate feedback, and delayed awareness. We looked into how well the medical staff in our neonatal and pediatric intensive care units adhered to HH. The main factor contributing to the high HAI rates was the low overall compliance with HH among physicians and nurses, which was found to be 31.9% and 41.4%, respectively.[33] Regarding HH compliance, we provided input to the NICU and PICU personnel as well as the hospital infection control committee. Training on HH was provided more often. Members of the infection control committee and NICU staff worked harder to reduce HAIs. HH compliance and active surveillance are the two key infection control strategies. To monitor and manage HAIs, we would like to reiterate the value of active surveillance and HH compliance. Therefore, we think that one factor contributing to the high HAI rates in Türkiye is the lack of knowledge about infection control preventive strategies.[34]

Low gestational age with extremely low birth weights (ELBW) infants (≤1000 g) are particularly at risk because they require more intensive care in neonatology units and undergo more invasive procedures.[1] Although all BW classes were affected by HAIs, ELBW neonates were particularly at risk of acquiring HAIs. We found that HAI rates in the <1000 gram groups were very high compared to the other groups by birth weight, which is consistent with the literature.[13-15]

In this study, BSI (33.1%), pneumonia (24.4%), and UTI (12.7%) were the most prevalent HAI types (Table 3). According to recent reports, BSI and pneumonia are the most common HAI types in the NICU.[13-18] Depending on the department, hospital population, and setting, the relative occurrence of different HAI types may vary.

In this study, 172 (45.5%) causative pathogens were isolated in 378 HAIs. The isolation rate for HAIs was reported to be 88% in the USA.[35] Our isolation rate was lower, possibly due to inadequate sampling and technical insufficiencies in the microbiology laboratories. The main pathogens that cause newborn infections vary not only from country to country and from nursery to nursery, but they also alter over the years in the same location.[36] *K. pneumoniae*, various gram-negative rods, and staphylococci are common infection agents in NICUs, and antimicrobial resistance is a significant issue in developing countries.[37,38] The most frequently isolated pathogen among all HAIs in this study was *Klebsiella spp.*. In the present study, over 60% of *Klebsiella spp.* and *E. coli* isolates were ESBL-positive, which is similar to the rates in 2008–2010 in the former hospital building.[12] An international, multicenter study including Türkiye showed that 78% of *K. pneumoniae* strains produce ESBLs.[39] Susceptibility patterns of *P. aeruginosa* and *A. baumannii* vary over time and in different hospital settings. The prevalence of *P. aeruginosa* and *A. baumannii* infections in NICUs is also rising as a result of the use of broad-spectrum antibiotics.[12] In this study, the overall carbapenem resistance rates were 70% and 62.5% among *A. baumannii* and *P. aeruginosa* isolates. All of the *A. baumannii* strains were susceptible to colistin. Previous national studies have demonstrated that the carbapenem susceptibility rates for *P. aeruginosa* were between 48% and 71%.[11,12,40,41]

We took into account the persistently high rates of resistance caused by inadequate adherence to infection control procedures and inappropriate and prolonged use of broad-spectrum antibiotics in critically ill newborns in the NICU. Active surveillance allows physicians to estimate antibiogram patterns, which may aid in the empirical use of antibiotics. Some pathogenic bacteria are resistant to commonly used antibiotics. They are frequently observed in hospitals and are associated with contaminated water supplies. They can colonize patient mucosa and the surfaces of numerous devices in NICUs. Regular monitoring of water and water-related devices in NICUs could aid infection control measures.

CONCLUSION

We reported a high prevalence of HAIs in a newly opened NICU. The high rates of HAIs with resistant bacteria identified in our study could be attributed to a number of factors, including lack of infrastructure, late adoption of HAI surveillance, lack of infrastructure, and lack of ability to implement HH. This manuscript underlines once again the need to use active surveillance data to analyze the characteristics of HAIs, which can improve the treatment of patients and increase the survival of preterm newborns in developing countries such as Türkiye.

Ethical approval

This study has been approved by the Marmara University Clinical Research Ethics Committee (approval date 09.08.2023, number 09.2023-1107). Written informed consent was obtained from the participants.

Author contribution

Surgical and Medical Practices: SA, AÇM, EK, YP, HSB, EÖ, AS; Concept: SA, AS; Design: SA, AÇM, AS; Data Collection or Processing: YP; Analysis or Interpretation: SA, AÇM, AS; Literature Search: SA, AÇM; Writing: SA, AÇM, AS. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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