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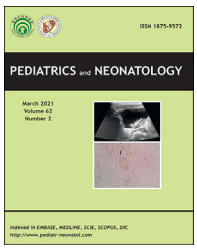

Original Article

The prevalence and diagnostic criteria of health-care associated infections in neonatal intensive care units in Turkey: A multicenter point- prevalence study

Tuğba Bedir Demirdağ [a,*], Esin Koç [b], Hasan Tezer [a], Suna Oğuz [c], Mehmet Satar [d], Özge Sağlam [e], Saime Sündüz Uygun [f], Esra Önal [b], İbrahim Murat Hirfanoğlu [b], Kadir Tekgündüz [g], Nihal Oygür [h], Ali Bülbül [i], Adil Umut Zübarioğlu [j], Nuran Üstün [k], Sezin Ünal [l], Canan Aygün [m], Belma Saygılı Karagöl [n], Ayşegül Zenciroğlu [o], M. Yekta Öncel [p], Adviye Çakıl Sağlık [q], Emel Okulu [r], Demet Terek [s], Nejat Narlı [t], Didem Aliefendioğlu [u], Tuğba Gürsoy [v], Sevim Ünal [w], Münevver Kaynak Türkmen [x], Fatma Kaya Narter [y], Nükhet Aladağ Çiftdemir [z], Serdar Beken [aa], Salih Çağrı Çakır [ab], Şule Yiğit [ac], Asuman Çoban [ad], Ayse Ecevit [ae], Yalçın Çelik [af], Ferit Kulalı [ag]

[a] *Gazi University, Faculty of Medicine, Department of Pediatric Infectious Diseases, Ankara, Turkey*
[b] *Gazi University, Faculty of Medicine, Department of Neonatology, Ankara, Turkey*
[c] *University of Health Sciences, Zekai Tahir Burak Women's Health Education and Research Hospital, Department of Neonatology, Ankara, Turkey*
[d] *Çukurova University, Faculty of Medicine, Department of Neonatology, Adana, Turkey*
[e] *University of Health Sciences, Kanuni Sultan Süleyman Training and Research Hospital, Department of Neonatology, Istanbul, Turkey*
[f] *Konya Selcuk University, Faculty of Medicine, Department of Neonatology, Konya, Turkey*
[g] *Atatürk University, Faculty of Medicine, Department of Neonatology, Erzurum, Turkey*
[h] *Akdeniz University, Faculty of Medicine, Department of Neonatology, Antalya, Turkey*
[i] *University of Health Sciences, Sisli Etfal Training and Research Hospital, Department of Neonatology, Istanbul, Turkey*
[j] *Yeni Yüzyıl University Faculty of Medicine, Department of Neonatology, Istanbul, Turkey*

* Corresponding author. Gazi University, Faculty of Medicine, Block D 2nd Floor, Yenimahalle, Ankara, Turkey. Fax: +903125969912.
E-mail address: tugbabedir@gmail.com (T. Bedir Demirdağ).

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[k] *Medeniyet University. Goztepe Training and Research Hospital, Department of Neonatology, Istanbul, Turkey*
[l] *University of Health Sciences, Etlik Zübeyde Hanim Women's Health Training and Research Hospital, Department of Neonatology, Ankara, Turkey*
[m] *Ondokuz Mayıs University, Faculty of Medicine, Department of Neonatology, Turkey*
[n] *University of Health Sciences, Gülhane Training and Research Hospital, Department of Neonatology, Ankara, Turkey*
[o] *University of Health Sciences, Dr. Sami Ulus Maternity and Children Education and Research Hospital, Department of Neonatology, Ankara, Turkey*
[p] *University of Health Sciences Izmir Tepecik Training and Research Hospital, Department of Neonatology, Izmir, Turkey*
[q] *Osmangazi University, Faculty of Medicine, Department of Neonatology, Eskisehir, Turkey*
[r] *Ankara University, Faculty of Medicine, Department of Neonatology, Ankara, Turkey*
[s] *Ege University, Faculty of Medicine, Department of Neonatology, Izmir, Turkey*
[t] *Metro Private Hospital, Neonatology Unit, Adana, Turkey*
[u] *Kırıkkale University, Faculty of Medicine, Department of Neonatology, Kırıkkale, Turkey*
[v] *Koc University, Faculty of Medicine, Department of Neonatology, Istanbul, Turkey*
[w] *University of Health Sciences, Ankara Hematology Oncology Children's Training and Research Hospital, Department of Neonatology, Ankara, Turkey*
[x] *Adnan Menderes University, Faculty of Medicine, Department of Neonatology, Aydın, Turkey*
[y] *University of Health Sciences, Kartal Dr Lutfi Kirdar Training and Research Hospital, Department of Neonatology, Istanbul, Turkey*
[z] *Trakya University, Faculty of Medicine, Department of Neonatology, Edirne, Turkey*
[aa] *Acıbadem University, Faculty of Medicine, Department of Neonatology, Istanbul, Turkey*
[ab] *Uludağ University, Faculty of Medicine, Department of Neonatology, Bursa, Turkey*
[ac] *Hacettepe University, Faculty of Medicine, Department of Neonatology, Ankara, Turkey*
[ad] *Istanbul University, Faculty of Medicine, Department of Neonatology, Istanbul, Turkey*
[ae] *Baskent University, Faculty of Medicine, Department of Neonatology, Ankara, Turkey*
[af] *Mersin University, Faculty of Medicine, Department of Neonatology, Mersin, Turkey*
[ag] *University of Health Sciences, Dr. Behcet Uz Children's Health and Diseases and Surgery Training and Research Hospital, Department of Neonatology, Izmir, Turkey*

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Key Words
health-care associated infection;
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Background: Healthcare-acquired infections (HAIs) in the neonatal period cause substantial morbidity, mortality, and healthcare costs. Our purpose was to determine the prevalence of HAIs, antimicrobial susceptibility of causative agents, and the adaptivity of the Centres for Disease Control and Prevention (CDC) criteria in neonatal HAI diagnosis.
Methods: A HAI point prevalence survey was conducted in the neonatal intensive care units (NICUs) of 31 hospitals from different geographic regions in Turkey.
Results: The Point HAI prevalence was 7.6%. Ventilator-associated pneumonia (VAP) and central line-associated bloodstream infections (CLABSI) and late onset sepsis were predominant. The point prevalence of VAP was 2.1%, and the point prevalence of CLABSI was 1.2% in our study. The most common causative agents in HAIs were Gram-negative rods (43.0%), and the most common agent was *Klebsiella spp* (24.6%); 81.2% of these species were extended spectrum beta-lactamase (ESBL) (+). Blood culture positivity was seen in 33.3% of samples taken from the umbilical venous catheter, whereas 0.9% of samples of peripherally inserted central catheters (PICCs) were positive. In our study, 60% of patients who had culture positivity in endotracheal aspirate or who had purulent endotracheal secretions did not have any daily FiO2 change ($p = 0.67$) and also 80% did not have any increase in positive end-expiratory pressure (PEEP) ($p = 0.7$). On the other hand, 18.1% of patients who had clinical deterioration compatible with VAP did not have endotracheal culture positivity ($p = 0.005$).
Conclusions: Neonatal HAIs are frequent adverse events in district and regional hospitals. This at-risk population should be prioritized for HAI surveillance and prevention programs through improved infection prevention practices, and hand hygiene compliance should be conducted. CDC diagnostic criteria are not sufficient for NICUs. Future studies are warranted for the diagnosis of HAIs in NICUs.

1. Introduction

Healthcare-acquired infections (HAIs) are one of the most severe problems in the neonatal period because of their illness, immature immunity, and exposure to invasive procedures or medical devices such as mechanical ventilators or central venous catheters.[1,2] In addition, resistant microorganisms make it more challenging to cope with HAIs. Healthcare-associated infections increase mortality, morbidity, and cause prolonged hospital stay.[2]

It is essential to monitor infection rates for each medical center individually and also generally in a country to provide safe and high-quality healthcare services[3] because the incidence and causes of infections vary widely among neonatal intensive care units (NICUs).[2,4] For instance, the prevalence of infection is higher in developing countries, where Gram-negative bacteria are usually reported to be the predominant pathogens.[5]

Point Prevalence Surveys are examples of studies that collect information relevant to the management of infectious diseases in hospitalized patients and complement surveillance.[6,7] Incidence surveillance is the gold standard for the surveillance of HAIs in high-risk specialties such as intensive care, oncology or neonatal care, and for selected infections such as ventilator-associated pneumonia (VAP) and catheter-associated urinary tract (CAUTI) and bloodstream infections. Nevertheless, it may be hard to perform for all kinds of infection because it is cumbersome and costly. A point prevalence survey is an alternative method to incidence surveillance to estimate the hospital-wide burden of HAIs within a reasonable budget and effort. Point prevalence surveys can be used a wider range of settings including institutions with limited resources and they allow broader comparison of rates across a wider range of sociocultural contexts.[7]

HAIs are generally diagnosed according to the criteria and recommendations published by the US CDC; however, these criteria were defined for adult patients and are not suitable for the neonatal population. The CDC 2008 criteria involve patients younger than one year, but still not neonates.[8–10]

We aimed to determine the incidence of nosocomial infections in NICUs, to establish the etiologic agent of these infections, as well as the antibiotic susceptibility of the dominant microorganisms, and to review the infection control protocols across the NICUs of the hospitals in our country. In addition, we compared the CDC 2008 and 2013 HAI definitions in terms of the diagnosis of HAIs in NICUs.

2. Methods

2.1. Distribution and features of the NICUs

Thirty-one hospitals from different geographic regions in Turkey were included in the study. Ten of these hospitals were training and research hospitals, 20 were university hospitals, and one was a private hospital, thus including a variety of universities, training and research hospitals, and private hospitals among this sample. The regional distribution of patients can be seen in Fig. 1. All of these hospitals were tertiary care centers. The capacity of the NICUs ranged between 3 and 130 patients.

2.2. Data acquisition

A survey consisting of 34 questions was administered in all 31 hospitals. The first 14 questions considered the infection control precautions within the hospitals, whereas the rest concerned patients who were predicted to have nosocomial infections. These questions were about the presence and duration of the central arterial or venous catheter indwelling, invasive ventilatory support, urinary catheter, total parenteral nutrition and patients' laboratory markers such as leukocyte count, procalcitonin, C-reactive protein, and platelet count. White blood cell counts were defined as normal or high according to the cut-off values in concordance with the calendar day and the gestational age of the newborn.[11] Microorganisms were grown in cultures obtained through central catheters, endotracheal aspirates or peripheral blood samples, and the antibiotic susceptibility of these microorganisms was also documented. The BacT/ALERT 3D (bioMérieux, Inc., Durham, NC, USA) blood culture system was used to process blood cultures. Afterwards, the point prevalence of HAIs in the NICUs was stated according to the collected data. In addition, parameters that are used for diagnosis of VAP according to the CDC criteria [e.g, FiO2 changes and positive end-expiratory pressure (PEEP) changes, infiltration on chest X-ray and physical findings] were collected, and endotracheal aspirate culture-positive samples and groups were compared according to these findings.

2.3. Definitions

HAI, catheter-related sepsis, and VAP were defined according to the United States of America -CDC/National Healthcare Safety Network (NHSN) definitions.[8–10] Although the CDC definitions were revised in 2013, this revision does not include patients under 18 years, so the 2008 definitions of the CDC were used in order to identify patients with VAP.[8–10]

Catheter-related bloodstream infection was defined as laboratory-confirmed bloodstream infection where an eligible bloodstream infection organism was identified, and an eligible central line was present on the laboratory-confirmed bloodstream infection date of the event, or the preceding day.

VAP was diagnosed when a patient who was under mechanical ventilation for at least 48 h, who had hypoxia or

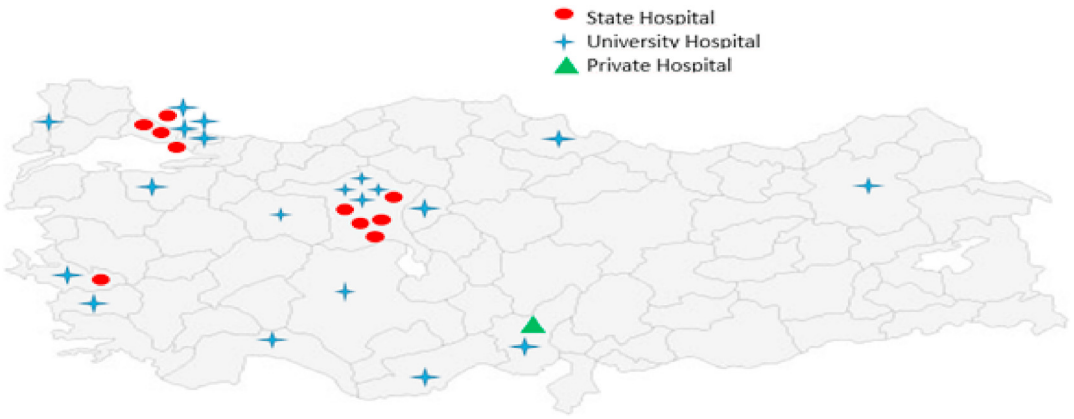


Fig. 1 Regional distribution of hospitals.

hypercarbia (plus one of the following: fever or hypothermia, leukocytosis or leukopenia, newly developed purulent secretion, tachycardia or tachypnea) and new infiltration on chest X-ray.[10] According to the latest CDC diagnostic criteria, patients with a diagnosis of VAP should have at least one of the following indicators of worsening oxygenation: (1) increase in daily minimum FiO_2 of $\geq$0.20 (20 points) over the daily minimum FiO_2 of the first day in the baseline period, sustained for $\geq$ 2 calendar days; (2) increase in daily minimum PEEP values of $\geq$3 cm H_2O over the daily minimum PEEP of the first day in the baseline period, sustained for $\geq$ two calendar days.[8,9]

2.4. Ethical approval

This study was reviewed and approved by a local ethics committee (ref no: 2019/171).

2.5. Statistical analyses

All statistical analyses were conducted using the SPSS software (version 22, IBM, Chicago, IL, USA). Median, range (smallest and largest values), mean, standard deviation, number, and percentage were used as descriptive statistics in the study. Point prevalence was established using SPSS and confidence intervals (CI) were obtained. The level of significance was considered as $p < 0.005$. The Chi-square test was also used for the comparison of the culture-positive and negative groups in terms of FiO2 change, PEEP change, clinical deterioration, and infiltration.

3. Results

On the day of this point prevalence study, there were 849 (min–max: 6–112) patients hospitalized in NICUs. The diagnoses of 65 of these patients were accepted as HAIs, and the point prevalence of HAIs was 7.6%. There were no outpatients in the study group. The patient characteristics are shown in Table 1.

The median number of patients per nurse was 4 (min–max:1–5). All of these hospitals had an infection control committee. There was no significant difference between university hospitals and training and research hospitals in cases of HAI (both VAP and CLABSI) ($p = 0.5$).

Table 1 Characteristics of patients.

		Gestation Age (weeks)				Sex	
		<28 weeks	28–32 weeks	32–37 weeks	37–42 weeks	Male	Female
	n (%)	26 (40%)	13 (20%)	10 (15.4%)	16 (24.6%)	36 (55.4%)	29 (44.6%)
HAI classification							
VAP	+	7 (38.9%)	2 (11.1%)	5 (27.8%)	4 (22.2%)	9 (50%)	9 (50%)
	–	19 (40.4%)	11 (23.4%)	5 (10.6%)	12 (25.5%)	27 (57.4%)	20 (42.5%)
CLABSI	+	7 (63.6%)	3 (27.3%)	0 (0%)	1 (9.1%)	8 (72.7%)	3 (27.3%)
	–	19 (35.2%)	10 (18.5%)	10 (18.5%)	15 (27.8%)	28 (51.9%)	26 (48.1%)
Late onset sepsis	+	11 (37.9%)	7 (24.1%)	3 (10.3%)	8 (27.6%)	15 (51.7%)	14 (48.3%)
	–	15 (41.7%)	6 (16.7%)	7 (19.4%)	8 (22.2%)	21 (58.3%)	15 (41.7%)
Urinary tract infection	+	0	0	2 (40%)	3 (60%)	4 (80%)	1 (20%)
	–	26 (43.3%)	13 (21.7%)	8 (13.3%)	13 (21.7%)	32 (53.3%)	28 (46.7%)
Meningitis	+	1 (50%)	1 (50%)	0	0	2 (100%)	0
	–	25 (39.7%)	12 (19.0%)	10 (15.9%)	16 (25.4%)	36 (57.1%)	27 (42.9%)

HAI, heatlh-care associated infection; VAP, ventilatory associated pneumonia; CLABSI, central line associated blood stream infection.

Table 2 The microorganisms responsible of in hospital associated infections.

	Agent	n	%
Ventilator Associated Pneumonia[a]	*Klebsiella pneumoniae*	4	22.2
	Methicillin-resistant *Staphylococcus aureus*	1	5.6
	Stenotrophomonas maltophilia	2	11.1
	Acinetobacter baumanii	1	5.6
	Enterobacter species	1	5.6
Central line associated blood stream infections	*Klebsiella pneumoniae*	3	27.2
	Escherichia coli	1	9.0
	Acinetobacter baumanii	1	9.0
	Methicillin-resistant Staphylococcus epidermidis	4	36.3
	Candida Albicans	1	9.0
	Enterobacter species	1	9.0
Urosepsis	*Klebsiella pneumoniae*	3	60.0
	Serratia marcescens	1	20.0
	Stenotrophomonas maltophilia	1	20.0
Meningitis	*Klebsiella pneumoniae*	2	100
Late Onset Sepsis	*Klebsiella pneumoniae*	4	40
	Methicillin-resistant Staphylococcus aureus	1	10
	Stenotrophomonas maltophilia	1	10
	Acinetobacter baumanii	2	20
	Enterococcus fecalis	1	10
	Methicillin-susceptible Staphylococcus aureus	1	10

[a] All of the etiologic patiens couldn't be isolated for VAP and late onset sepsis.

On the day of the study, many different antimicrobial agents were used for the treatment of these patients. The most common of these agents were carbapenems (50%), aminoglycosides (47.3%), and glycopeptides (59.2%). Antimicrobial prophylaxis was not administered in any of the centers, but antifungal prophylaxis (AF) was given to patients according to birth weight. Twenty-three centers performed antifungal prophylaxis for newborns whose birth weight was under 1500 g (74.1%). In 56.5% of these centers, AF prophylaxis was performed for neonates weighing <1000 g. At the time of the study, 32 (49.2%) patients were receiving antifungal prophylaxis.

Forty-two patients had a central line for a minimum of 2 days. Eleven of these patients had central line-associated bloodstream infections (CLABSI) (26.1%). The causative agents of CLABSIs were *Candida albicans* in one (9%) patient, *Methicillin-resistant Staphylococcus epidermidis* (MRSE) in four (36.3%) patients, *Klebsiella pneumoniae* in three (27.2%) patients, *Acinetobacter baumanii* in one (9%) patient, *Enterobacter spp.* in one (9%) patient, and *Escherichia coli* in one (9%) patient (Table 2).

The point prevalence of CLABSI was 1.2% in our study (SD = 0.003, CI: 0.002—0.007). We observed that the most frequently used catheter was the umbilical venous catheter (UVC) (50%), followed by the peripheral and central venous catheter (26.1%). Blood culture positivity was observed in 33.3% of samples obtained from the UVC, whereas 0.9% of samples of peripherally inserted central catheters (PICCs) were positive. Fig. 2 shows the commonly used catheters and their culture positivity.

The number of patients who on mechanical ventilator support for a minimum of 2 days was 47 (61.8%). Eighteen of these patients had VAP (38.2%). The point prevalence of VAP was 2.1% (SD = 0.006, CI: 0.004—0.016) in our study. The causative agents of VAP were *Klebsiella spp.* in four patients (22.2%), (MRSA) in one patient (5.6%), Stenotrophomonas maltophilia in two patients (11.1%), *A. baumanii* in one patient (5.6%), and *E. spp.* in one patient (5.6%). The microorganism could not be isolated in nine patients. All of the Klebsiellas were extended-spectrum beta-lactamase (ESBL)-positive (Table 2). The distribution of pathogens for VAP and CLABSI is shown in Fig. 3a and b.

Twenty-nine patients had late-onset sepsis. The microorganism was isolated in 10 of these patients. Causative agents were *K. pneumoniae* in four patients, *A. baumanii* in two patients, *Enterococcus faecalis* in one patient,

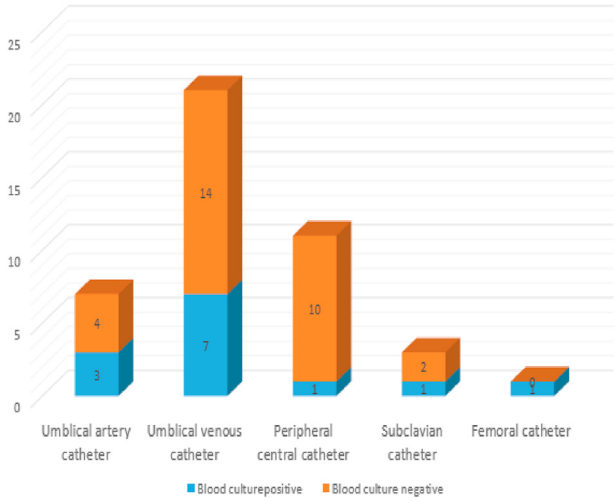
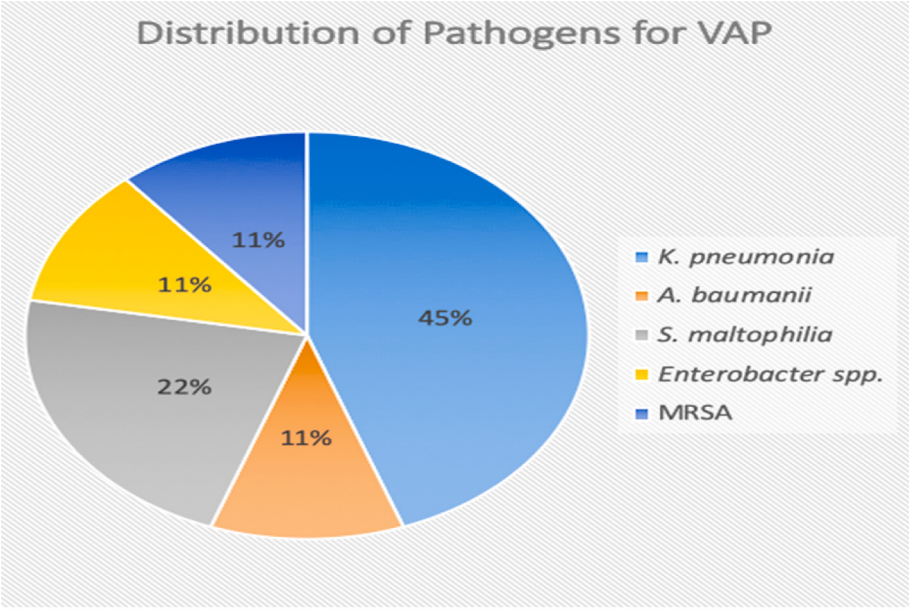


Fig. 2 The catheters used extensively and their culture positivity.



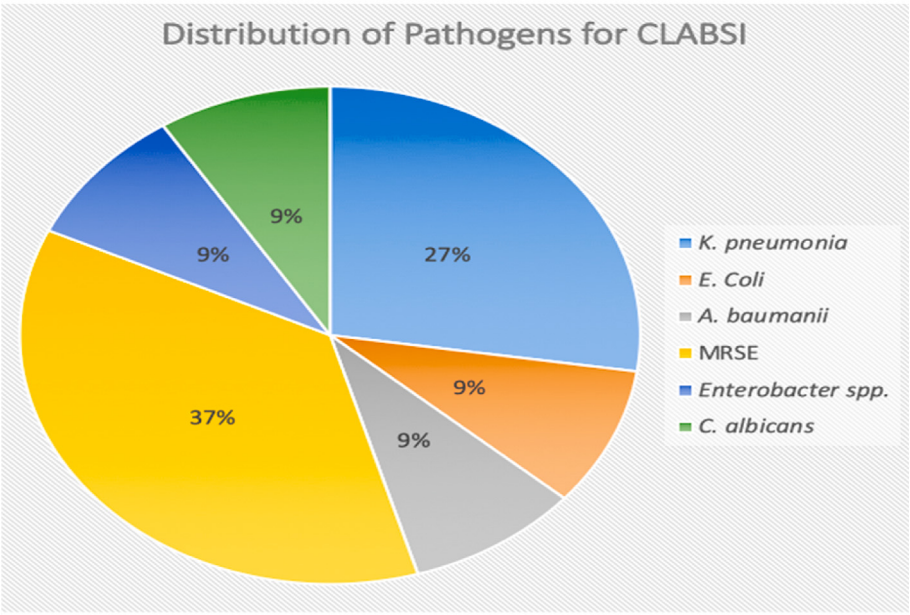


Fig. 3 a Distribution of the isolated pathogens for ventilatory associated pneumonia. b Distribution of pathogens for central line associated blood-stream infections.

Stenotrophomonas maltophilia in one patient, MRSA in one patient, and Methicilline sensitive staphylococcus aureus (MSSA) in one patient. Other than these, five patients had urosepsis, and two patients had meningitis. Urosepsis was caused by *K. pneumoniae* in three patients, *Serratia marcescens* in one patient, and *S. maltophilia* in one patient. Both cases of meningitis were caused by *K. pneumoniae* (Table 2).

In our study, 60% of patients who had culture positivity in endotracheal aspirate culture ($\geq 10^5$ colony-forming units/mL or corresponding semi-quantitative result) and purulent endotracheal secretions (that contained >25 neutrophils and <10 squamous epithelial cells per low-power field [LPF x100]), had no daily FiO2 change ($p = 0.67$), and 80% had no increase in PEEP ($p = 0.41$). On the other hand, 18.1% of patients who had clinical deterioration compatible with VAP had no endotracheal culture positivity ($p = 0.005$), but infiltration on chest X-ray, leukocytosis and CRP positivitiy did not differ between patients whose endotracheal aspirate was culture positive or negative (Table 3).

4. Discussion

Survival rates of patients have increased according to developments in life support techniques, medical conditions,

Table 3 Evaluation of patients with ventilator associated pneumonia.

		Culture positive patients n (%)	Culture negative patients n (%)	
Total patients		9 (50%)	9 (50%)	
FiO2 Change	No	6 (60.0%)	4 (50.0%)	
	Yes	4 (40.0%)	4 (40.0%)	p = 0.67
PEEP Change	No	8 (80.0%)	5 (62.5%)	
	Yes	2 (20.0%)	3 (37.5%)	p = 0.41
Clinical deterioration	No	1 (10.0%)	6 (75.0%)	
	Yes	9 (90.0%)	2 (25.0%)	p = 0.005
Infiltration	No	1 (10.0%)	0 (0%)	
	Yes	9 (90.0%)	8 (100%)	p = 0.35
Leukocytosis[a]	No	1(10%)	3 (37.5%)	
	Yes	9 (90%)	5 (62.5%)	p = 0.16
C- reactive protein positive[b]	No	4 (40.0%)	4 (40.0%)	
	Yes	6 (60.0%)	4 (60.0%)	p = 0.67

PEEP, positive end expiratory pressure; PEEP change, increase in daily minimum PEEP values of $\geq$3 cm H_2O over the daily minimum PEEP of the first day in the baseline period, sustained for $\geq$ two calendar days; FiO2 change, increase in daily minimum FiO_2 of $\geq$0.20 (20 points) over the daily minimum FiO_2 of the first day in the baseline period, sustained for $\geq$ two calendar days.

[a] Leukocytosis is defined according to the gestational age, and calendar day of the patient.[11]

[b] CRP $\geq$6 mg/L was accepted as positive.

and treatment options in NICUs.[12,13] There are significant differences in methodology in various studies, so it is difficult to compare infection rates between studies.[2] In our research, the point prevalence of HAIs was 7.6%, for CLABSI it was 1.2% and for VAP it was 2.1%. Causative agents of HAI were 43% Gram-negative rods; Gram-negative agents comprised 73.6% of the microorganisms isolated. ESBL positivity was 81.2% in *K. spp*. These data are similar to the prevalence reports from some developed countries and better than the results from some developing countries.[14,15] However, HAIs in NICUs are still an unresolved and significant problems for our country.

The incidence of HAIs in NICUs differs in developed and developing countries. Pediatric data from national and multinational prevalence surveys in different countries are summarized on Table 4.[2,12–14,16–18] A report from Serbia stated that the incidence of HAIs was 18.6% in their one-year prospective study.[12] Zingg et al. reported an analysis of pediatric data from the European CDC point-prevalence survey. In this survey, the prevalence of patients with one or more HAIs was 10.7% (9.0—12.7).[16] A point prevalence study by Olivier et al. from South Africa stated that the pooled point HAI prevalence was 7.0% in neonates.[19] The rate of HAIs in NICU was found to be 11.3% and 16.1/1000 patient days in a study from Marmara University Hospital.[20] In another study, the rate of HAIs was 8.3% and 7.69/1000 patient days.[13] The overall prevalence of HAIs in our study was 7.6%.

Previous studies reported that the rates of healthcare-associated bloodstream infection in the NICU ranged from 5% to 32%.[15,16] The most frequent HAIs were bloodstream infections (4.8%) in Sadowska-Krawczenko et al.'s report.[2] Olivier et al. stated that hospital-acquired pneumonia was the predominant HAI in their study (33.3%), followed by bloodstream infection (20.0%).[19] In Folgori et al.'s report, bloodstream infections were the most common type of HAIs, followed by lower respiratory tract infections.[21] In Djordjevic et al.'s report, the most frequent HAI was pneumonia (64.9%).[12] In our study, supporting the literature above, the most frequent HAIs were late onset sepsis, CLABSI and VAP; however, VAP was more common than CLABSI. It is also important that, in our study, one of every three patients who had mechanical ventilation had VAP. This finding suggests that there must be a focus on hand hygiene and other infection control precautions.

In Olivier et al.'s study, the most frequently used empirical antimicrobials for HAI were piperacillin-tazobactam plus amikacin (46.7%) and third-generation cephalosporins (cefotaxime or ceftriaxone) (26.7%).[19] In our study, carbapenems, glycopeptides, and aminoglycosides were the most commonly used antibiotics in NICUs. This use of broad-spectrum antibiotics might be because of the individual center's infection statistics/antibiotic susceptibilities. Nevertheless, it is evident that effort should be made to decrease the misuse/overuse of these broad-spectrum antibiotics. Otherwise, the risk of multidrug-resistant microorganisms will be a threat for NICUs.

In our study, the most common causative agents in HAIs were Gram-negative rods (43.0%), and the most common agent was *K. spp*. (24.6%); 81.2% of these species were ESBL (+). The most frequent second agents in HAIs, according to our study, were *Staphylococci* (10.7%) (*Staphylococcus epidermidis* n = 4, MRSA n = 2, MSSA n = 1). Methicillin resistance was 85.7%. Although there has been a shift in developed countries toward Gram-positive bacteria as agents responsible for pneumonia, Gram-negative bacilli and their antibiotic resistance are still a significant problem in less developed countries.[22] In Kumar et al.'s report, HAI showed predominance of Gram-positive pathogens with MRSA being the most common isolate. *A. baumanii* was the primary Gram-negative organism, followed by *Enterobacter* and *E. coli*.[23] In a Serbian prevalence study, more than half of all registered HAIs were

Table 4 Pediatric data from national and multinational prevalence surveys in different countries.

	Sadowska-Krawczenko et al.[2]	Djordjevic et al.[12]	Zingg et al.[16]	Sarvikivi et al.[17]	Abdel-Wahab et al.[18]	Urzedo et al.[14]	Tekin R et al.[13]	Bedir Demirdag et al. (present study)
Period	2005–2010	2012	2011–2012	2008–2009	2009–2010	1997–2012	2008–2011	2016
Number of patients	2610	381	231 459	1281	238	4615	6932	849
HAI prevalence	7.32%	18.6%,	10.7%	12.8%	21.4% incidence density: 13.8/1000 days.	19%	8.3% (incidence rate: 7.69/1000 patient days.)	7.6%
CLABSI or Blood stream infections	Prevalence rate: 4.8% Percentage in HAI: 65.4%	–	44.6%	Early onset HAI: 5% of total infections. Late onset HAI: 20% of total infections.	8.8%	17.3/1000 central-line days	76.4% of total infections. incidence rate: 6.4/1000 patient days	1.2%
UTI	prevalence: 1.6%	20.3% of total infections	–	Early onset HAI: 3% of total infections. Late onset HAI: 5% of total infections.	3.1%		–	0.6%
VAP or health-care associated pneumonia	prevalence: 0.8%	64.9% of total infections	22.2%	Early onset HAI: 19.0% of total infections. Late onset HAI: 8% of total infections.	11.3%	3.2/1000 ventilator days	13.1 of total infections. incidence rate: % 1.1/1000 patient days	2.1%
Causative pathogens	Coagulase-negative staphylococci 36.1% *Klebsiella pneumoniae* 29.3% *Enterobacter cloacae* 7.9%	*Klebsiella-Enterobacter* (39.3%) *Escherichia coli* (25.0%)	Coagulase-negative staphylococci 31% *Staphylococcus aureus* 14% *Enterobactericeae* 26%	Early onset HAI: *Streptococcus agalactiae* Late onset HAI: coagulase-negative staphylococci, *Staphylococcus aureus* and *Escherichia coli*	*Klebsiella spp.*33.3% *Escherichia coli* 21.6% Coagulase-negative staphylococci 17.6% *Pseudomonas spp.* 17.6%	Coagulase-negative staphylococci 34.3% *Staphylococcus aureus* 15.6%	*Acinetobacter baumannii* 48% *Pseudomonas aeruginosa* 32% *Klebsiella spp.* 6%	*Klebsiella spp.* (24.6%), *S.maltophilia (6.1%)* *A.baumanii (6.1%)* Coagulase-negative staphylococci (6.1%)

caused by *Klebsiella, Enterobacter* (39.3%), and *E. coli* (25.0%); these were followed by coagulase-negative staphylococci, *Acinetobacter spp*, *C. albicans*, and *S. maltophilia*.[12] In Sadowska-Krawczenko et al.'s report, the most common HAI pathogens in all neonates were coagulase-negative staphylococci (36.1%) and *K. pneumoniae* (29.3%). The Gram-negative rods were 80.4% ESBL (+).[2] In Zingg et al.'s point prevalence study, coagulase-negative staphylococci was the most common HAI pathogen, followed by enterobactericeae in neonates. Forty-four percent of enterobacteriaceae isolates were resistant to third-generation cephalosporins, and 9% were resistant to carbapenems.[16]

Another important point of our study is that *Streptococcus agalactiae* was not isolated from any of the patients, and *C. albicans* was isolated from only one. The reported rates of invasive Candida infections in NICU settings range between 0.5 and 2%, depending on the gestational age and birth weight of patients in the cohorts. The risk is greatest among preterm infants with extremely low birth weight (<1000 g).[24,25] Antibiotic prophylaxis was not administered in any of the centers, but antifungal prophylaxis was performed in 74.1% of the centers. At the time of the study, 32 (49.2%) patients were receiving antifungal prophylaxis. This may be the reason why Candida infections were less common in our research.

According to the literature, infection rates increase with prolonged use of umbilical catheters. PICCs are increasingly used after an initial short period of umbilical catheters on the assumption that they decrease the risk of infection.[26] Supporting this information, UVCs were more related with CLABSI, whereas PICCs seemed to be safer according to our study. In order to reduce catheter-related infections, physicians and healthcare workers should maintain bundles properly, re-evaluate catheter necessity, and promptly remove catheters when they are no longer needed; and if the catheter is still needed, PICCs should be preferred.

Our findings showed that 60% and 80% of neonates who had purulent endotracheal secretions and culture positivity had no FiO2 or PEEP change. In addition, 18.1% of patients who had clinical deterioration compatible with VAP had no endotracheal culture positivity ($p = 0.005$). The diagnosis of VAP is still controversial for neonates due to the lack of the most appropriate diagnostic criteria. Reports still use definitions based on CDC criteria, but these age-based criteria (either CDC 2008 or CDC 2013) do not cover the neonatal period.[12–14,27] These findings emphasize the gap in VAP definitions for neonates, and future studies are warranted to establish clear and objective criteria in the diagnosis of VAP in NICUs.

5. Conclusion

In this study, general surveillance data of neonates from multiple hospitals were documented. It is important to state and follow the current prevalence reports individually and globally. Particular care should be taken to prevent the development of HAIs in neonates, which are still some of the leading problems in healthcare services. In addition, clinicians should try to decrease the misuse of broad-spectrum antibiotics and to avoid the use of central catheters for longer than needed. Future prospective studies are merited to obtain knowledge about epidemiologic data across the world and to follow the causative agents and their changing antimicrobial susceptibility, and also to formulate more suitable definitions for HAIs for NICUs.

Declaration of competing interest

We declare that there are no competing financial interests in relation to the work described.

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