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Original Article

The frequency and distribution of healthcare-associated infections in children

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Abstract

Background Healthcare-associated infections (HAIs) are major contributors to increased morbidity, mortality, and healthcare costs. Ongoing epidemiological surveillance of nosocomial infection is needed to accurately assess their burden and inform prevention strategies.

Objective To determine the frequency and distribution of HAIs.

Methods A 26-month prospective cohort study (February 2016 to April 2018) was carried out at Dr. Sardjito Hospital, a tertiary hospital in Yogyakarta, Central Java, Indonesia, where pediatric patients hospitalized in the wards and pediatric ICU were monitored daily. The HAIs were defined according to the criteria set by the *Centers for Disease Control and Prevention*.

Results Out of 1,855 patients enrolled in the study period, 314 (16.9%) had HAI with an incidence density rate of 20.1 infections per 1,000 patient-days (416/20,672). The incidence of nosocomial urinary tract infection (UTI) was 4.3% (82/1,855) and the catheter-associated urinary tract infection (CAUTI) incidence density rate was 16.5 CAUTIs/1,000 patient-days (36/2,179). The incidence of nosocomial pneumonia, which includes both hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP), was 3.2% (59/1,885), while the specific incidence rate of VAP was 5.1 per 1,000 patient-days (14/1,359). The incidence of nosocomial bloodstream infection was 1.9% (36/1,855) and the central line-associated bloodstream infection (CLABSI) incidence rate was 4.4 CLABSIs/1,000 patient-days (5/1,121). The incidences of surgical site infection, phlebitis, nosocomial upper respiratory infection, and nosocomial gastroenteritis were 0.2% (3/1,855), 0.9% (17/1,855), 2.9% (54/1,855), and 3.4% (63/1,855), respectively.

Conclusion One-sixth of children in our hospital developed HAIs, with an incidence rate of 20.1 HAI/1,000 days. The most common HAI was CAUTI, followed by VAP and CLABSI. **[Paediatr Indones. 2025;65:382-9; DOI: https://doi.org/10.14238/pi65.5.2025. 382-9]**.

Keywords: *healthcare-associated infection; surveillance; frequency; distribution; pediatrics; low- and middle-income countries*

Healthcare-associated infections (HAIs) are acquired by patients during the process of care, typically appearing at least 48 hours following admission or up to 30 days following healthcare intervention.[1] In Italy, an estimated 641,065 new HAI cases occur annually, contributing to approximately 29,375 deaths.[2] The incidence of HAIs in Australia may be closer to 165,000 per year.[3] The burden of disease of HAIs can be evaluated by mortality and morbidity, as well as economic impact. In a study conducted in China, the healthcare expenses for patients who developed HAIs were considerably greater than for those who did not acquire HAIs.[4] The total annual cost is estimated to be £774 million in the UK.[5]

The HAIs have emerged as a significant public health issue especially in low- and middle-income countries due to limited resources and

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infection control measures. This surveillance study provides detailed information on the epidemiology of nosocomial infection to determine the burden of HAI and design an effective intervention to reduce these infections in Yogyakarta, Indonesia.[6-8] In our earlier publication using the same study cohort, we assessed the long-term impact of a multifaceted infection control intervention on reducing HAIs.[8] In this current study, we aimed to perform a detailed analysis of the frequency and distribution of HAIs in pediatric patients following the implementation of a combined infection prevention and antibiotic management program - an aspect not explored in the previous report.[8]

Methods

This study was carried out in both the Pediatric Intensive Care Unit (PICU) and pediatric wards of Dr. Sardjito Hospital, a tertiary referral hospital in Yogyakarta, Central Java, Indonesia, from February 1, 2016 to April 30, 2018. As a major referral center for the Yogyakarta region and southern Central Java, Dr. Sardjito Hospital provides care to around 3.6 million individuals.[8]

We employed a prospective cohort design to assess the frequency and distribution of HAIs and to evaluate the sustained impact of a previously implemented multifaceted infection prevention program, which included care bundles, hand hygiene promotion, staff education, antimicrobial stewardship, and HAI surveillance.[8] Patients anticipated to stay in the pediatric ward or PICU for at least 48 hours were included in the study.

Data collection followed the approach of a previous study on HAI deduction.[7,8] The HAIs were identified based on definitions established by the US *Centers for Disease Control and Prevention* (CDC) through the *National Healthcare Safety Network* (NHSN) and the *National Nosocomial Infections Surveillance* (NNIS) system.[9,10] Each child was assessed daily for HAI criteria, and if met, clinical staff collected specimens from blood, urine, or other aseptic sites on that day to obtain relevant cultures.

Standard culture methods validated at our hospital were employed using *BACTEC® 9120* (*BD Diagnostics*, Sparks, MD, USA). Microbial isolation and antimicrobial susceptibility testing were performed following clinical pathology protocols.[11] For each positive culture, data were recorded on the organism type, number of positive sites, time to positivity, clinical signs of infection, and overall illness severity, enabling differentiation between true pathogens and contaminants.[12]

The primary outcomes were the proportions and rates of HAI, while the secondary outcome was the distribution patterns of HAI. Ethical approval was granted from the Institutional Review Board of the Universitas Gadjah Mada.

Data were presented as frequencies and rates, including the proportion of HAI. The proportion of HAIs was calculated by dividing the total number of HAIs by the overall patient admissions, then multiplying the result by100%. The CAUTI rate was determined by dividing the number of catheter-associated urinary tract infections by the total catheter days, then multiplying by 1000. The VAP rate was determined by dividing the total VAP cases by the number of ventilator days, then multiplying the result by 1,000. The CLABSI rate was computed as the number of infections per 1,000 central line days. The SSI rate was expressed as a percentage, obtained by dividing the total SSIs by the total surgeries performed, then multiplying by 1,000.

Statistical analyses were conducted using *STATA version 12.1* (*StataCorp LP*, Texas). Proportional differences were assessed using Chi-square test, with $P<0.05$ deemed to denote statistical significance.

Results

During the study period 1,855 patients were recruited. About a quarter of the children admitted were less than one year old. One sixth of recruited patients were admitted to the PICU. The proportion of underlying diseases among enrolled patients was classified based on sub-specialty areas in our Pediatrics Department (**Table 1**).

Of 1,855 subjects, 16.9% were identified as having one or more HAIs during the study period, 13% children had one HAI and 3.9% had two or more HAIs (**Table 2**).

The average median hospital stay before the onset of HAI signs was 7 (interquartile range/IQR

5-13) days. The probability of patients developing HAIs in the PICU was significantly higher than in the general pediatric wards (26.6% *vs.* 15.3%, P<0.001). Furthermore, the risk of developing HAIs was significantly higher in the infectious ward compared to the non-infectious ward ((18.7% *vs.* 13.4%, P=0.04).[8]

Among the 314 HAI patients, 416 episodes of HAIs were detected; the total number of patient-days was 20,672. Therefore, the incidence density rate of HAIs was 20.1 infections per 1,000 patient-days. In the PICU, 107 episodes of HAIs were detected; the total number of patient-days was 3,760. The incidence density rate of HAIs in the PICU was 28.4 infections over 1,000 patient-days. In the pediatric ward, 207 episodes of HAIs were detected; the overall number of patient-days was 16,912. Therefore, the incidence density of HAIs in the pediatric ward was 12.4 infections per 1000 patient-days.

Among the 84 positive bacterial cultures from children with a diagnosis of HAI, gram-negative bacteria were the most common microorganisms isolated (69% of all positive cultures), followed by gram-positive bacteria (23.8%) and fungal nosocomial infections (7.1%). The most commonly isolated HAI pathogen was Klebsiella pneumoniae (28.6%), Enterococcus spp (14.3%), Acinetobacter spp (11.9%), and Pseudomonas aeruginosa (8; 9.5%) (**Table 3**).

The most common HAI in this population was urinary tract infection. The incidence of nosocomial urinary tract infection was (4.3%), of which 1.8% were culture positive. *Enterococcus spp.*, *Escherichia coli*, and

Table 1. Baseline characteristics of subjects

Characteristics	(N=1,855)
Male sex, n (%)	943 (50.8)
Age, n (%)	
≤12 months	483 (26.1)
>12-60 months	479 (25.8)
>60-120 months	366 (19.7)
>120 months	527 (28.4)
Ward or setting, n (%)	
PICU	286 (15.4)
Pediatric wards	
Infectious	538 (29)
Non-infectious	1,031 (55.6)
Underlying diseases, n (%)	
Neurology	338 (18.2)
Nephrology	179 (9.7)
Respiratory	153 (8.3)
Cardiovascular	478 (25.8)
Hematology and oncology	17 (0.9)
Gastrohepatology	236 (12.7)
Infectious	209 (11.3)
Immunology	123 (6.6)
Sepsis	49 (2.6)
Endocrinology	26 (1.4)
Malnutrition	7 (0.4)
Surgery	40 (2.2)
Source of patients, n (%)	
Community	774 (41.7)
Referred from another hospital	975 (52.6)
Transferred from another hospital unit	106 (5.7)

Table 2. Incidence of HAIs by site (N=1,855)

Type of infection	HAIs			
	Patients, n[a]	Patients, (%)[b]	HAI, n[c]	Relative HAI, (%)[d]
Culture positive BSI	6	(0.4)	9	(2.2)
Culture negative likely BSI	30	(4.1)	42	(10.1)
VAP	14	(0.8)	21	(5.1)
Nosocomial pneumonia	45	(2.4)	65	(15.6)
CAUTI	26	(1.4)	33	(7.9)
Nosocomial UTI	56	(3.1)	65	(15.6)
SSI	3	(0.2)	5	(1.2)
GIT	63	(6.4)	77	(18.5)
Phlebitis	17	(0.9)	29	(7)
URTI	54	(2.9)	70	(16.8)
Total	314	(16.9)	416	(100)

BSI=bloodstream infection; GI=nosocomial gastrointestinal infection; URTI=nosocomial upper respiratory tract infection; [a]Number of patients with healthcare-associated infection (site-specific number); [b]percentage of patients with healthcare-associated infection (site-specific incidence); [c]number of healthcare-associated infections; [d]percentage of total number of HAIs (relative percentage)

Klebsiella pneumoniae were found to be the primary causes of urinary tract infections, with incidences 31.4% vs 20% vs 17.1%, respectively (**Table 3**).

A total of 310 patients used urinary catheters. Of 82 patients with nosocomial UTIs, 43.9% patients used urinary catheters. Mean duration of catheter use among patients with nosocomial UTI was 12.3 (SD 8) days, with a duration of urinary catheter use of 407 patient-days. Total duration of urinary catheter uses among the 310 patients was 2,179 patients-days. The incidence density rate of CAUTI was 16.5 CAUTIs per 1,000 patient urine catheter days.

The incidence of culture-positive nosocomial bloodstream infection was 0.3%, with an additional 30 children fulfilling the criteria for culture-negative bloodstream infections, leading to a total of 1.9% nosocomial bloodstream infections in the study period (**Table 2**).

Among 36 patients with nosocomial bloodstream infection, etiological pathogens were isolated from 9 cultures. Klebsiella pneumoniae was found to be the cause of 33.3% of nosocomial bloodstream infecti*ons (3/9 culture-proven bloodstream infection) (*Table 3).

Ninety patients had central venous catheters. Of 6 patients with nosocomial bloodstream infection, 5 (80.3%) patients had a central venous catheter (CVC). Mean duration of central venous catheter USE among patients with nosocomial BSI was 19.6 (SD 11.3) days. The CVC duration was 93 patient-days. Total duration of CVC use was 1,121 patients-days across 90 patients. The rate of central line-associated bloodstream infection (CLABSI) was 4.4 CLABSIs over 1,000 central line days.

Nosocomial pneumonia was the most common infections identified in our study. The nosocomial pneumonia incidence was 3.2% and 1.5% were culture positive. The most commonly isolated etiologic pathogens were Klebsiella pneumoniae (10/28) and Pseudomonas aeruginosa and Acinetobacter spp (7/28) (**Table 3**).

During the study period, 159 patients were managed with mechanical ventilation. Of 59 patients with nosocomial pneumonia, 14 (23.7%) patients received mechanical ventilation. Mean duration of ventilator use was 11.7 (SD 10.2) days in patients with nosocomial pneumonia, with a cumulative duration of mechanical ventilation use of 216 patient-days. Total duration of mechanical ventilation use in the 159 patients using a ventilator was 1,359 patient-days. The VAP rate was 10.3 VAPs over 1,000 patient ventilator days.

In this study, other nosocomial infections consisted of phlebitis, surgical site infections, nosocomial gastrointestinal infections or gastroenteritis, and

Table 3. Distribution of pathogens isolated in HAI episodes by type of infections in the pre-intervention period

Pathogens isolated, n	BSI (n=9)	Nosocomial pneumonia (HAP/VAP) (n=28)	CAUTI/UTI (n=35)	SSI (n=3)	GIT (n=7)	Total (N=84)
Pseudomonas aeruginosa	-	7	-	-	1	8
Klebsiella pneumoniae	3	10	6	1	4	24
Escherichia coli	-	1	7	-	-	8
Enterobacter spp	1	-	2	-	1	4
Acinetobacter spp	2	7	1	-	-	10
Staphylococus spp	1	1	3	1	-	7
Enterococcus spp	-	1	22	-	-	12
Candida albicans	-	-	1	-	1	3
Candida spp	1	-	2	-	-	3
Kocuria rhizophila	-	-	1	-	-	1
Providencia stuartii	-	-	1	-	-	1
CONS	-	1	-	-	-	1
Stenotropomonas maltophilia	-	-	-	1	-	1
Sphigomonas paucimobilis	1	-	-	-	-	1

nosocomial upper respiratory tract infections. The incidence of phlebitis was 0.9% and of surgical site infection was 0.2%.The incidence of nosocomial gastroenteritis was 3.4% and of nosocomial upper respiratory infection was 2.9% (**Table 2**).

Discussion

This surveillance of nosocomial infection was done to describe the frequency and distribution of HAIs. Standardized CDC criteria were used to determine HAI during the surveillance. We found that the burden of HAI in children in Yogyakarta, Indonesia remained high, despite the implementation of infection prevention and rational antibiotic use protocols.[8]

The cumulative incidence of HAIs in the study population was 16.9%. This was equivalent to an incidence density of 20.1 infections over 1,000 patient-days. HAIs were much more prevalent in the PICU compared to the pediatric ward.8 In the PICU, the incidence of nosocomial infection was 26.6%, which was equivalent to an incidence density of 28.4 infections per 1,000 patient-days. In the pediatric ward, the incidence of nosocomial infection was 15.3%, which was equivalent to an incidence density of 12.4 infections per 1,000 patient-days.

Despite the implementation of multimodal intervention,[7,8] the burden of nosocomial infection was higher than that reported in a systematic review of 40 published studies conducted in neonates and children in developing countries. A meta-analysis showed that the pooled incidence of nosocomial infections was 5.7 (95%CI 2.3 to 13.1) patient-days in the pediatric ward and 10.9 (95%CI 2.8 to 34.5) patient-days in the children's hospital. Furthermore, the incidence density of nosocomial infection in the PICU was 1.6 to 46.1 per 1,000 patient-days in their meta-analysis.[13] An Egyption study reported an HAI incidence rate of 3.7%.[14] In contrast, a study conducted in South Africa found a higher HAI incidence rate of 31.1 per 1,000 patient-days (95%CI 28.2 to 34.2).[15]

A previous study conducted in the adult and pediatric wards in two teaching hospitals in Indonesia found that the prevalence of nosocomial infections was 5.9% and 8.3%, respectively.[16] These are likely underestimates of the true rate of nosocomial infections because the authors used a cross-sectional design and microbial cultures were obtained in only 10% of all patients in those hospitals.

The rate of HAIs in our population was approximately four times higher than the estimated 4.5 to 7.1% reported in high-income countries.[13,17-18] Globally, the risk of HAIs in developing nations is estimated to be 2 to 20 times greater than in high-income settings,[19] highlighting a significant public health challenge.

A study conducted in Indonesia identified several factors associated with an increased risk of HAIs, including a hospital stay longer than seven days, the use of urinary catheters and central venous catheters (CVC), inappropriate antibiotic use, age under one year, and severe sepsis.[20] A similar study in Egypt found that independent predictors of HAIs were multiple devices, CVC, urinary catheter, and length of stay >20 days.14 Many factors contribute to the higher proportion of HAI in settings with limited resources. Hospitals with limited resources face considerable health and hygiene problems that are also likely to cause the transmission of infections within hospitals.[21] Inadequate infrastructure, rudimentary equipment, insufficient infection control policies, and other unresolved major health problems, have been associated with the incidence of HAI.[21,22] However, the magnitude of HAI is frequently underestimated in developing nations because surveillance systems to collect data are unreliable and inconsistent.[22] The surveillance of HAI consumes time, resources, and expertise that are frequently unavailable in hospitals with limited resources.

The most prevalent HAI in our study was nosocomial UTI. The incidence of nosocomial UTI was 4.3% and Enterococcus spp was the primary cause. The incidence density rate of catheter-associated urinary tract infection (CAUTI) was 16.5 CAUTIs over 1,000 patient urinary catheter-days. This was much higher compared to the previous multicenter study in Colombia and in Saudi Arabia, which had a CAUTI rate of 1/1,000 catheter days.[23,24]

Nosocomial pneumonia (include HAP and VAP) was another major HAI in our study. The incidence of nosocomial pneumonia was 3.2% and the most frequently isolated pathogens were Klebsiella pneumoniae. The VAP incidence rate was 10.3/1,000 patient ventilator-days. This finding was consistent with the previous review in developing countries that reported a density between 4.4 and 143 per 1,000 ventilator-days [median 28.0 (range 10.9-88.3)].[8] Our result was higher compared to National Nosocomial Infection Surveillance (NNIS) data, with median VAP rate of 2.3 (IQR 0.9-4.8) /1,000 ventilator-days.[25] However, studies in Africa and Ukraine found that the most frequently reported HAI types were pneumonia (24.4% and 44.0%, respectively).[15,26]

Nosocomial bacteremia, or hospital-acquired bloodstream infection, was an uncommon type of HAI during the study period, with an incidence of 1.9% and *Klebsiella pneumoniae* as the main pathogen. Moreover, the incidence density of CLABSI was 4.4 CLABSIs/1,000 patient central line catheter-days. This finding was consistent with a study from Thailand, which reported an overall CLABSI incidence of 3.2 per 1,000 catheter days. Khieosanu et al. identified the number of CVC lumens and the catheter insertion site as significant risk factors in neonates and children, respectively. Additionally, CLABSI was linked to extended hospital stays and increased hospital costs.[27]

Our CLABSI incidence density was lower compared to a previous study[7] and a review on the challenge of endemic HAI in developing countries, with density between 10.2 and 60 CLABSIs per 1,000 catheter-days [median 18.7 (IQR 12.5-43)].[13] It was also lower compared to the incidence of CLABSI in a multicenter study in high-income countries, with median of 6.3 CLABSIs per 1,000 catheter-days (95%CI 5 to 8.9).[28]

The overall incidence of other HAIs was 7.3%, consisting of in order of frequency: nosocomial phlebitis (0.9%), nosocomial gastroenteritis (3.4%), surgical site infection (0.2%), and nosocomial upper respiratory infections (2.9%). The overall incidence of other HAIs was higher compared to nosocomial bloodstream infection, pneumonia, and UTI. These types of infection were considered to be mild and moderate in their severity of nosocomial infection.

A multicenter, multinational study examined factors influencing overall-cause mortality in ICU patients and identified several non-modifiable risk factors, including national income level (i.e the average economic status of the country), facility ownership (e.g public *vs.* private hospital, type of hospitalization (e.g. medical *vs.* surgical admission), as well as patient sex and age. But some modifiable risk factor, such as CLABSI, VAP, CAUTI length of stay (LoS) and mechanical ventilation utilization were also found to significantly influence outcomes and represent potential targets for intervention. It is important to focus on strategy to reduce the length of stay, minimize mechanical ventilation use, and apply evidence-based medicine to combat HAIs in order to decrease mortality of ICU patients.[29]

Our study showed that nosocomial infection in children in our hospital was a major burden, with a similar distribution of infections to other previous research in low- and middle-income settings. However, our study had some limitations. It was a single center study and the establishment of diagnosis of other HAIs was mostly based on the clinical criteria of CDC guidelines. Due to the limitations of diagnostic testing for viral infection, we could not ascertain the virologic diagnosis of these HAI.

In conclusion, this study showed a major burden of nosocomial infection in children in our hospital with the similar distribution of infections to previous studies in other low- and middle-income settings.

Conflict of interest

None declared.

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References

1. Revelas A. Healthcare - associated infections: a public health problem. Niger Med J. 2012;53:59-64. DOI: https://doi.org/10.4103/0300-1652.103543

2. Bordino V, Vicentini C, D'Ambrosio A, Quattrocolo F; Collaborating Group; Zotti CM. Burden of healthcare-associated infections in Italy: incidence, attributable mortality and disability-adjusted life years (DALYs) from a nationwide study 2016. J Hosp Infect. 2021;113:164-71. DOI: https://doi.org/10.1016/j.jhin.2021.04.023
3. Mitchell BG, Shaban RZ, MacBeth D, Wood C, Russo PL. The burden of healthcare-associated infection in Australian hospital: a systematic review of the literature. Infect Dis Health. 2017;22:117-28. DOI: https://doi.org/10.1016/j.idh.2017.07.001
4. Liu X, Spencer A, Long Y, Greenhalgh C, Steeg C, Verma A. A systematic review and meta-analysis of disease burden of healthcare-associated infections in China: an economic burden perspective from general hospitals. J Hosp Infect. 2022;123:1-11 DOI: https://doi.org/10.1016/j.jhin.2022.02.005
5. Manoukian S, Stewart S, Graves N, Mason H, Robertson C, Kennedy S, *et al*. Bed-days and costs associated with the inpatient burden of healthcare-associated infection in the UK. J Hosp Infect. 2021;114: 43-50. DOI: https://doi.org/10.1016/j.jhin.2020.12.027
6. Murni I, Duke T, Triasih R, Kinney S, Daley AJ, Soenarto Y. Prevention of nosocomial infections in developing countries, a systematic review. Paediatr Int Child Health. 2013;33:61-78. DOI: https://doi.org/10.1179/2046905513Y.0000000054
7. Murni IK, Duke T, Kinney S, Daley A, Soenarto Y. Reducing hospital-acquired infection and improving rational use of antibiotics in a developing country: an effectiveness study. Arch Dis Child. 2015;100:454-9. DOI: https://doi.org/10.1136/archdischild-2014-307297
8. Murni IK, Duke T, Kinney S, Daley AJ, Laksanawati IS, Rusmawatiningtyas D, *et al.* Multifaceted interventions for healthcare-associated infections and rational use of antibiotics in a low-to-middle-income country: Can they be sustained? PloS One. 2020;15:e0234233. https://doi.org/10.1371/journal.pone.0234233
9. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control. 2008;36:309-32. https://doi.org/10.1016/j.ajic.2008.03.002
10. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. Am J Infect Control. 1988;16:128-40. https://doi.org/10.1016/0196-6553(88)90053-3
11. Clinical and Laboratory Standards Institute. Methods for dilution of antimicrobial susceptibility tests for bacteria that grow aerobically; Approved Standard - 10th Edition. Wayne: CLSI Document M07-A10, Clinical and Laboratory Standards Institute; 2015.
12. Murni IK, Duke T, Daley AJ, Kinney S, Soenarto Y. True pathogen or contamination: validation of blood cultures for the diagnosis of nosocomial infections in a developing country. J Trop Pediatr. 2018;64:389-94. DOI: https://doi.org/10.1093/tropej/fmx081
13. Allegranzi B, Bagheri Nejad S, Combescure C, Graafmans W, Attar H, Donaldson L, *et al*. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet. 2011;377:228-41. DOI: https://doi.org/10.1016/S0140-6736(10)61458-4
14. Hassan R, El-Gilany AH, Abd Elaal AM, El-Mashad N, Azim DA. An overview of healthcare-associated infections in a tertiary care hospital in Egypt. Infect Prev Pract. 2020;2:100059. DOI: https://doi.org/10.1016/j.infpip.2020.100059
15. 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;94:364-72. DOI: https://doi.org/10.1016/j.jhin.2016.08.022
16. Duerink DO, Roeshadi D, Wahjono H, Lestari ES, Hadi U, Wille JC, *et al.* Surveillance of healthcare-associated infections in Indonesian hospitals. J Hosp Infect. 2006;62:219-29. https://doi.org/10.1016/j.jhin.2005.08.004
17. Klevens RM, Edwards JR, Richards CL Jr, Horan TC, Gaynes RP, Pollock DA, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep. 2007;122:160-6. https://doi.org/10.1177%2F003335490712200205
18. European Centre for Disease Prevention and Control. Annual epidemiological report on communicable diseases in Europe, 2008: Report on the State of Communicable Diseases in the EU and EEA/EFTA Countries. Stockholm: ECDC; 2008.
19. Allegranzi B, Pittet D. Healthcare-associated infection in developing countries: simple solutions to meet complex challenges. Infect Control Hosp Epidemiol. 2007;28:1323-7. https://doi.org/10.1086/521656
20. Murni IK, Duke T, Kinney S, Daley AJ, Wirawan MT, Soenarto Y. Risk factors for healthcare-associated infection among children in a low to middle income country. BMC Infect Dis. 2022:22;406. DOI: https://doi.org/10.1186/s12879-022-07387-2
21. Borg MA. Prevention and control of healthcare associated infections within developing countries. Int J Infect Control. 2010;6:1-6. DOI: https://doi.org/10.3396/ijic.v6i1.4356

22. Pittet D, Allegranzi B, Storr J, Bagheri Nejad SB, Dziekan G, Leotsakos A, *et al*. Infection control as a major World Health Organization priority for developing countries. J Hosp Infect. 2008;68:285-92. DOI: https://doi.org/10.1016/j.jhin.2007.12.013
23. Barrera L, Zingg W, Mendez F, Pittet D. Effectiveness of a hand hygiene promotion strategy using alcohol-based handrub in 6 intensive care units in Colombia. Am J Infect Control. 2011;39:633-9. DOI: https://doi.org/10.1016/j.ajic.2010.11.004
24. Ahmed NJ, Haseeb A, Elazab EM, Kheir HM, Hassali AA, Khan AH. Incidence of Healthcare-Associated Infections (HAIs) and the adherence to the HAIs' prevention strategies in a military hospital in Alkharj. Saudi Pharm J. 2021;29:1112-9. DOI: https://doi.org/10.1016/j.jsps.2021.08.012
25. NNIS. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. Am J Infect Control. 2004;32:470-85. DOI: https://doi.org/10.1016/j.ajic.2004.10.001
26. Salmanov A, Schlehlov D, Syyrydiuk O, Bortnik I, Mamonova M, *et al.* Epidemiology of healthcare-associated infections and mechanisms of antimicrobial resistance of responsible pathogens in Ukraine: a multicentre study. J Hosp Infect. 2023;131:129-38. DOI: https://doi.org/10.1016/j.jhin.2022.10.007
27. Khieosanuk K, Fupinwong S, Tosilakul A, Sricharoen N, Sudjaritruk T. Incidence rate and risk factors of central line-associated bloodstream infections among neonates and children admitted to a tertiary care university hospital. Am J Infect Control. 2022;50:105-7. DOI: https://doi.org/10.1016/j.ajic.2021.07.016
28. Jeffries HE, Mason W, Brewer M, Oakes KL, Munoz EI, Gornick W, *et al.* Prevention of central venous catheter-associated bloodstream infections in pediatric intensive care units: a performance improvement collaborative. Infect Control Hosp Epidemiol. 2009;30:645-51. DOI: https://doi.org/10.1086/598341
29. Rosenthal VD, Yin R, Lu Y, Rodrigues C, Myatra SN, Kharbanda M, *et al.* The impact of healthcare-associated infections on mortality in ICU: a prospective study in Asia, Africa, Eastern Europe, Latin America, and the Middle East. Am J Infect Control. 2023;51:675-82. DOI: https://doi.org/10.1016/j.ajic.2022.08.024