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ORIGINAL ARTICLE

Healthcare-associated infections in COVID-19 and non-COVID-19 patients during the SARS-CoV-2 pandemic in an Indonesian Referral Hospital

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Abstract

Background: Low- and middle-income countries (LMICs) face more challenges in overcoming healthcare-associated infections (HAIs) due to limited data surveillance, especially during the COVID-19 pandemic. We investigated the epidemiology and relationships between HAIs and COVID-19 status in a referral hospital in Indonesia.

Methods: A retrospective study was conducted at Universitas Indonesia Hospital from 2021 to 2022. HAI types were categorized into ventilator-associated event (VAE), central line-associated bloodstream infection (CLABSI), and catheter-associated urinary tract infections (CAUTIs). Data were collected from the inpatient ward, emergency department, and intensive care unit. The association among HAIs, COVID-19, and isolated bacteria was analyzed descriptively, and multivariate logistic regression for potential risk factors.

Results: We evaluated 255 patients who experienced HAIs, including 159 patients with COVID-19. The incidence of CLABSI was significantly associated with COVID-19 patients ($P < 0.001$), whereas the occurrence of VAE was significantly lower ($P = 0.001$). There was no significant association with CAUTI ($P = 0.870$). *Acinetobacter baumannii* was isolated as a common cause of HAIs (19%). Carbapenem resistance rates were high among *A. baumannii* (89.8%) and *Pseudomonas aeruginosa* (86.9%). Risk factors of CLABSI included COVID-19 status and chronic renal disease, while that of VAE included sex-male (aOR = 1.97).

Conclusions: CLABSI was significantly associated with the occurrence of HAIs in patients with COVID-19, while VAE was low, and CAUTI was not significantly impacted. In addition, the isolation rate of carbapenem-resistant bacteria was high. It highlights the urgent need to strengthen the infection prevention and control and antimicrobial stewardship (AMS) approaches through continuous education, monitoring, and enhanced surveillance efforts at the facility level.

Keywords: *healthcare-associated infections*; *infection prevention control*; *carbapenem-resistant*; *COVID-19*

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Healthcare-associated infections (HAIs) and antimicrobial resistance (AMR) now pose a global health threat. Worldwide, it is estimated that out of 100 patients, seven in high-income countries (HICs) and 15 patients in LMICs develop HAIs (1). LMICs face more challenges in overcoming HAIs because of limited data surveillance on which patient characteristics are most affected, and targeted interventions could be most effective. In contrast, most data come from HICs and upper-middle-income countries (UMICs) that give comprehensive HAIs data and guide targeted efforts (1–3).

A systematic review reported that the overall prevalence of HAIs in some Southeast Asian countries (Cambodia, Indonesia, Malaysia, Singapore, Thailand, and Vietnam) was 21.6% (4). Meanwhile, World Health Organization (WHO) reported that the HAIs rate was between 7 and 22% worldwide, which means the rate is nearing the upper limit, indicating the need for urgent action (4). Additionally, among those Southeast Asian countries, Indonesia has the highest prevalence rate (30.4%) (4).

During the COVID-19 outbreak, healthcare facilities became overcrowded, leading to increased hospital admissions and extended stays, which increased the risk of HAIs. The surge in patient numbers and rapid virus spread strained healthcare facilities, especially in LMICs with limited resources (5). Studies about the impact of COVID-19 on the prevalence of HAIs are mostly reported from HICs. In Italy, the prevalence of HAIs significantly increased during the pandemic compared to the pre-pandemic period (6). In the US, hospitals reported a 60% increase in central line-associated bloodstream infection (CLABSI) cases during the pandemic (7).

The HAIs' evaluation during the COVID-19 pandemic in Asia and LMICs is still inadequate. In a previous systematic review study reported from 67 selected studies, most of the HAIs studies are from HICs (68.7%), followed by the UMICs (17.9%), 11.9% from LMICs, and only 1 study from low-income countries (LICs) (1.49%) (8). In Nepal, there was an initial study in 2023 that revealed 96% of isolated bacteria from ventilator-associated event (VAE) patients were multidrug resistant (9). A study from a hospital in Singapore found a decrease in the cumulative incidence of healthcare-associated respiratory-viral infection (10). In Taiwan, infection prevention and control (IPC) measures during COVID-19 have reduced Vancomycin Resistant Enterococci (VRE), and in Singapore, MRSA infection decreased because of a comprehensive multimodal IPC bundle (11).

Since the COVID-19 pandemic, policies have increasingly emphasized IPC, making it essential to implement IPC while maintaining routine tasks typically performed during non-pandemic periods of COVID-19. However, the evaluation of the variations in HAIs types and contributing factors between patients with and without COVID-19 has not been extensively investigated in LMICs. Comprehending these distinctions and the prevalence of secondary infections in healthcare institutions during the pandemic is paramount. Severe Acute Respiratory Syndrome-Coronavirus 2 (SARS-CoV 2)

Methods

Study design and setting

This is a retrospective, hospital-based descriptive study. This study was conducted at Universitas Indonesia Hospital in Depok City, West Java, Indonesia. Since 2020, the hospital has been designated as a COVID-19 referral hospital. In 2022, 222 beds and more than 7,000 patients were admitted per year in the ward, high care unit, and intensive care unit. In 2024, more than 17,000 patients were admitted. We collected the electronic medical records and laboratory results for 2 years, from January 1, 2021, to December 31, 2022.

Patients enrolled in the study criteria

Inclusion criteria of this study were adult patients (aged over 18); hospitalized for at least 3 days; patients with positive culture results of blood, sputum, or urine; diagnosed HAIs; and stayed in the inpatient ward (isolation and non-isolation ward), Emergency Department, and intensive care unit (ICU) during the study period.

Data collection

The types of HAIs were assessed using the modified criteria for CLABSI, catheter-associated urinary tract infection (CAUTI), and VAE (the HAIs criteria are described in Supplementary Table 1). Due to the limited medical information and HAIs surveillance data during the pandemic, modified HAIs definition criteria from National Healthcare Safety Network (NHSN) and Centers for Disease Control and Prevention (CDC) were developed in this study.

The status of COVID-19 was obtained from the electronic medical record system and the 10th International Classification of Diseases (ICD 10) or Polymerase Chain Reaction (PCR) Severe Acute Respiratory Syndrome-Coronavirus 2 (SARS-CoV 2) result. Culture results and the Minimal Inhibitory Concentration (MIC) data information were collected using the automated microdilution method. The breakpoints of the antibiotic susceptibility testing were obtained based on Clinical & Laboratory Standards Institute (CLSI) M100.

Positive culture results were obtained during the hospital stay. For each patient, the first positive culture after more than 2 days of admission was included in the analysis to identify HAIs. Subsequent cultures from the same patient and same specimens were excluded to avoid duplication of infection episodes.

Primary, secondary, or more diagnosis, comorbidity, device days, anthropometry information, and steroid use were also obtained in this study. Variables for trauma, asthma, and Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome (HIV/AIDS) were excluded from the analysis owing to insufficient data.

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Data analysis

Categorical variables are summarized as frequencies and percentages. Continuous variables were calculated as mean for normal distribution and median interquartile range (IQR) for non-normal distribution. The associations/differences of COVID-19 status and types of HAIs were identified using chi-square, χ^2. The associations between COVID-19 status and device days were evaluated using the Wilcoxon rank sum/Mann-Whitney test.

The possible HAIs-associated factors were analyzed using crude odds ratios (crude ORs). Variables with p-values less than 0.05 were included to calculate adjusted ORs, with a significance level set at $P < 0.05$. Data were analyzed using STATA/BE 17.0 (StataCorp LLC, 2023).

Results

Patient characteristics, incidence rate, and device days of HAIs

In total, 255 patients with 311 HAIs diagnoses were enrolled (some patients had more than one episode of HAIs) (Table 1). COVID-19 patients were 62.3% (n = 159). The incidence of CLABSI was higher in COVID-19 patients, and VAE was significantly lower in patients with COVID-19 (66% vs. 31.3% ($P < 0.01$), and 47.8% vs. 69.8% ($P = 0.001$)), while the incidence of CAUTI was not significantly different. The duration of device use (ventilator, central line, and urinary catheter) was not normally distributed. Patients without COVID-19 who use these devices showed significantly longer device days.

Isolated microorganisms grouped by the COVID-19 status and type of HAIs

In the analysis of 311 HAIs cases, the distribution of the isolated microorganisms differed depending on the type of HAIs, but gram-negative rod-shaped bacteria accounted for the majority (Table 2).

In the multivariate analysis, the association between CLABSI and COVID-19 remained high (aOR=2.28); however, the association with VAE decreased (aOR = 0.46). As shown in Table 3, VAE showed significantly higher rates of *Acinetobacter baumannii* isolation in patients with COVID-19, but other HAIs pathogens, such as *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, were more frequently isolated in non-COVID-19 patients. However, in CLABSI and CAUTI, the frequency of isolation of *Acinetobacter baumannii* was higher in non-COVID-19 patients, and particularly, the frequency of isolation of *K. pneumoniae*, including Extended-Spectrum Beta-Lactamases (ESBL)-producing strains, was higher in COVID-19 patients in CLABSI.

Table 1. Baseline demographic information

Variables	Overall	COVID-19	Non-COVID-19	*P*
	N = 255 (%)	*N* = 159 (%)	*N* = 96 (%)	
Age				
< 60 years	138 (54.1)	99 (62.3)	39 (40.6)	-
≥ 60 years	117 (45.9)	60 (37.7)	57 (59.4)	-
Median	58	57	63	-
IQR	26–82	28–80	37–79	-
Sex				
Male	129 (50.6)	84 (52.8)	45 (46.9)	-
Female	126 (49.4)	75 (47.2)	51 (53.1)	-
Ward Location				
ICU	229 (89.8)	139 (87.4)	90 (93.8)	-
General Wards	26 (10.2)	20 (12.6)	6 (6.3)	-
Emergency ward	0 (0.0)	0 (0.0)	0 (0.0)	-
Medical Device Use				
Ventilator	188 (73.7)	106 (66.7)	82 (85.4)	0.001
Central Line	246 (96.5)	153 (96.2)	93 (96.9)	0.786
Catheter Urine	244 (95.7)	149 (93.7)	95 (99.0)	0.046
Medical Device's Days (median)				
Ventilator Days	7	5	13	<0.001
Central Line Days	10	8	14	<0.001
Catheter Urine Days	11	9	16	<0.001

Table 2. Microorganisms isolated

Microorganism	Overall	COVID-19	Non-COVID-19
	N = 311 (%)	*N* = 202 (%)	*N* = 109 (%)
Gram negative rods (*n* = 247)			
Acinetobacter baumannii	59 (19.0)	46 (22.8)	13 (11.9)
Klebsiella pneumoniae	38 (12.2)	24 (11.9)	14 (12.8)
Pseudomonas aeruginosa	23 (7.4)	2 (1.0)	21 (19.3)
ESBL-*producing Klebsiella pneumoniae*	21 (6.8)	18 (8.9)	3 (2.8)
Escherichia coli	16 (5.1)	13 (6.4)	3 (2.8)
Chryseomonas luteola	12 (3.9)	8 (4.0)	4 (3.7)
ESBL-*producing Escherichia coli*	12 (3.9)	8 (4.0)	4 (3.7)
Stenotrophomonas maltophilia	9 (2.9)	4 (2.0)	5 (4.6)
Klebsiella pneumoniae ss. ozoneae	8 (2.6)	6 (3.0)	2 (1.8)
Pseudomonas putida	5 (1.6)	2 (1.0)	3 (2.8)
Acinetobacter lwoffii	5 (1.6)	4 (2.0)	1 (0.9)
Raoultella terrigena	4 (1.3)	3 (1.5)	1 (0.9)
Klebsiella oxytoca	4 (1.3)	3 (1.5)	1 (0.9)
Enterobacter cloacae	4 (1.3)	3 (1.5)	1 (0.9)
Citrobacter freundii	3 (1.0)	1 (0.5)	2 (1.8)
Proteus mirabilis	2 (0.6)	1 (0.5)	1 (0.9)
Serratia plymuthica	2 (0.6)	1 (0.5)	1 (0.9)
ESBL-*producing Klebsiella pneumoniae ss. Ozoneae*	2 (0.6)	2 (1.0)	0 (0.0)
Pseudomonas fluorescens	2 (0.6)	1 (0.5)	1 (0.9)
Serratia marcescens	2 (0.6)	0 (0.0)	2 (1.8)
Others	14 (4.5)	6 (3.0)	8 (7.4)
Gram negative Cocci (*n* = 0)	0 (0.0)	0 (0.0)	0 (0.0)
Gram positive Rods (*n* = 5)			
Corynebacterium diphtheroids	2 (0.6)	2 (1.0)	0 (0.0)
Corynebacterium sp.	2 (0.6)	2 (1.0)	0 (0.0)
Corynebacterium jeikeium	1 (0.3)	1 (0.5)	0 (0.0)
Gram positive Cocci (*n* = 64)			
Enterococcus faecalis	16 (5.1)	14 (6.9)	2 (1.8)
Staphylococcus haemolyticus	9 (2.9)	4 (2.0)	5 (4.6)
Staphylococcus epidermidis	6 (1.9)	2 (1.0)	4 (3.7)
Staphylococcus aureus	6 (1.9)	4 (2.0)	2 (1.8)
Staphylococcus warneri	6 (1.9)	5 (2.5)	1 (0.9)
Staphylococcus lugdunensis	6 (1.9)	4 (2.0)	2 (1.8)
Enterococcus faecium	5 (1.6)	4 (2.0)	1 (0.9)
Staphylococcus hominis ss hominis	2 (0.6)	2 (1.0)	0 (0.0)
Staphylococcus saprophyticus	2 (0.6)	2 (1.0)	0 (0.0)
Others	6 (1.9)	4 (1.5)	3 (2.8)

The carbapenem resistance rate was 89.8% for *A. baumannii* and 86.9% for *P. aeruginosa*.

COVID-19 status with comorbidity

Most patients had comorbidity (Table 4). The underlying disease criteria are shown in Supplementary Table 5. Compared to non-COVID-19 patients, COVID-19 patients had a lower frequency of cardiovascular disease, neurological disease, and tuberculosis but a higher frequency of obesity. Steroid use among COVID-19 status was not analyzed in the bivariate analysis because most patients with COVID-19 received it as a therapy.

Factors associated with HAIs

In the crude OR results, for CLABSI, COVID-19 infection and obesity were considered risk factors, while age and neurological disease were not related to the occurrence of CLABSI (Table 5). For VAE, male sex and

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Table 3. Bivariate analysis between type of HAIs and COVID-19 status

Microorganism	Overall	COVID-19	Non-COVID-19	*P*
	N = 255 (%)	*N* = 159 (%)	*N* = 96 (%)	
VAE	143 (56.1)	76 (47.8)	67 (69.8)	**0.001**
Acinetobacter baumannii	43 (30.1)	36 (47.4)	7 (10.5)	**< 0.001**
Pseudomonas aeruginosa	22 (15.4)	2 (2.6)	20 (29.9)	**< 0.001**
Klebsiella pneumoniae	15 (10.5)	7 (9.2)	8 (11.9)	0.595
Stenotrophomonas maltophilia	7 (4.9)	2 (2.6)	5 (7.5)	0.182
ESBL-producing Klebsiella pneumoniae	6 (4.2)	4 (5.3)	2 (3.0)	0.498
Others	50 (34.9)	25 (32.9)	25 (37.2)	-
CLABSI	135 (52.9)	105 (66.0)	30 (31.3)	**< 0.001**
Klebsiella pneumoniae	16 (11.9)	12 (11.4)	4 (13.3)	0.776
ESBL-producing Klebsiella pneumoniae	14 (10.4)	14 (13.3)	0 (0.0)	0.035
Acinetobacter baumannii	13 (9.6)	9 (8.6)	4 (13.3)	0.436
Enterococcus faecalis	11 (8.2)	10 (9.5)	1 (3.3)	0.274
Staphylococcus haemolyticus	8 (5.9)	4 (3.8)	4 (13.3)	0.051
Others	73 (54)	56 (53.4)	17 (56.8)	-
CAUTI	33 (12.9)	21 (13.2)	12 (12.5)	0.870
Escherichia coli	9 (27.3)	8 (38.1)	1 (8.3)	0.065
Klebsiella pneumoniae	7 (21.2)	5 (23.8)	2 (16.7)	0.629
Enterococcus faecalis	5 (15.2)	4 (19.1)	1 (8.3)	0.409
ESBL-producing Escherichia coli	3 (9.1)	1 (4.8)	2 (16.7)	0.252
Acinetobacter baumannii	3 (9.1)	1 (4.8)	2 (16.7)	0.252
Others	6 (18.1)	2 (9.4)	4 (33.3)	-

Bold values indicate statistically significant results ($p < 0.005$)

Table 4. Bivariate analysis of COVID-19 status and comorbidities

Variables	Overall	COVID-19	Non-COVID-19	*P*
	N = 255 (%)	*N* = 159 (%)	*N* = 96 (%)	
Sex				
Male	129 (50.6)	84 (52.8)	45 (46.9)	0.357
Comorbidity				
Yes	242 (94.9)	148 (93.1)	94 (97.9)	
Numbers of Comorbidities	2 (0.9)	2 (0.9)	2 (0.8)	
Cardiovascular Disease	190 (74.5)	109 (68.5)	81 (84.4)	**0.005**
Nervous System Disease	92 (36)	23 (14.5)	69 (71.9)	**< 0.001**
Diabetes Mellitus	131 (51.4)	92 (57.9)	39 (40.6)	0.008
Trauma	2 (0.8)	1 (0.6)	1 (1.0)	0.717
Obesity	70 (27.45)	63 (39.6)	7 (7.3)	**< 0.001**
Asthma	2 (0.8)	1 (0.6)	1 (1.0)	0.717
Chronic Obstructive Pulmonary Disease (COPD)	3 (1.2)	1 (0.6)	2 (2.1)	0.297
Chronic Kidney Disease (CKD)	28 (11.0)	14 (8.8)	14 (14.6)	0.153
Tuberculosis	11 (4.3)	2 (1.3)	9 (9.4)	**0.002**
Immunocompromise				
HIV/AIDS	4 (1.6)	3 (1.9)	1 (1.0)	0.599
Cancer	8 (3.1)	3 (1.9)	5 (5.2)	0.140
Steroid	190 (74.5)	151 (95.0)	39 (40.6)	

Bold values indicate statistically significant results ($p < 0.005$)

Table 5. Crude and adjusted odd ratios of HAIs

Variables	Crude OR						Adjusted OR			
	VAE		CLABSI		CAUTI		VAE		CLABSI	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	1.01 (0.99–1.03)	0.152	0.96 (0.95–0.98)	**0.003**	1.01 (0.97–1.03)	0.672	1.00 (0.98–1.02)	0.732	0.98 (0.96–1.00)	0.177
Sex										
Male	1.85 (1.12–3.06)	**0.015**	0.65 (0.39–1.06)	0.088	0.65 (0.39–1.06)	0.535	1.97 (1.16–3.34)	**0.012**	0.58 (0.33–1.00)	0.051
COVID Status										
COVID-19	0.39 (0.23–0.67)	**0.001**	4.07 (2.37–6.99)	**<0.001**	0.89 (0.42–1.84)	0.757	0.46 (0.23–0.90)	**0.025**	2.28 (1.17–4.43)	**0.014**
Comorbid										
Cardiovascular Disease	0.87 (0.49–1.55)	0.654	0.97 (0.55–1.71)	0.924	1.77 (0.70–4.48)	0.227	0.64 (0.34–1.20)	0.170	1.80 (0.93–3.48)	0.080
Nervous System Disease	2.43 (1.41–4.17)	**0.001**	0.28 (0.16–0.48)	**<0.001**	1.59 (0.77–3.28)	0.204	1.78 (0.91–3.50)	0.091	0.54 (0.28–1.05)	0.073
Diabetes Mellitus	1.10 (0.67–1.80)	0.698	1.21 (0.74–1.99)	0.432	1.14 (0.55–2.34)	0.711	1.33 (0.77–2.28)	0.296	0.97 (0.55–1.69)	0.917
Obesity	0.70 (0.39–1.24)	0.229	3.23 (1.74–5.955)	**<0.001**	0.71 (0.30–1.68)	0.44	1.07 (0.56–2.02)	0.834	1.83 (0.92–3.63)	0.082
COPD	1	(-)	0.43 (0.03–4.84)	0.497	1	(-)	1	(-)	0.55 (0.03–7.84)	0.664
CKD	0.39 (0.17–0.88)	**0.025**	1.98 (0.86–4.57)	0.107	1.42 (0.50–4.04)	0.503	0.32 (0.13–0.77)	**0.011**	2.97 (1.20–7.37)	**0.019**
Tuberculosis	1.38 (0.39–4.87)	0.607	1.05 (0.31–3.54)	0.934	1	(-)	1.19 (0.31–4.54)	0.791	2.03 (0.54–7.64)	0.290
Cancer	0.45 (0.10–1.96)	0.293	0.87 (0.21–3.56)	0.848	0.89 (1.06–7.50)	0.919	0.51 (0.10–2.45)	0.403	1.09 (0.24–4.96)	0.903

Bold values indicate statistically significant results ($p < 0.05$)

neurological disease were considered as risk factors, while COVID-19 infection and CKD were not considered risk factors. For CAUTI, no clear risk factors were identified.

In the calculation of the adjusted OR, it was thought that COVID-19 infection and CKD were risk factors for CLABSI, and that male sex was a risk factor for VAE, but it was thought that COVID-19 infection and CKD were not related to VAE.

Discussion

This study showed that COVID-19 infection might lead to more CLABSI, and this result might align with previous report (12), while VAE prevalence was not high in the COVID-19-positive patients. Furthermore, in the context of HAIs infections, numerous gram-negative rod-shaped bacteria, including *Acinetobacter* ssp., *Klebsiella* ssp., and *Pseudomonas aeruginosa*, have been identified as common causative agents. It has been observed that over 80% of these bacterial strains exhibit resistance to carbapenems. The proportion of drug-resistant Gram-Negative Rods (GNR) in HAIs was higher than previously reported in Saudi Arabia. Multidrug Resistance (MDR) was 40.59%, and Carbapenem-resistant *Enterobacteriaceae* was 21.78% (13).

COVID-19 patients might be more susceptible to CLABSI. One of the risk factors of CLABSI might be the use of steroids like dexamethasone (14). Corticosteroids are anti-inflammatory medications and have immunosuppressive effects by suppressing macrophage production such as Interleukin-1 and Interleukin-6 (15). During the COVID-19 pandemic, corticosteroids are widely used to treat COVID-19 patients. In the study about COVID-19 and secondary infections, patients with steroid therapy had longer stay, intubation day, and higher frequency of secondary infections (16). Due to the use of steroids in combination therapy in many COVID-19 cases, comparative evaluation analysis was complex.

Other possible reasons for increased CLABSI in COVID-19 patients were decreased central line care during insertion, maintenance owing to overwhelmed staff, and the challenges of monitoring patients in prone positions (17). In this study, data on the adequacy of bundle of CLABSI were not available. During the COVID-19 pandemic, IPC monitoring and audits were limited, and the CLABSI prevention bundles compliance may have been compromised due to the overwhelmed healthcare system. Although this study did not examine central line management, it was possible that the care typically provided before the COVID-19 pandemic disaster was less attentive than it usually would have been. In addition, limited compliance with CLABSI prevention bundles during the pandemic may have contributed to the increased incidence of CLABSI. These bundles, which include for central line insertion and maintenance, are effective in reducing CLABSI rates (18). For example, a study conducted in a coronary ICU of a cardiac hospital reported a reduction in CLABSI incidence from 3.1 per 1,000 device-days (2015–2016) to 0.4 per 1,000 device-days (2017–2019), following the implementation of CLABSI bundles that emphasized teamwork, compliance monitoring, and feedback (18).

In our research, COVID-19 patients were less likely to develop VAE. There are several possible explanations for our findings. First, COVID-19 patients had fewer comorbidities than non-COVID-19 patients. More than half (84.4 and 71.9%) of the patients with cardiovascular and nervous system diseases were non-COVID-19 patients, Table 4. The number and severity of comorbidities were reported as the risk factors for HAIs (19), but in our study, we could not find the difference in the number of comorbidities between COVID-19 status and did not investigate the severity of comorbidities. Second, median ventilator days in COVID-19 patients were shorter (5 days) than those for non-COVID-19 patients (13 days). The device duration was reported as the strongly associated factor with developing HAIs (20), and this result might be consistent with the report. Third, over half of COVID-19 patients were younger than 60 (62.3%). Previous research has shown that the incidence of HAIs is higher in those over 65 years old (21). Patient age might be a confounding factor in the risk of developing VAE in COVID-19 patients in this study.

This study described patients' demographics with and without COVID-19 by age and sex. Most patients with COVID-19 were adults below 60 years, while non-COVID-19 patients had a higher proportion of elderly patients aged 60 years and above. This result aligns with a previous study in Indonesia, which reported that 79% of patients with COVID-19 were in the 19–64 age group (22). No significant gender differences were observed among COVID-19 patients, consistent with earlier studies, showing that 52% of patients with COVID-19 were male (23). Most patients were from the ICU, followed by general wards. This confirms previous findings that HAIs are 5–10 times more frequent in the ICU than in other wards (24). In the ICU, patients are often in critical condition and require more invasive devices, such as mechanical ventilation. No HAIs cases were reported in the emergency ward, possibly because patients are typically transferred to the ICU or general wards within 3 days after being admitted to the emergency ward. Another reason is that culture tests are often conducted in other wards for patients with prolonged stays in the emergency ward.

In this study, gram-negative rods were the most common bacteria isolated from HAIs, but there was a bias in the species. In VAE patients with COVID-19, *Acinetobacter baumannii* was isolated significantly more frequently, but the frequency of isolation of *Pseudomonas aeruginosa*, which is often isolated as a cause of HAIs, was significantly lower. One of the possible reasons for this bias might be steroid therapy. Steroid therapy is considered a risk factor for *A. baumannii* infection in COVID-19 patients (25), and in this study, almost all COVID-19 patients (95%) received steroids. When a patient with COVID-19 is suspected of having VAE, it was thought that treatment that covers *Acinetobacter* should be considered regarding the antibiogram.

Among CLABSI, the primary causative agents were *Klebsiella pneumoniae*. More than half of the *K. pneumoniae* isolated from CLABSIs in patients with COVID-19 were ESBL-producing bacteria. Interestingly, all patients with CLABSI caused by ESBL-producing *K. pneumoniae* had received corticosteroid therapy, although the difference was not statistically significant. Previous studies reported that the corticosteroid usage, particularly higher doses, increases the risk of infection, including ESBL-producing *K. pneumoniae* (26, 27). The mechanism involves corticosteroid-induced immunosuppression and hyperglycemia, which can impair host defense and more susceptible with infection (26, 27). Therefore, although our findings did not show statistical significance, the observed trend suggests possible further investigation.

The rate of ESBL-producing *K. pneumoniae* in the study site's antibiogram was 67.8%, which was higher than the isolation rate in CLABSIs in patients with COVID-19. As a reason for this, past reports have shown a potential association between COVID-19 infection and increased prevalence of ESBL-producing *K. pneumoniae.* A possible contributing factor is the widespread use of antibiotics since the beginning of the pandemic for the COVID-19 management, which may lead to increased antibiotic-resistant strains (28).

In CAUTI patients, the most isolated bacteria were *E. coli* and *K. pneumoniae*, consistent with the previous report (29).

This study showed that the carbapenem resistance ratio of *Acinetobacter baumannii* and *Pseudomonas aeruginosa* was high at the study site, regardless of patients' COVID-19 status. The spread of carbapenem resistance has also been reported in other regions during the COVID-19 pandemic (30), indicating the difficulty of selecting the first drug to use in the empiric therapy of patients with HAIs. The results of this study also highlight the need to promote the appropriate use of antimicrobial agents in the future.

During the pandemic, the hospital made great efforts to manage COVID-19, including re-bedding, providing Personal Protective Equipment (PPE), and protecting staff. Healthcare workers had higher workloads and limited human resources. In LMIC, which has limited human resources and professional experts, IPC activities focus more on COVID-19 policy and management. The primary barriers in LMICs might be inadequate information systems, medical records, diagnostic tests, and a lack of professional expertise. Although HAIs are preventable, these resource limitations make prevention difficult.

Some studies investigated challenges to implementing IPC in LMIC during the COVID-19 pandemic (31). Based on the results of this study, it is necessary to promote IPC and thoroughly implement basic infection control measures in Indonesia in the future.

Limitations of this study

This study has some limitations. First, the usage of antimicrobials was not monitored. Analyzing the relationship between the increase in resistant bacteria and the antimicrobial stewardship (AMS) approach is not feasible. Second, the definitions of HAIs were modified for this study due to the limited settings of information resources. The disease definitions in this study were simplified, making it difficult to compare with studies using universal disease definitions. Third, we could not collect information on hand hygiene practices, proper use of PPE, and hand sanitizing alcohol usage because IPC programs were disrupted during the COVID-19 pandemic. However, we believe this study might be valuable, particularly in countries lacking HAIs surveillance data. In the future, LMICs will also need to build systems that can collect information more easily and reliably and better use the data.

Conclusion

This study showed that CLABSI was the most common HAIs in patients with COVID-19, VAE was rare, and CAUTI was not significantly affected. In addition, the distribution of causative bacteria was not uniform, and the rate of carbapenem resistance was also high. Although Indonesia has recently established a national HAIs surveillance system, the findings highlight the urgent need for enhanced IPC and AMS approaches through education, strengthened monitoring, and sustained surveillance efforts at the facility level.

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Author contributions

GMP was responsible for conceptual ideas, study design, data collection, methodology, analysis, and writing the manuscript. TT and SK were responsible for the study design, revising the manuscript, and supervised this research. DS, AI, and IPP were responsible for data collection and supervising this research. MT and KI were responsible for supervising this research. All the authors drafted, reviewed, and approved the final version of the manuscript.

Conflict of interests

The authors declare no potential conflicts of interests.

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Ethical approval statement

Ethics approval was obtained from the School of Tropical Medicine and Global Health-Nagasaki University, Japan (Approval number: NU_TMGH_2023_264_1) Institutional Review Board and Universitas Indonesia Hospital (Approval number: S-083/KETLIT/RSUI/XI/2023).

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