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Original Article

Healthcare-associated infections in Japanese hospitals: results from a large-scale multicenter point-prevalence survey in Aichi, 2020

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Abstract

Objective: Healthcare-associated infections (HAIs) pose significant challenges to healthcare systems worldwide. Epidemiological data are essential for effective HAI control; however, comprehensive information on HAIs in Japanese hospitals is limited. This study aimed to provide an overview of HAIs in Japanese hospitals.

Methods: A multicenter point-prevalence survey (PPS) was conducted in 27 hospitals across the Aichi Prefecture between February and July 2020. This study encompassed diverse hospital types, including community, university, and specialized hospitals. Information on the demographic data of the patients, underlying conditions, devices, HAIs, and causative organisms was collected.

Results: A total of 10,199 patients (male: 5,460) were included in this study. The median age of the patients was 73 (interquartile range [IQR]: 56–82) years, and the median length of hospital stay was 10 (IQR: 4–22) days. HAIs were present in 6.6% of patients, with pneumonia (1.83%), urinary tract infection (1.09%), and surgical site infection (SSI) (0.87%) being the most common. The prevalence of device-associated HAIs was 0.91%. *Staphylococcus aureus* (17.3%), *Escherichia coli* (17.1%), and *Klebsiella pneumoniae* (7.2%) were the primary pathogens in 433 organisms; 29.6% of the *Enterobacterales* identified showed resistance to third-generation cephalosporins. Pneumonia was the most prevalent HAI in small-to-large hospitals (1.69%–2.34%) and SSI, in extra-large hospitals (over 800 beds, 1.37%).

Conclusions: This study offers vital insights into the epidemiology of HAIs in hospitals in Japan. These findings underscore the need for national-level PPSs to capture broader epidemiological trends, particularly regarding healthcare challenges post-COVID-19.

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Introduction

Healthcare-associated infections (HAIs) are infections that patients acquire during treatment or surgery in healthcare

facilities, many of which are preventable through appropriate measures.[1] HAIs are serious events for patients, hospitals, and governments, leading to increased mortality, lengthy hospital stays, and increased medical costs.[2] The World Health Organization (WHO) reported that the prevalence of HAIs is 7% in high-income countries and 15% in low- and middle-income countries; the overall HAI-associated mortality rate is approximately 10%.[3] In the European Union and European Economic Area, more than 3.5 million cases of HAIs are estimated to occur each year, leading to more than 90,000 deaths.[1] Several factors increase the risk of acquiring HAIs, such as invasive surgical procedures, severity of illness, inappropriate infection prevention measures (eg, poor hand hygiene and prolonged use of devices), and inappropriate antibiotic use.[4] The control and prevention of HAIs have become a worldwide concern. Large-scale and precise inpatient data are essential for formulating effective policies to reduce HAI.

Catheter-related bloodstream infection (CRBSI), catheter-associated urinary tract infection (CAUTI), and ventilator-associated pneumonia (VAP) are well-known device-associated HAIs,[4] accounting for 9.8%–25.6% of all HAIs.[5,6] Targeted surveillance has been commonly conducted to monitor HAIs worldwide and can determine the incidence of these HAIs. However, it cannot provide a complete picture of the HAIs in a hospital at a particular time.

The point-prevalence survey (PPS) is a useful tool for understanding the prevalence of HAIs and antimicrobial use at a certain time. PPSs have been conducted worldwide, including a multistate PPS in the United States, a multi-country PPS in Europe, and a global PPS.[7–11] However, only small PPSs in one to four university hospitals and two community hospitals have been conducted in Japan, revealing the prevalence of HAIs to be 7.4%–9.0%.[5,12,13] This study aimed to investigate the epidemiology and characteristics of inpatients, HAIs, and causative organisms in Japanese hospitals using a multicenter PPS.

Methods

Setting and patients

Aichi Prefecture is in central Japan and is the fourth most populous prefecture, with approximately 7.5 million residents in 2020. Nagoya City is the most populous city in Aichi Prefecture, with approximately 2.3 million residents in 2020.[14] In 2020, there were 321 hospitals with 66,487 beds in Aichi Prefecture.[15] In the fiscal year 2019, 57 hospitals charged an infection prevention fee-1 (IPF-1). The IPF-1 can be charged when hospitals meet specific infection control criteria: having an infection control team (ICT), employing full-time ICT staff, conducting regular conferences on infection control with other hospitals, and mutually assessing infection control.[16]

Participating IPF-1 charged hospitals were recruited publicly via meetings or letters sent by the research group of our institution from January 2019 to October 2019. Letters were sent to the chief of ICT at each IPF-1 charged hospital and included the description of the PPS, the purpose of the study, and the benefits and expected burden of participation. First, multicenter PPSs were planned for use from February 2020 to April 2020. However, owing to the COVID-19 pandemic, the study period was extended to the end of July 2020.

All patients in the hospital at 9:00 am on the PPS day were eligible, except those who declined to participate. Due to the excessive workload imposed by the COVID-19 pandemic, participating hospitals were given the option to conduct either a full survey or a half survey. For the half survey, the initial step involved compiling a complete list of all patients. The selection of patients was then based on choosing either an odd or even number from the patient list number, with the decision on which numbering system to use left to the discretion of the hospital.

Data collection

The PPS protocol was adapted from the 2016 European Centre for Disease Prevention and Control (ECDC) PPS protocols version 5.3.[17] The collected data included hospital information (eg, bed count, hospital category, and staff), patient information (age, sex, admission date, ward type, department, and devices in place), specific underlying diseases (malignant tumor, hematological diseases, and bone marrow transplantation), active HAIs, causative pathogens, and antimicrobial use. A history of malignant tumor was excluded if the patient was clinically cured (eg, >5 years post-treatment).

Prior to data collection, the research group at our institution conducted comprehensive briefings for all participating hospitals. These briefings included a detailed explanation of the PPS protocol and definitions of HAIs. Updated questions and answers were distributed to the hospitals in a timely manner. Each hospital's surveyor, either an ICT member or a pharmacist, examined the patients' records. Hospitals identified the devices in place through medical records or interviews.

Ethical statement

This study complied with the Japanese Ethical Guidelines for Epidemiological Studies, and all study protocols were approved by the Institutional Review Board of Nagoya University Graduate School of Medicine (approval no. 15,728). The requirement for written informed consent was waived due to the retrospective nature of the study.

Definitions of HAIs

HAIs were defined according to the ECDC-PPS protocols and the 2019 version of the National Healthcare Safety Network (NHSN 2019) Patient Safety Component Manual.[17,18] The definitions of HAI in both the ECDC-PPS protocol 5.3 and NHSN 2019 are nearly identical but differ in some aspects. Supplementary Table S1 lists the codes and sources of the HAI used in this study.

Surgical site infection (SSI) is evaluated within 30 days after the operation if no implant is in place and within 90 days if an implant is present. Catheter-related infection (CRI) encompasses both CRBSI and CRI without positive blood culture. Laboratory-confirmed bloodstream infection (LCBI) is defined by at least one set of positive blood cultures under the following conditions: (1) no evident origin of infection, and (2) the development of at least two sets in cases involving common commensal organisms. It is important to note that LCBI does not include CRBSI. Notably, NHSN definitions do not encompass the category of systemic infection, which includes suspected infection without clear diagnosis (clinical sepsis) and viral infection (disseminated infection); thus, we adopted the systemic infection category from ECDC-PPS protocol 5.3.

In this study, active HAIs were defined as follows: (1) HAIs that met the definition of any HAIs for which antimicrobials were administered. (2) HAIs that developed 48 h after admission, patients who presented with an infection but were readmitted less

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Table 1. Background data of patients

	All patients (n = 10199)		Patients with HAI (n = 677)		Patients without HAI (n = 9522)		*P* value
Hospital Information							
Number of beds							
200–399	1584	(15.5)	92	(13.6)	1492	(15.7)	.55
400–599	3085	(30.2)	212	(31.3)	2873	(30.2)	
600–799	3411	(33.4)	230	(34.0)	3181	(33.4)	
800–	2119	(20.8)	143	(21.1)	1976	(20.8)	
Categories							
Community hospitals	7883	(77.3)	514	(75.9)	7369	(77.4)	.30
University hospitals	1593	(15.6)	105	(15.5)	1488	(15.6)	
Specialized hospitals	723	(7.1)	58	(8.5)	665	(7.0)	
Patients' Information							
Sex[a]							
Male	5460	(53.5)	405	(59.8)	5055	(53.1)	<.01
Age							
Median (IQR)	73	(56–82)	75	(63–85)	72	(55–82)	<.01
Categories							
0	311	(3.0)	17	(2.5)	294	(3.1)	<.01
1–4	156	(1.5)	7	(1.0)	149	(1.6)	
5–9	104	(1.0)	7	(1.0)	97	(1.0)	
10–17	151	(1.5)	12	(1.8)	139	(1.5)	
18–39	731	(7.2)	33	(4.9)	698	(7.3)	
40–64	2008	(19.7)	106	(15.7)	1902	(20.0)	
65–79	3605	(35.3)	271	(39.9)	3334	(35.0)	
80–	3133	(30.7)	224	(33.1)	2909	(30.5)	
Duration of hospital stay, day, median (IQR)	10	(4–22)	23	(13–40)	9	(4–21)	
Categories							
1–7	3959	(38.8)	75	(11.1)	3884	(40.8)	<.01
8–14	2245	(22.0)	118	(17.4)	2127	(22.3)	
15–30	2207	(21.6)	247	(36.5)	1960	(20.6)	
31–90	1492	(14.6)	194	(28.7)	1298	(13.6)	
91–180	199	(2.0)	27	(4.0)	171	(1.8)	
181–	97	(1.0)	16	(2.4)	81	(0.9)	
Baseline diseases							
Solid organ malignant tumor	2831	(27.8)	210	(31.1)	2621	(27.5)	.06
Hematological diseases	407	(4.0)	94	(13.9)	313	(3.3)	<.01
Bone marrow transplantation	59	(0.6)	26	(3.8)	33	(0.3)	<.01
Department							
Internal medicine	4671	(45.8)	334	(49.3)	4337	(45.5)	.04
Surgery	4247	(41.6)	280	(41.4)	3967	(41.7)	
Obstetrics and gynecology	493	(4.8)	14	(2.1)	479	(5.0)	
Pediatric internal medicine	338	(3.3)	22	(3.3)	316	(3.3)	
Neonetal medicine	180	(1.8)	12	(1.8)	168	(1.8)	
Psychiatrics	74	(0.7)	2	(0.3)	72	(0.8)	
Palliative care medicine	39	(0.4)	3	(0.4)	36	(0.4)	

(*Continued*)

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Table 1. (*Continued*)

	All patients (n = 10199)		Patients with HAI (n = 677)		Patients without HAI (n = 9522)		*P* value
Emergency medicine/Intensive care	18	(0.2)	2	(0.3)	16	(0.2)	
Others		(1.4)	8	(1.2)		(1.4)	
Units							
General units	9343	(91.6)	616	(91.0)	8727	(91.7)	.19
Intensive care units	365	(3.6)	34	(5.0)	331	(3.5)	
Chronic care units	188	(1.8)	12	(1.8)	176	(1.8)	
NICU/GCU	180	(1.8)	12	(1.8)	168	(1.8)	
MFICU	49	(0.5)	0	0 (0)	49	(0.5)	
Hospice	70	(0.7)	3	(0.4)	67	(0.7)	
Others	4	(0.0)	0	0 (0)	4	(0.0)	
Devices in place							
Peripheral venous catheter[b]	4040	(39.6)	413	(61.0)	3627	(38.1)	<.01
CVC/PICC/CV port	779	(7.6)	147	(21.7)	632	(6.6)	<.01
Urinary catheter	1358	(13.3)	158	(23.3)	1200	(12.6)	<.01
Tracheal-tracheostomy tube	161	(1.6)	37	(5.4)	124	(1.3)	<.01

Note. Data were presented unweighted number (percentage) of patients unless otherwise indicated. **Abbreviations:** HAI, healthcare-associated infection; CI, confidence interval; IQR, interquartile range; NICU, neonatal intensive care unit; GCU, growing care unit; MFICU, maternal and fetal intensive care unit; CVC, central venous catheter; PICC, peripherally inserted central venous catheter; CV; central venous.
[a, b]One missing data in patients without HAI.

than 48 h after previous admission to an acute care hospital, or patients meeting the definition of SSIs. "Device-associated HAIs" comprised VAP, CAUTI, and CRBSI.[17]

Statistical analysis

Categorical variables are presented as total number and percentages and evaluated using Fisher's exact test. Continuous variables are expressed as mean and interquartile ranges (IQR) and evaluated using the Mann–Whitney test. All statistical analyses were two-sided, and statistical significance was set at $P < .05$. All statistical analyses were performed using R (version 4.3.2; The R Foundation for Statistical Computing, Vienna, Austria).

Results

Table 1 summarizes the backgrounds of the hospitals and patients. Twenty-seven hospitals participated, including 22 community hospitals, 2 university hospitals, and 3 specialized hospitals (geriatric, pediatric and cancer hospitals). The hospital size categories were as follows: eight small (200–399 beds), nine medium (400–599 beds), seven large (600–799 beds), and three extra-large (800+ beds; one community and two university) hospitals. The hospitals were located in areas with varying population densities: 10 in high-density cities (Nagoya City, 7,121/km^2, 3,712 patients), 10 in medium-density areas (2,000–4,000/km^2, 4,408 patients), and 6 in low-density areas (<2,000/km^2, 2,079 patients) (Supplementary Table S2). Data were collected in February (10 hospitals), March (8 hospitals), and April–July 2020 (9 hospitals). A total of 10,199 patients were included, and none were excluded due to refusal or privacy concerns. Two community hospitals (medium and large) surveyed half of the inpatients, whereas 25 hospitals surveyed all inpatients. Of all the patients, 77.3% (7,883/10,199) were admitted to community hospitals. There was one missing data point each for sex and peripheral venous catheterization. The data of the participating hospitals and patients' information by hospital size are shown in Supplementary Table S3.

Of the 10,199 patients, 53.5% (5,460) were male. The median age of the patients was 73 (IQR: 56–82) years, and the median duration of hospital stay was 10 (IQR: 4–22) days. Patients in the intensive care unit (ICU) constituted 3.6% (365/10,199) of all patients. The prevalence of solid-organ malignant tumor, hematological diseases, and post bone marrow transplantation was 27.8%, 4.0%, and 0.6%, respectively. The prevalence of devices in place was as follows: peripheral venous catheters (PVC), 39.6%; central venous lines (including peripherally inserted central venous catheters and central venous ports), 7.6%; urinary catheters (UC), 13.3%; and tracheostomy tubes, 1.6%.

Overall, 6.6% (677/10,199; 95% confidence interval [CI]: 6.2–7.1) of the patients had at least one HAI. Of these, 26 (3.8%) patients had two HAIs. Patients with HAIs were significantly older (75 [IQR: 63–85] vs 72 [IQR: 55–82], $P < .01$) and had longer hospital stays (9 [IQR: 4–21] vs 23 [IQR: 13–40], $P < .01$) than those without HAIs. Patients with hematological diseases (13.9% [94/677] vs 3.3% [313/9,523], $P < .01$) and bone marrow transplantation (3.8% [94/677] vs 3.3% [313/9,523], $P < .01$) had a significantly higher rate of HAIs than those without HAIs.

Table 2 lists the HAIs and their causative organisms. A total of 703 active HAIs were identified in 677 patients. Pneumonia (1.87%, 95% CI: 1.59–2.11), urinary tract infection (UTI, 1.09%, 95% CI: 0.90–1.30), systemic infection (1.08%, 95% CI: 0.90–1.30), SSI (0.87%, 95% CI: 0.71–1.07), and gastrointestinal system infection (GI, 0.70%, 95% CI: 0.54–0.88) were the top five HAIs. The prevalence of the total device-associated HAIs was 0.91% (93/10,199; 95% CI: 0.74–1.12). Figure 1 shows the prevalence of HAIs

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Table 2. Number and prevalence of healthcare-associated infections

Healthcare-associated infections	Total (n = 703)	Prevalence (%)	95% CI
Pneumonia	187	1.83	1.59–2.11
(Ventilator-associated pneumonia)	(21)		
Urinary tract infection	111	1.09	0.90–1.30
(Catheter-associated urinary tract infections)	(49)		
Systemic infections	110	1.08	0.90–1.30
(Clinical sepsis)	(100)		
(Viral infection)	(10)		
Surgical site infection	89	0.87	0.71–1.07
Gastrointestinal system infection	71	0.70	0.55–0.88
(*Clostridioides difficile* infection)	(10)		
Catheter-related infection	34	0.33	0.24–0.47
(Catheter-related bloodstream infections)	(23)		
Laboratory-confirmed bloodstream infection	33	0.32	0.23–0.45
Skin and soft tissue infection	21	0.21	0.13–0.31
Bone and joint infection	14	0.14	0.06–0.19
Eye, ear, nose, or mouth infection	11	0.11	0.05–0.17
Lower respiratory tract infection, other than pneumonia	9	0.09	0.04–0.17
Cardiovascular system infection	5	0.05	0.02–0.11
Central nervous system infection	5	0.05	0.02–0.11
Reproductive tract infection	3	0.03	0.01–0.09

Note. Data were presented unweighted number of healthcare-associated infections or causative pathogens. Prevalence was calculated as follows: (number of infection)*100/total patients (10,199). **Abbreviations:** CI, confidence interval; VAP, Ventilator-associated pneumonia; CAUTI, Catheter-associated urinary tract infections; R, resistant; 3GC, third-generation cepharosporin.

according to hospital size. Pneumonia was the most common HAI in small (2.34%, 95% CI: 1.65–3.21), medium (1.69%, 95% CI: 1.26–2.20), and large (2.20%, 95% CI: 1.73–2.75) hospitals. SSI was the top HAI in extra-large hospitals (1.37%, 95% CI: 0.92–1.96). Pneumonia and UTI accounted for 60.2% (56/93) of HAI in small hospitals, while 38.2% (83/217) in medium, 48.7% (116/238) in large, and 31.6% (49/155) in extra-large hospitals.

A total of 433 causative pathogens were identified for the HAIs. *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae* were the most common organisms. Only 10 *Clostridioides difficile* cases were identified. A total of 135 *Enterobacterales* were identified, of which 29.6% (40/135), 33.3% (45/135), and 2.2% (3/135) were resistant to third-generation cephalosporins (3GCs), fluoroquinolones (FQs), and carbapenems (CARs), respectively. Forty-five *Enterococci* were identified, but no vancomycin-resistant enterococci (VRE) were detected. Three *Acinetobacter baumannii* strains were identified in this study, all of which were drug-susceptible to CARs, FQs, and aminoglycosides. Table 3 shows the causative organisms of the HAIs. UTIs had the most causative organisms, followed by pneumonia. *E. coli* was the most common causative organism of UTIs; 34.1% and 43.2% of the *E. coli* strains detected in UTIs were resistant to 3GCs and FQs, respectively. S*treptococcus aureus* and *Pseudomonas aeruginosa* were the top two most frequent pathogens in pneumonia, and 50.0% of the *S. aureus* strains isolated from pneumonia were methicillin-resistant Staphylococcus aureus (MRSA). Supplementary Table S4 displays the relationship between the pathogens of HAIs and hospital size.

Discussion

This study reports the epidemiology in Japanese hospitals in Aichi Prefecture from February 2020 to July 2020. To our knowledge, this is the largest multicenter PPS conducted in Japanese hospitals. This PPS also revealed the epidemiology of hospitalized patients. The prevalence of HAIs (6.7%), details of HAI according to hospital size, and causative organisms with or without resistance are reported in this survey.

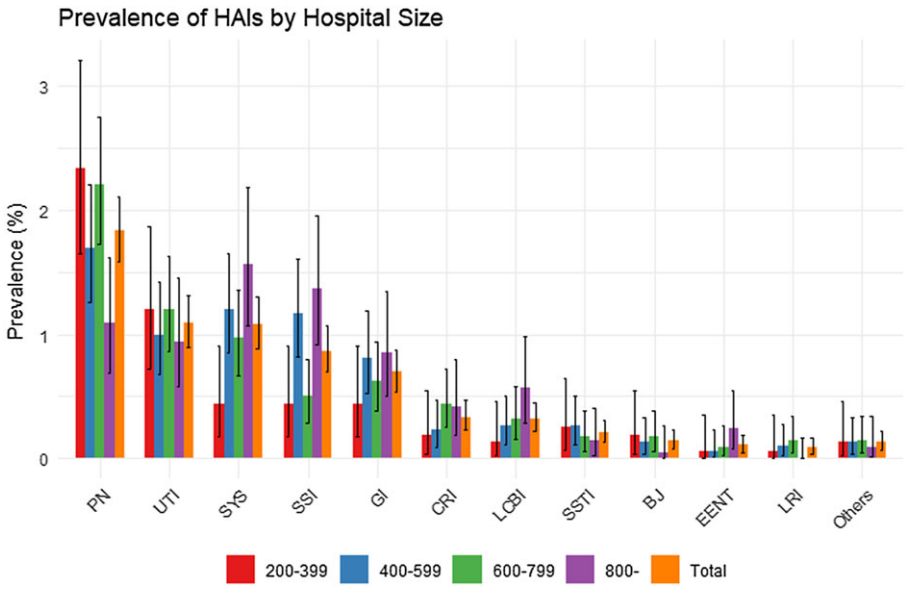

Figure 1. PN, pneumonia; UTI, urinary tract infection; SYS, systemic infection; SSI, surgical site infection; GI, gastrointestinal system infection; CRI, catheter-related infection; LCBI, laboratory-confirmed bloodstream infection; SSTI, skin and soft tissue infection; BJ, bone and joint infection; EENT, eye, ear, nose, throat, or mouth infection; LRI, lower respiratory system infection other than pneumonia.

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Table 3. Reported causative pathogens by HAI categories

Pathogens	UTI (n = 102)	PN (n = 92)	SSI (n = 56)	GI (n = 49)	LCBI (n = 40)	CRI (n = 36)	SST (n = 14)	BJ (n = 14)	Others (n = 30)	Total (n = 433)
Staphylococcus aureus	3 (2.9)	26 (28.3)	9 (16.1)	4 (8.2)	4 (10.0)	10 (27.8)	5 (35.7)	8 (57.1)	6 (20.0)	75 (17.3)
(Methicillin-resistance)	3	13	3	3	2	7	4	4	2	41
Escherichia coli	44 (43.1)	9 (9.8)	4 (7.1)	6 (12.2)	5 (12.5)	0 (0)	2 (14.3)	1 (7.1)	3 (10)	74 (17.1)
(3GC-resistance)	15	2	2	3	2	0	1	1	2	28
(Fluoroquinolone-resistance)	19	4	3	3	3	0	1	1	2	36
Klebsiella pneumoniae	13 (12.7)	8 (8.7)	1 (1.8)	5 (10.2)	3 (7.5)	1 (2.8)	0 (0)	0 (0)	0 (0)	31 (7.2)
(3GC-resistance)	1	1	0	2	0	1	0	0	0	5
(Fluoroquinolone-resistance)	1	1	0	2	0	1	0	0	0	5
Pseudomonas aeruginosa	8 (7.8)	13 (14.1)	5 (8.9)	0 (0)	1 (2.5)	1 (2.8)	0 (0)	0 (0)	1 (3.3)	29 (6.7)
(Carbapenem-resistance)	1	1	1	0	0	0	0	0	0	3
(Fluoroquinolone-resistance)	0	1	1	0	0	1	0	0	0	3
Staphylococcus epidermidis	0 (0)	2 (2.2)	4 (7.1)	0 (0)	8 (20.0)	6 (16.7)	1 (7.1)	0 (0)	0 (0)	21 (4.8)
Enterococcus faecalis	10 (9.8)	0 (0)	4 (7.1)	4 (8.2)	2 (5.0)	0 (0)	0 (0)	1 (7.1)	0 (0)	21 (4.8)
Enterococcus faecium	3 (2.9)	2 (2.2)	4 (7.1)	6 (12.2)	1 (2.5)	1 (2.8)	0 (0)	0 (0)	2 (6.7)	19 (4.4)
Cytomegalovirus	0 (0)	1 (1.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (33.3)	11 (2.5)
Clostridioides difficile	0 (0)	0 (0)	0 (0)	10 (20.4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (2.3)
Candida albicans	1 (1.0)	1 (1.1)	0 (0)	1 (2.0)	1 (2.5)	4 (11.1)	0 (0)	0 (0)	1 (3.3)	9 (2.1)
Others	20 (19.6)	30 (32.6)	25 (44.6)	13 (26.5)	15 (37.5)	13 (36.1)	6 (42.9)	4 (28.6)	7 (26.7)	133 (30.7)

Note. Data were presented unweighted number (percentage) of causative pathogens. Percentage was calculated as follows: (number of pathogens)*100/total number of pathogens in each column. **Abbreviations:** HAI, healthcare-associated infection; 3GC, 3rd generation cephalosporin; UTI, urinary tract infection; PN, pneumonia; SSI, surgical site infection; GI, gastrointestinal system infection; LCBI, laboratory-confirmed bloodstream infection; CRI, catheter-related infection; SST, skin and soft tissue infection; BJ, bone and joint infection

Although a PPS is valuable to comprehend the information of hospitalized patients, it is infrequently conducted in Japan due to the significant labor demands placed on healthcare professionals.[5,12,13,19] In the present PPS, the prevalence of HAIs in the 27 hospitals was 6.7%, similar to that of the ECDC-PPS (5.9%) and a WHO report (7%), and higher than that of a USA-PPS (3.2%–4.0%).[3,8,11] This PPS could demonstrate higher median age of patients (73 years), a longer median length of stay (10 days) and less devices in place (PVC: 39.6%, UC: 13.3%) than those in EU/EEA (median age: 66 years, median length of stay: 5.9 days, PVC: 48.7%, UC: 17.7%).[11] The prevalence of HAIs in four university hospitals and two community hospitals was previously reported as 7.7% (246/3,199) and 7.4% (61/820), respectively.[5,12] The picture of fewer devices and longer hospital stays in Japanese hospitals suggests that the number of patients who require aggressive medical treatment is lower than in other countries.

This PPS included several hospital categories across several regions; therefore, this report depicts the hospital epidemiology more precisely than did previous studies.[5,12,13] The top three HAIs were pneumonia, UTIs, and SSIs; these results are similar to those of the ECDC-PPS and an Australian PPS.[11,20] In this study, the prevalence of HAIs differed between the small and extra-large hospitals. Our study also showed that small hospitals often admit long-term and chronic care inpatients besides acute care patients, and invasive surgeries are performed less frequently in small hospitals than in other hospitals.[21] Small hospitals are characterized by lower HAI rates, especially due to fewer malignant and hematologic disease complications and fewer devices in place. In contrast, medium-sized or large community hospitals admit more acute care patients or patients with malignant tumors or hematological diseases than do small hospitals. In university hospitals and specialized hospitals, most patients have malignant or other underlying diseases. Highly invasive surgeries and chemotherapies are performed at these hospitals. The highest rates of pneumonia in small hospitals and SSIs in extra-large hospitals reflect the patients' characteristics. These data suggest that different approaches are necessary to reduce HAIs according to hospital category.

Our data indicate that the top three causative organisms are similar to those in the ECDC-PPS report. However, the drug-resistant rates of these organisms in the ECDC-PPS report differ from those in our PPS. In the ECDC-PPS report, the following data were reported: 22.3% of 3GC-resistant *E. coli*, 1.2% of CAR-resistant *E. coli*, 55.3% of 3GC-resistant *K. pneumoniae*, 18.3% of CAR-resistant *K. pneumoniae*, 30.9% of MRSA, and 10.8% of VRE. *Clostridioides difficile* is the top causative organism of HAI in the United States[8]; however, only 10 cases were identified in this study. Drug-resistant *A. baumannii* has been frequently identified as a causative organism of HAIs in Southeast Asia[22,23]; however, our study had different results. Our PPS data are similar to Japanese surveillance data on drug resistance.[24] Being an island country with successful infection control measures might explain the difference in the detection of drug-resistant bacteria in Japan compared with other countries. Highly drug-resistant organisms were relatively rare in this PPS; however, continuous surveillance is necessary to monitor changes in drug-resistant organisms.

This study was significantly influenced by the COVID-19 pandemic. Following the Japanese government's declaration of a state of emergency on April 7, notable decreases were observed in community-acquired infections (eg, influenza, pneumonia), as well as in scheduled surgical procedures.[25–28] During the fiscal year of 2020, the daily number of outpatients and the average number of inpatients decreased by 9.9% and 5.6%, respectively.[29] Data from the National Clinical Database indicated a reduction of 2.5–5.0% in the total number of 20 surgical procedures compared to 2018 and 2019, with April 2020 experiencing particularly significant declines.[27] Consequently, this study may underestimate the prevalence of SSI compared to the pre-pandemic period. At the time of our survey, no effective antiviral agents were administered during the study. Therefore, COVID-19 could not be categorized as an active HAI because the definition of HAI requires "patients with antimicrobials". To our knowledge, no COVID-19 outbreak occurred in the participating hospitals during the study period. However, in the ongoing "with COVID-19 era", nosocomial outbreaks of COVID-19 are increasingly common in Japanese hospitals.[30] Given that this PPS was conducted at the beginning of the COVID-19 pandemic, further evaluation of HAIs by PPS in the 'with COVID-19 era' should be conducted.

This study had several limitations. First, the PPSs were conducted only in Aichi Prefecture. Although there were several participating hospitals, this study reflects regional epidemiology. Second, the PPSs were conducted only in IPF-1 fee-charged hospitals. Therefore, these data cannot be applied to non-IPF-1 charged hospitals. Third, a validation study is necessary to ensure the accuracy of the study. However, due to the lack of ICT staff in each hospital and the COVID-19 pandemic, validation study was abandoned. Fourth, the definitions of HAIs in this study were based on both the ECDC-PPS protocol and the NHSN definitions. Although these are nearly identical, the definitions of HAI are slightly different from those based on the original ECDC-PPS[17,18]. Therefore, readers should keep in mind that the definitions of HAIs in this study were not the same as the original ECDC-PPS and NHSN definitions. Fifth, the PPSs were conducted from winter to summer in 2020 due to COVID-19. Some HAIs may be affected by season (such as seasonal viral infection, SSI).[31,32] Therefore, it is preferable to conduct the survey multiple times throughout the year or in the same season to eliminate the difference between the seasons.

In conclusion, this study provides epidemiological information on patient backgrounds, HAI prevalence, and causative organisms in Japanese hospitals. This study also reports hospital epidemiology and HAIs according to hospital category. Repeated multicenter PPSs throughout Japan are necessary to confirm the accuracy of the PPSs and investigate changes after the COVID-19 outbreak.

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