Ankyra Medical Journal

ORIGINAL ARTICLE DOI: 10.51271/ANKMJ-0002

Healthcare-associated infections: prospective rotational surveillance data of a training and research hospital

Yavuz Çekli, Şaban Çavuşoğlu

Department of Infectious Diseases and Clinical Microbiology, Gülhane Military Medical Academy Haydarpaşa Training Hospital, İstanbul, Turkiye

Cite this article: Çekli Y, Çavuşoğlu Ş. Healthcare-associated infections: prospective rotational surveillance data of a training and research hospital. *Ank Med J.* 2024;3(1):6-12.

Received: 01.01.2024 ◆ **Accepted:** 28.01.2024 ◆ **Published:** 31.01.2024

ABSTRACT

Aims: The monitoring and prevention of healthcare-associated infections (HAIs) are considered to be among the key measures to improve the effectiveness and quality of healthcare services. This study aimed to ascertain the prevalence of HAIs in various hospital departments and identify the causative bacterial profile, risk factors, and associations with mortality.

Methods: This prospective study included 3117 patients who were monitored in various departments of a training and research hospital. The identified HAI cases were monitored using an active, prospective, rotational surveillance method. Patient data on HAIs were recorded daily with pre-established tracking forms.

Results: The mean hospital stay of the patients was 9.9±7.5 days. The HAI prevalence was 4.5% and the HAI rate was 5.5%. The HAI rate showed no difference between internal medicine and surgical departments (5.7% vs 5.5%, $p>0.05$), but it was higher in intensive care units (ICUs) ($p<0.001$). The majority of the isolated agents (65.2%) were gram-negative bacteria. Advanced age, intrinsic risk factors such as malignancy, and invasive procedures (use of central, peripheral, and urinary catheters) were associated with the development of HAIs. The frequency of HAIs was higher among deceased patients compared to survivors (25.4% vs 4.1%, $p<0.001$).

Conclusion: HAIs remain a major concern in hospital settings, particularly in ICUs, and they strongly correlate with intrinsic risk factors and invasive procedures. Optimized infection control measures for these risk factors can make a significant contribution to improving patient outcomes.

Keywords: Healthcare-associated infection, intensive care unit, surveillance, mortality

INTRODUCTION

Healthcare-associated infections (HAIs) affect hundreds of millions of patients worldwide and are among the most common causes of mortality and morbidity in hospitals.[1] Furthermore, they increase hospital costs due to additional medication use and prolonged patient hospital stays.[2,3]

Many studies have shown that the hospital environment may be responsible for the transmission of significant nosocomial pathogens to patients.[4,5] Bacteria isolated from hospital settings differ from those originating from the community. Troublesome bacteria such as *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and methicillin-resistant *Staphylococcus aureus* (MRSA) more frequently cause HAIs.[6-8] Infections caused by these bacteria with high resistance rates typically require the use of broad-spectrum antibiotics, resulting in significant costs and an increase in antimicrobial resistance. The spread of resistant pathogens within and between hospitals can be mitigated with effective infection control measures. One of the most crucial components of these measures is effective surveillance methods.[9,10] Monitoring and preventing HAI cases are considered key measures to enhance the effectiveness and quality of healthcare services. In this context, providing accurate and sufficient information about HAI cases is essential for initiating effective prevention programs in hospitals.

In this study, by implementing an active, prospective, rotational surveillance method, we aimed to determine the frequency of HAIs in our hospital's wards and ICUs, the distribution of cases across wards, the bacterial profile responsible for HAIs, risk factors in HAI cases, and the impact of HAIs on mortality.

METHODS

The study was approved by the Gülhane Military Medical Academy Haydarpaşa Training Hospital Clinical Researches Ethics Committee (Date: 08.08.2001, Decision No: 0530-63-01/264). All patients were informed about the details of the research prior to the beginning of the study. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Corresponding Author: Yavuz Çekli, yavuz.cekli@outlook.com

This prospective study was conducted at Gülhane Military Medical Academy Haydarpaşa Training Hospital Hospital between March 2002 and November 2003, utilizing an active, prospective, rotational surveillance method with the aim of monitoring hospital infections.

During the study period, a total of 3117 patients were monitored in various departments and ICUs. All cases were actively monitored using a prospective, rotational surveillance method. Cases from the department of psychiatry, dermatology, pulmonary diseases and tuberculosis, endocrinology, hematology, and oncology of our hospital were not included in the surveillance data. Cases from the departments included in the study were monitored in three phases (Table 1). Information pertaining to patients who developed HAIs was recorded with pre-established patient tracking forms, and all collected data were recorded daily.

Inclusion criteria for the study were as follows: patients admitted to any department or ICU of the hospital included in the study who were hospitalized for more than 48 hours and were present in the department when data collection began, and, if they had undergone any surgery, they returned within a week with signs of infection or, in the event of a foreign body/prosthesis during surgery, within a year with infection symptoms. Patients who had stayed in the department or ICU for less than 48 hours, who died or were transferred to another hospital within the first 48 hours, who showed early infection symptoms during outpatient visits or at the time of admission, whose laboratory and culture results did not support the clinical findings, or who were not suspected of HAI were not included in the study.

The rates and frequencies of HAIs were calculated using the formulas below based on the criteria set by the Centers for Disease Control and Prevention (CDC) and the National Nosocomial Infection Surveillance System (NNIS):

$$\text{Incidence}=\left(\frac{\textit{Number of HAIs}}{\textit{Number of hospitalized patients}}\right)\times 100$$

Device-associated infection rate=

$$\left(\frac{\textit{Number of infections associated with a specific device}}{\textit{Number of device days}}\right)\times 1000$$

Surgical site infection data were evaluated using surgical wound classification and the American Society of Anesthesiologists (ASA) scoring system.[11,12]

Statistical Analysis

All data were analyzed with SPSS 11.0 for Windows (SPSS Inc., Chicago, IL, USA). Numerical data determined to be normally distributed based on the results of Kolmogorov-Smirnov tests are given as mean±standard deviation, while non-normally distributed variables are given as median (min-max). For comparisons between two groups, the Student t-test and Mann-Whitney U test were used in line with the normality of the considered distribution. For comparisons between three or more groups, ANOVA and Kruskal-Wallis tests were used in line with the normality of the considered distribution. Categorical variables are given as numbers and percentages, and inter-group comparisons were conducted with chi-square and Fisher exact tests. Significance was accepted at p<0.05 (*) for all statistical analyses.

Table 1. Services included in the study and surveillance dates

Services	**Bed Capacity**	**PERIODS**							
		I			**II**			**III**	
		01-31 March 2002	**01-30 April 2002**	**01-31 May 2002**	**01-31 December 2002**	**01-31 January 2003**	**01-28 February 2003**	**01-31 October 2003**	**01-30 November 2003**
Physical Therapy	34	X				X			X
General Surgery Clinic	74	X				X		X	
General Surgery Intensive Care Unit	8	X				X		X	
Urology	27	X				X		X	
Gastroenterology	41	X				X		X	
Plastic Surgery	26	X				X		X	
Burn Unit	10	X				X		X	
Anesthesia and Reanimation Intensive Care Unit	10	X				X		X	
Orthopedics	70		X				X		X
Otorhinolaryngology	31		X				X		X
Ophthalmology	40		X				X		X
Cardiovascular Surgery Clinic	18		X				X	X	
Cardiovascular Surgery Intensive Care Unit	8		X				X	X	
Nephrology	29		X				X		X
Pediatrics	26		X				X		X
Neonatology	6								
Cardiology Clinic	53		X			X			X
Cardiology Intensive Care Unit	6		X				X		X
Neurosurgery Clinic	54			X	X			X	
Neurosurgery Intensive Care Unit	6			X	X			X	
Neurology Clinic	55			X	X			X	
Neurology Intensive Care Unit	6			X	X			X	
Internal Medicine Clinic	30			X	X			X	
Internal Medicine Intensive Care Unit	12			X	X			X	
Obstetrics and Gynecology	25			X	X				X
Infectious Diseases and Clinical Microbiology	42			X	X				X
Underwater and Hyperbaric Medicine	18			X	X			X	

RESULTS

The age range of the patients was 1-100 years (mean: 36.7±23.2 years), 72% of them (n=2245) were male, and 28% (n=872) were female. The hospitalization duration was determined to range from 2 to 31 days, with a mean of 9.9±7.6 days. In the first period, 778 patients were monitored, while 1166 were monitored in the second period and 1173 in the third period. The distributions of gender, age, and hospitalization duration showed no differences between the periods (p>0.05) (Table 2).

Table 2. Demographic characteristics of patients according to periods

Periods	Gender		Total	Age, years (Mean±SD)	Length of hospitalization, day (Mean±SD)
	Male n (%)	Female n (%)			
First period	599 (77)	179 (23)	778	33.4±22.6	9.6±7.6
II. period	804 (69)	362 (31)	1166	37.0±23.3	10.8±7.8
III. period	842 (71.8)	331 (28.2)	1173	38.6±23.1	9.1±6.6
Total	2245 (72)	872 (28)	3117	36.7±23.2	9.9±7.6

Abbreviations: SD, standard deviation

Patients were monitored in surgical and internal departments. Of the analyzed cases, 59.8% were in surgical departments, while 40.2% were in internal departments. In terms of patient density, the top three services in the surgical departments were general surgery (11.9%), orthopedics (10.9%), and urology (6.5%). In internal departments, the top three were neurology (5.7%), gastroenterology (5.3%), and physical medicine and rehabilitation (5.2%).

From among the 3117 patients monitored, 173 HAIs were identified to have occurred in 141 patients (4.5%). The HAI rate was determined to be 5.5% or 5.6 per 1000 patient days. In internal medicine departments, these rates were respectively 5.7% or 5.4 per 1000 patient days, while in surgical departments, they were 5.5% or 5.8 per 1000 patient days (p>0.05). From the internal medicine departments, in the Underwater and Hyperbaric Medicine Service, where severe cases such as diabetic foot, osteomyelitis, and necrotizing fasciitis are monitored, the HAI rate was identified as 31.3% or 19.6 per 1000 patient days (Table 3).

The HAI rate in the ICUs was found to be higher compared to the general services (p<0.001). In the anesthesia ICU, the HAI rate was 180% or 117.4 cases per 1000 patient days. Meanwhile, the neurology ICU had rates of 82.3% and 44.7/1000 patient days, the neurosurgery ICU had rates of 58.8% and 39/1000 patient days, the burn unit had rates of 50% and 34.8/1000 patient days, the general surgery ICU had rates of 33.9% and 24.9/1000 patient days, and the internal medicine ICU had rates of 18.9% and 27.9/1000 patient days.

The most common cause of HAI was bloodstream infection (30.1%), followed by urinary tract infection (UTI) at 28.3%, surgical site infection (SSI) at 23.6%, skin and soft tissue infection at 11.6%, and pneumonia at 6.4%. In the first period, UTIs and SSIs were the most prevalent infections, while in the second and third periods, bloodstream infections and UTIs were most frequently observed. However, no significant difference was found between these periods (p>0.05).

The most frequently encountered intrinsic risk factors among the cases were malignancy (4.7%), diabetes mellitus (4.4%), and H2 receptor blocker usage (4.1%). Medical care-related risk factors were predominantly peripheral catheter (41.7%), urinary catheter (8.9%), and central catheter usage (4.9%) (Table 4).

Table 3. Distribution of healthcare-associated infections rates by services

Section	Services	Number of inpatients	Number of HAI patients	HAI rate (%)	HAI rate (per 1000 patient days)
Surgical					
	Anesthesia Intensive Care	15	27	180	117.4
	Burn Unit	17	10	58.8	34.9
	General Surgery	425	28	6.6	6.7
	Plastic Surgery	110	7	6.4	5.6
	Neurosurgery	190	10	5.3	4.7
	Orthopedics	341	18	5.3	4.1
	Urology	203	2	1	1.9
	Obstetrics and Gynecology	191	0	0	0
	Otorhinolaryngology	151	0	0	0
	Ophthalmology	134	0	0	0
	Cardiovascular Surgery	93	0	0	0
	TOTAL	1870	102	5.5	5.8
Internal					
	Underwater and Hyperbaric Medicine	32	10	31.3	19.6
	Internal Medicine	202	19	9.4	11.2
	Neurology	194	17	8.8	6.8
	Nephrology	116	8	6.9	6.1
	Neonatology	70	2	2.9	4.6
	Cardiology	106	3	2.8	2.6
	Physical Medicine and Rehabilitation	161	4	2.5	1.9
	Pediatrics	120	3	2.5	5.2
	Gastroenterology	166	4	2.4	1.8
	Infectious Diseases and Clinical Microbiology	80	1	1.3	1.4
	TOTAL	1247	71	5.7	5.4
TOTAL		3117	173	5.5	5.6

Abbreviations: HAI, healthcare-associated infections.

Table 4. Presence of intrinsic and medical care-related risk factors

Risk Factors	Total		Periods		
			I	II	III
	n	%	%	%	%
Intrinsic					
Malignancy	145	4.7	6.2	3.9	4.4
Burns	11	0.4	0.4	0.7	0
Liver failure	17	0.5	0.4	0.5	0.7
General body trauma	0	0	0	0	0
Diabetes mellitus	137	4.4	1.7	4.5	6.1
AIDS/HIV infection	0	0	0	0	0
Loss of consciousness	19	0.6	0.4	0.5	0.9
H2 receptor blocker	127	4.1	4.1	3.9	4.2
Immunosuppression	3	0.1	0.4	0	0
Transplantation	0	0	0	0	0
Respiratory failure	21	0.7	0.5	0.8	0.7
Neutropenia	0	0	0	0	0
Kidney failure	70	2.2	2.6	1.7	2.6
Transfusion	75	2.4	2.8	2.3	2.2
Medical care-related					
Urinary catheter	278	8.9	8.8	9.1	9.1
Peripheral catheter	1301	41.7	53.1	62.6	61.5
Central catheter	154	4.9	5.4	5	4.6
Intubation	80	2.6	3.1	2.7	2.1
Mechanical ventilation	53	1.7	1.2	2.7	1.1
Arterial cannula	47	1.5	1.4	1.3	1.8
Nasogastric tube	109	3.5	1.9	4.7	3.3
Tracheostomy	20	0.6	0.8	0.8	0.4
Peritoneal dialysis	1	0.01	0	0.01	0
Hemodialysis	14	0.5	1.7	0.09	0
Drainage catheter	93	3	4.8	2.2	2.6
Prosthesis/foreign body	125	4	6.7	3.1	3.2
Other interventions	51	1.6	2.2	1.6	1.3

Abbreviations: AIDS, acquired immune deficiency syndrome; HIV, human immunodeficiency virus

The incidence of HAIs in the first period was 5.8%, in the second period was 3.8%, and in the third period was 4.4% (p=0.110). The incidence of HAIs was higher among female patients compared to male patients (7.1% vs 3.5%, p<0.001). Intrinsic risk factors associated with the development of HAIs included the presence of malignancy, burns, diabetes mellitus, altered consciousness, anti-acid usage, respiratory failure, and renal failure requiring transfusion therapy (p<0.001). Additionally, it was found that other invasive procedures, excluding peritoneal dialysis (p=0.828), were also associated with the development of HAIs (p<0.001) (Table 5).

It was determined that advanced age (p<0.001), prolonged hospital stay (p<0.001), and the duration of invasive procedures (p<0.001) influenced the development of HAIs, but there was no statistically significant relationship between ASA scores and the development of HAIs (p=0.263) (Table 6).

During the study period, a causative agent was isolated in 155 of 173 HAI cases (89.5%). In 18 cases (10 SSI and 8 pneumonia) where the causative agent could not be isolated, the diagnosis of HAI was made based on clinical symptoms. The majority of the isolated agents were gram-negative bacteria (65.2%), followed by gram-positive bacteria (31%) and *Candida* species (3.8%). The most common bacterium causing HAIs was *Escherichia coli* (25.2%), followed by *staphylococci* [coagulase-negative *staphylococci* (CoNS) 16.1%, *Staphylococcus aureus* 8.4% (with 98% methicillin resistance)], *Klebsiella* spp. (14.2%), and *Pseudomonas aeruginosa* (13%) (Table 7).

Regarding bloodstream infections, the most prevalent pathogens were CoNS (44.2%), followed by *Pseudomonas aeruginosa* (13.5%) and *Acinetobacter* spp. (13.5%). In cases of UTIs, *Escherichia coli* (40.7%), *Pseudomonas aeruginosa* (12.2%), and *Enterococcus* spp. (12.2%) were the primary pathogens. Among SSIs, the leading pathogens were *Escherichia coli* (35.5%), *Staphylococcus aureus* (19.4%), and *Klebsiella* spp. (16.1%) (Table 8).

During the study period, a total of 59 patients died. The HAI rate was higher among deceased patients compared to survivors (25.4% vs 4.1%, p<0.001).

Table 5. Relationship between the prevalence of healthcare-associated infections and risk factors/invasive interventions

Risk factors		HAI		p
		n	%	
Gender	Male	79	3.5	0.001
	Female	62	7.1	
Period	First period	45	5.8	0.111
	II. period	44	3.8	
	III. period	52	4.4	
Malignancy	Yes	18	12.4	0.001
	No	123	4.1	
Burn	Yes	5	45.5	0.001
	No	136	4.4	
Liver Failure	Yes	0	0	0.368
	No	141	4.5	
Diabetes Mellitus	Yes	25	18.2	0.001
	No	116	3.9	
Unconsciousness	Yes	9	47.4	0.001
	No	132	4.3	
H2 Receptor Blocker	Yes	40	31.5	0.001
	No	101	3.4	
Immunosuppression	Yes	1	33.3	0.016
	No	140	4.5	
Respiratory Failure	Yes	15	71.4	0.001
	No	125	4.0	
Renal Insufficiency	Yes	11	15.7	0.001
	No	130	4.3	
Transfusion	Yes	25	33.3	0.001
	No	116	3.8	
Urinary Catheter	Yes	87	31.3	0.001
	No	54	1.9	
Peritoneal Dialysis	Yes	0	0	0.828
	No	141	4.5	
Hemodialysis	Yes	7	24.1	0.001
	No	134	4.3	
Intubation	Yes	24	30.0	0.001
	No	117	3.9	
Mechanical Ventilation	Yes	26	49.1	0.001
	No	115	3.8	
Tracheostomy	Yes	18	90.0	0.001
	No	123	4.0	
Central Catheter	Yes	51	33.1	0.001
	No	90	3.0	
Peripheral Catheter	Yes	136	10.5	0.001
	No	5	0.3	
Drainage Catheter	Yes	20	21.5	0.001
	No	121	4.0	
Prosthesis	Yes	20	16.0	0.001
	No	121	4.0	
Nasogastric Tube	Yes	45	41.3	0.001
	No	96	3.2	
Arterial Cannula	Yes	22	46.8	0.001
	No	119	3.9	

Abbreviations: HAI, healthcare-associated infections.

Table 6. Relationship of healthcare-associated infections development with age, hospitalization duration, ASA score, and duration of invasive procedures

Variables	HAI	n (%)	Mean±SD	p
Age, years	Yes	141 (4.5)	54.9±24.5	0.001
	No	2976 (95.5)	35.8±22.7	
Length of stay, day	Yes	141 (4.5)	18.9±8.7	0.001
	No	2976 (95.5)	9.4±7.2	
ASA score	Yes	44 (4.6)	2.1±0.5	0.263
	No	908 (95.4)	2.0±0.1	
Duration of urinary catheter, day	Yes	87 (31.2)	17.1±9.2	0.001
	No	191 (68.8)	8.1±7.3	
Duration of intubation, day	Yes	24 (30)	12.1±9.4	0.001
	No	56 (70)	2.8±3.5	
Duration of central catheter, day	Yes	51 (33.1)	14.6±8.9	0.001
	No	103 (66.9)	5.7±5.4	
Duration of peripheral catheter, day	Yes	138 (10.6)	18.4±8.7	0.001
	No	1163 (89.4)	6.4±5.6	

Abbreviations: HAI, healthcare-associated infections; SD, standard deviation.

Table 7. Distribution of healthcare-associated infections agents by periods

HAI agents	Periods						Total	
	I		II		III			
	n	%	n	%	n	%	n	%
Gram (+) bacteria	11	26.8	20	37.1	17	28.3	48	31.0
CoNS	3	7.3	11	20.4	11	18.3	25	16.1
Staphylococcus aureus	5	12.2	5	9.3	3	5.0	13	8.4
Enterococcus spp.	3	7.3	4	7.4	3	5.0	10	6.5
Gram (-) bacteria	29	70.7	31	57.4	41	68.3	101	65.2
Escherichia coli	8	19.5	14	26.0	17	28.3	39	25.2
Klebsiella spp.	11	26.9	4	7.4	7	11.7	22	14.2
Pseudomonas aeruginosa	4	9.6	8	14.8	8	13.3	20	13.0
Acinetobacter spp.	2	4.9	2	3.7	6	10.0	10	6.5
Proteus spp.	2	4.9	3	5.5	3	5.1	8	5.1
Enterobacter spp.	2	4.9	0	0	0	0	2	1.3
Candida spp.	1	2.5	3	5.5	2	3.4	6	3.8
Total	41	100	54	100	60	100	155	100

Abbreviations: CoNs, Coagulase-negative *staphylococci*; HAI, healthcare-associated infections; spp, species.

DISCUSSION

In Turkiye, the HAI rate is generally reported to be between 1% and 16.5%, and in ICUs, it ranges from 5.3% to 65.3%.[13-16] Based on these studies, the HAI rate in our research (5.5%) is comparatively low. This variation could be attributed to differences in hospital bed capacities, the types of patients, distinct risk factors, and the non-inclusion of certain departments where HAIs are more prevalent, such as hematology, oncology, and transplantation, in our study.

In our study, the HAI rates identified in the ICUs, ranging from 18.9% to 180%, were higher compared to those of general services. In the period in which our study was conducted, HAI rates in the reanimation units of university hospitals in our country were reported to range broadly between 5.3% and 171.8%.[17,18] The HAI rate of 180% obtained for the resuscitation unit in our study was slightly higher than the upper limit of the studies mentioned above. The reason for this might be that our hospital's resuscitation department admits patients with severely deteriorated general conditions due to ease of patient care. Compared to other departments, patients might stay longer in this unit and experience multiple HAI episodes. Additionally, the combination of fewer patients staying for extended periods and experiencing multiple HAI events diminishes the denominator in incidence calculations, resulting in an elevated rate.

The types of HAIs observed in ICUs vary according to the type and capacity of the particular ICU. In our study, bloodstream infections were the most common cause. This was followed by UTIs, SSIs, skin and soft tissue infections, and pneumonia, respectively. In studies conducted in ICUs during the same period in different countries, similar HAI rates were found, excluding the rates for pneumonia.[18,19] The low rate of hospital-acquired pneumonia in our study might be due to reduced utilization of equipment such as ventilators that heightens infection risk and the complexities of diagnosis during the period in question. However, in a recent study, it was reported that 83.7% of HAIs were lower respiratory tract infections, while only 2.9% were bloodstream infections.[20] It was also reported that the preventive and control measures taken in response to the COVID-19 pandemic reduced the rate of nosocomial infections in almost all departments excluding ICUs, and particularly respiratory, gastrointestinal, and oral infections. However, no difference was observed in rates of bloodstream infections and catheter-related infections before and after the COVID-19 pandemic.[6]

Ventilators, endotracheal tubes, catheters, and surgical wounds are identified as the most common risk factors contributing to the development of HAIs.[8,21] Furthermore, there is a positive correlation between the type of procedure and the resulting HAI. In ICUs where urinary catheter usage is high, UTIs are more frequent. Likewise, when central or peripheral catheter usage is involved, catheter infections or bloodstream infections are commonly observed. Invasive procedures, excluding peritoneal dialysis, were found to be associated with the development of HAIs. In cases where HAIs developed, the durations of intubation and central catheter, urinary catheter, and peripheral catheter usage were longer compared to cases without HAIs, and, in parallel, there was an elevated risk of HAIs.[21,22]

Table 8. Distribution of isolated agents according to the type of healthcare-associated infections

Agents	Bloodstream Infections		Urinary Tract Infections		Surgical Site Infections		Skin Infections		Pneumonia	
	n	%	n	%	n	%	n	%	n	%
Klebsiella spp.	6	11.5	5	10.2	5	16.1	6	30	0	0
Escherichia coli	3	5.8	20	40.7	11	35.5	5	25	0	0
Pseudomonas aeruginosa	7	13.5	6	12.2	2	6.5	4	20	1	33.3
Staphylococcus aureus	3	5.8	1	2.1	6	19.4	2	10	1	33.3
CoNS	23	44.2	0	0	2	6.5	0	0	0	0
Acinetobacter spp.	7	13.5	2	4.1	0	0	0	0	1	33.3
Enterobacter spp.	0	0	1	2.1	1	3.2	0	0	0	0
Candida spp.	1	1.9	5	10.2	0	0	0	0	0	0
Enterococcus spp	1	1.9	6	12.2	2	6.5	1	5	0	0
Proteus spp.	1	1.9	3	6.1	2	6.5	2	10	0	0
Total	52	100	49	100	31	100	20	100	3	100

Abbreviations:CoNs, coagulase-negative *staphylococci*.

Bacteria isolated from hospital environments differ from those originating from the community, and specific problematic bacteria are the primary causes of HAIs.[23,24] The isolated agents vary according to the types of HAIs. In previous studies, it was reported that the most frequently isolated agents in cases of catheter-related bloodstream infection were CoNS and *Staphylococcus aureus*, while in cases of UTIs, the agents were *Escherichia coli*, other gram-negative bacteria, *Pseudomonas aeruginosa*, and CoNS. In cases of ventilator-associated pneumonia, the reported agents were *Pseudomonas aeruginosa*, *Acinetobacter* spp., and other gram-negative bacteria. In cases of burn-related infections, *Staphylococcus aureus* is typically identified as the causative agent in the initial 7 days, whereas in later stages, *Pseudomonas aeruginosa* and other gram-negative bacteria are found to be responsible.[6-8,18-20] In our study, we found that CoNS were the predominant agents in bloodstream infections, while *Escherichia coli* was responsible for UTIs and SSIs.

In addition to negative impacts such as prolonged hospitalization and economic losses, the most significant consequence of HAIs is a high rate of mortality. Among cases that ended in death, the HAI prevalence was greater than that observed among survivors. The general health of the patient, comorbidities, duration of ICU stay, surgeries undertaken, invasive methods, the nature of the infection, and the causative agent's type and sensitivity to antibiotics are all risk factors directly influencing the prognosis.[12]

CONCLUSION

In hospitals, HAIs are among the significant causes of increased morbidity and mortality. Although their development might be viewed as inevitable, various strategies can be implemented to mitigate this risk, including conducting active surveillance in hospitals, emphasizing education, promoting hand hygiene habits, strictly adhering to asepsis and antisepsis rules, avoiding unnecessary diagnostic and therapeutic interventional procedures, monitoring invasive interventions closely, preventing the colonization of pathogenic bacteria, regulating antibiotic use in the hospital to maintain low levels of microbial resistance, and using broad-spectrum antibiotics only for treatment purposes rather than prophylactically. The implementation of these controls and precautions can be beneficial in preventing and reducing HAIs.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was performed in accordance with the Declaration of Helsinki and was approved by the Gülhane Military Medical Academy Haydarpaşa Training Hospital Ethics Committee (Date: 08.08.2001, Decision No: 0530-63-01/264).

Informed Consent

The need for informed consent was waived with the approval of the Gülhane Military Medical Academy Haydarpaşa Training Hospital Ethics Committee due to the study's retrospective design.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Ulusal sağlık hizmeti ilişkili enfeksiyonlar sürveyans rehberi (2017). TC Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğ, Ankara. 2019:1-60.
2. Burke JP. Infection control - a problem for patient safety. *N Engl J Med.* 2003;348(7):651-656.
3. Askarian M, Gooran NR. National nosocomial infection surveillance system-based study in Iran: additional hospital stay attributable to nosocomial infections. *Am J Infect Control.* 2003;31(8):465-468.
4. Facciola A, Pellicano GF, Visalli G, et al. The role of the hospital environment in the healthcare-associated infections: a general review of the literature. *Eur Rev Med Pharmacol Sci.* 2019;23(3):1266-1278.
5. Voidazan S, Albu S, Toth R, Grigorescu B, Rachita A, Moldovan I. Healthcare associated infections-a new pathology in medical practice? *Int J Environ Res Public Health.* 2020;17(3):760.
6. Su C, Zhang Z, Zhao X, et al. Changes in prevalence of nosocomial infection pre- and post-COVID-19 pandemic from a tertiary hospital in China. *BMC Infect Dis.* 2021;21(1):693.
7. Lemiech-Mirowska E, Kiersnowska ZM, Michalkiewicz M, Depta A, Marczak M. Nosocomial infections as one of the most important problems of healthcare system. *Ann Agric Environ Med.* 2021;28(3):361-366.
8. Pezhman B, Fatemeh R, Amir R, Mahboobeh R, Mohammad F. Nosocomial infections in an Iranian educational hospital: an evaluation study of the Iranian nosocomial infection surveillance system. *BMC Infect Dis.* 2021;21(1):1256.
9. Storr J, Twyman A, Zingg W, et al. Core components for effective infection prevention and control programmes: new WHO evidence-based recommendations. *Antimicrob Resist Infect Control.* 2017;6(1):6.
10. Struelens MJ. The epidemiology of antimicrobial resistance in hospital acquired infections: problems and possible solutions. *BMJ.* 1998;317(7159):652-654.
11. Smyth E, Emmerson A. Surgical site infection surveillance. *J Hospital Infect.* 2000;45(3):173-184.
12. Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS. Surgical site infection (SSI) rates in the United States, 1992–1998: the national nosocomial infections surveillance system basic SSI risk index. *Clin Infect Dis.* 2001;33(Supplement_2):69-77.
13. Sönmez A, Öztürk ŞB, Abacigil F. Sağlık hizmeti ilişkili enfeksiyon epidemiyolojisi ve sürveyansı. *Hemşirelik Bilimi Derg.* 2021;4(1):41-45.
14. Erdem HA, Sipahi OR, Kepeli N, et al. Ege Üniversitesi Hastanesi'nde hastane infeksiyonları nokta prevalansı. *Mediterranean J Infect Microbes Antimicrobials.* 2015;4:12.
15. Buke C, Sipahi O, Tasbakan M, et al. İç hastalıkları yoğun bakımda gelişen enfeksiyonların değerlendirilmesi. *Enfeksiyon Derg.* 2005;19(1):67-73.
16. Görenek L, Beşirbellioğlu B, Gül C, Tabak F, Hacıbektaşoğlu A. GATA Eğitim Hastanesi'nde hastane infeksiyonu insidansı. *Hastane İnfeksiyonları Derg.* 1997;1:97-100.
17. Arslan H, Gürdoğan K. Yoğun bakım ünitelerinde gözlenen hastane infeksiyonları. *Hastane İnfeksiyonları Derg.* 1999;3:165-170.
18. Erol S, Kürflat H, Özkurt Z, Parlak M, Taflyaran M. Reanimasyon ünitemizdeki hastane infeksiyonlari. *Hastane İnfeksiyonları Derg.* 2000;4:97-100.
19. Saltoğlu N, Öztürk C, Taşova Y, İncecik Ş, Paydaş S, Dündar İH. Yoğun bakım ünitelerinde infeksiyon nedeniyle izlenen hastalarda etkenler, risk faktörleri, antibiyotik direnci ve prognozun değerlendirilmesi. *Flora.* 2000;5(4):229-237.
20. Alanlı R, Beşirbellioğlu BA. Erişkin yoğun bakım ünitesindeki hastane enfeksiyonu etkenlerinin değerlendirilmesi: retrospektif çalışma. *Akdeniz Tıp Derg.* 2023;9(1):37-43.
21. Karami G, Khazei M, Rasuli Ravandi F, Emtiyazipoor Z. Evaluating the effect of hospital medical instruments on the nosocomial infection risk. *Nursing Midwifery J.* 2015;13(7):579-587.

22. Hugonnet S, Sax H, Eggimann P, Chevrolet JC, Pittet D. Nosocomial bloodstream infection and clinical sepsis. *Emerg Infect Dis.* 2004;10(1): 76-81.
23. Sib E, Lenz-Plet F, Barabasch V, et al. Bacteria isolated from hospital, municipal and slaughterhouse wastewaters show characteristic, different resistance profiles. *Sci Total Environ*. 2020;746:140894.
24. Dalton KR, Rock C, Carroll KC, Davis MF. One health in hospitals: how understanding the dynamics of people, animals, and the hospital built-environment can be used to better inform interventions for antimicrobial-resistant gram-positive infections. *Antimicrob Resist Infect Control*. 2020;9(1):78.