ARTIGO ORIGINAL

Epidemiological analysis of healthcare-associated bacterial infections in a public university hospital in Belo Horizonte

Análise epidemiológica das infecções bacterianas relacionadas à assistência à saúde em hospital público universitário de Belo Horizonte

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ABSTRACT

Background: Healthcare-associated bacterial infections (HAIs) are of great concern due to the impact on hospitalization length stay, hospital lethality, high costs, and an increase in multi-resistant microorganisms, therefore, it is extremely important to draw preventive action strategies for HAIs. **Objectives:** To analyze the profile of HAIs in a public university hospital. **Methods:** This is a cross-sectional and retrospective study, carried out at a hospital between January 1st and December 31st, 2020, which included all patients diagnosed with HAIs through Hospital Infection Control Committee (HICC) data and analysis of patient medical records. **Results:** 163 patients were diagnosed with HAIs, 50.3% were women, and 49.7% were men. The mean age was 66.4 years (DP=14.6). Regarding the infection site, we have 62 urinary tract infections (34.8%); 58 primary bloodstream infections (32%); 28 surgical site infections (15.7%); of the 178 infections, we have 34 infections of *Klebsiella pneumoniae* (19.1%), *Staphylococcus aureus* 29 (16.3%), *Escherichia coli* 27 (15.2%), *Proteus mirabilis* 17 (9.6%), *Pseudomonas aeruginosa* 16 (9%). The most used classes of antibiotics were cephalosporins, aminoglycosides, and quinolones. Furthermore, 66.7% of patients were discharged and 33% died, 73.6% of which were related to HAIs. **Conclusion:** HAIs has a high impact on patient costs and outcome. The data found can help in the outcome of infected patients and in the reduction of infections based on new measures implemented by the HICC.

Keywords: *Healthcare-associated infections. Bacterial resistance. Antibiotics.*

RESUMO

Introdução: As Infecções Relacionada à Assistência à Saúde (IRAS) geram preocupação em decorrência do impacto na duração das internações, letalidade hospitalar, custos elevados e aumento de microrganismos multirresistentes, sendo, portanto, de suma importância traçar estratégias de ações preventivas contra as IRAS. **Objetivos:** Analisar o perfil das IRAS causadas por bactérias em um hospital universitário. **Métodos:** Trata-se de um estudo transversal, retrospectivo realizado em um hospital universitário entre 01 de janeiro a 31 de

dezembro de 2020 que incluiu todos os pacientes diagnosticados com IRAS através de informações da Comissão de Controle de Infecção Hospitalar (CCIH) e análise dos prontuários médicos. **Resultados**: Dos 163 pacientes diagnosticados com IRAS, 50,3% eram mulheres e 49,7% homens. A média de idade foi 66,4 anos (DP=14,6). Acerca do sítio da infecção, observa-se 62 de ITU (34,8%); 58 de infecção primária de corrente sanguínea (32%); 28 de infecção do sítio cirúrgico (15,7%). Das 178 infecções, temos 34 por *Klebsiella pneumoniae* (19,1%), *Staphylococcus aureus* 29 (16,3%), *Escherichia coli* 27 (15,2%), *Proteus mirabilis* 17 (9,6%), *Pseudomonas aeruginosa* 16 (9%). As classes de antibióticos mais utilizadas foram as cefalosporinas, aminoglicosídeos e as quinolonas. 66,7% dos pacientes tiveram alta e 33% vieram a óbito, sendo 73,6% destes, relacionados à IRAS. **Conclusão**: As IRAS possuem alto impacto nos custos e prognóstico do paciente. Os dados encontrados podem auxiliar no prognóstico dos pacientes infectados e na diminuição das infecções a partir de novas medidas implementadas pela CCIH.

Palavras-chave: *Infecção Hospitalar. Resistência Bacteriana. Antibióticos*.

INTRODUCTION

Healthcare-associated bacterial infections (HAIs) are a public health issue affecting millions of people every year worldwide. HAIs are defined as an infection occurring in a patient admitted to the healthcare settings for more than 48 hours without any evidence that the infection was present or incubating at the time of admission[1].

They can occur in different health care delivery areas, such as in hospitals, long-term care facilities, and ambulatory settings, and may appear after discharge. Infection occurs when pathogen(s) spread to a susceptible patient host. In modern healthcare, invasive procedures and surgery, indwelling medical devices, and prosthetic devices are associated with these infections[2].

One factor of great impact on HAIs is the association with multidrug-resistant microorganism which refers to a type of bacteria that has developed resistance to multiple antimicrobials, making it more difficult to treat with conventional drugs. These bacteria can be resistant to different classes of antibiotics, limiting the available treatment options, which leads to even more consequences that are drastic. In this scenario, the World Health Organization (WHO) released in 2017 a list of antibiotic-resistant bacteria that should be prioritized in the search for new medications. In it, the "ESKAPE" group (*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter spp.*) stand out, and classified as critical priority (*Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa*, and *Enterobacter spp.*) and high priority (*Enterococcus faecium and Staphylococcus aureus*)[3].

Furthermore, HAIs are the most common adverse event in health care that affects patient safety. They contribute to significant morbidity, mortality, and financial burdens on patients, families, and healthcare systems. The emergence of multi-drug resistant organisms is another complication seen with HAIs event[2]. Therefore, it is very important to evaluate the HAIs profile in order to draw specific strategies in each location, through the Hospital Infection Control Committee (HICC), and actions such as better use of antimicrobials, population awareness, and training of health professionals can be taken. The data found can help in the outcome of infected patients and in the reduction of infections based on new measures implemented by the HICC. In this context, the present study aimed to analyze the profile of HAIs in a public university hospital.

METHODS

The present study is a documental, cross-sectional and retrospective study, carried out at a public university hospital, located in the city of Belo Horizonte, from January 1, 2020, to December 31, 2020.

Sample

From the inclusion criteria, a sample of 178 infections distributed in 163 different patients of both genders, older than 18 years of age, who had been affected by HAIs in the described period and diagnosed by the HICC of the hospital in question were evaluated. The diagnostic criteria for a Healthcare Associated Infection (HAIs) used by the HICC consist of evaluating the patient's clinical context, such as signs and symptoms, fevers, chills, inflammation, drainage of secretions, and other indications of infection with microbiological criteria such as positive blood, urine or sputum cultures. Finally, epidemiological criteria such as length of hospitalization, exposure to invasive procedures, use of medical devices, prior use of antibiotics, and the use of antibiotics are also used to fit these patients into the HAIs group. Patients younger than 18 years old, hospital infections of a non-bacterial nature, and inconclusive data in the medical records were the exclusion criteria of this study.

Instruments

Data analysis were performed from medical records, individual exams of each patient diagnosed, and from the hospital's HICC database.

Procedures

The variables were correlated among themselves and evaluated separately: age (years), gender (male or female), outcomes (discharge or death), risk factor (presence or absence), anatomical site of infection (urinary tract infection, primary bloodstream infection, surgical site infection, tracheobronchitis, respiratory tract infection, and skin and soft tissue infection). Diagnostic material (blood, urine, surgical wound secretion, tracheal secretion, catheter tip, eschar, and bronchial aspirate), hospital service (internal medicine, intensive care center, orthopedics, nephrology, and others), bacterial agents present and antibiotics used. All collected data were transcribed and cataloged in Excel for better evaluation and analysis.

Statistical analysis

Categorical variables were presented as absolute, relative frequencies, and numerical variables as mean ± standard deviation and median (1st quartile–3rd quartile). The association between the age group and the evolution of the condition were evaluated by the Chi-square test. The analyses were performed using the R version 4.0.3 software and a 5% significance level was considered.

Ethical aspects

All procedures regarding the work were performed in accordance with the guidelines and regulatory standards for research involving human beings (Resolution 466/2012 of the National Health Council).

The project was submitted and approved by the Research Ethics Committee, under 4.566.827. Waiver of the Informed Consent Form was requested, since old medical records would be analyzed and the search for these patients could cause discomfort to the patients and their families, besides increasing the cost of carrying out the study to obtain their authorization. Data collection was authorized by the hospital where the study was performed. Confidentiality regarding the identity of the patients was maintained. This research was conducted in accordance with the required ethical standards Resolutions 466/2012–510/2016–580/2018, of the Ministry of Health.

RESULTS

There were 178 cases of HAIs caused by bacteria diagnosed during the period from January 2020 to

December 2020, including 163 patients of which 15 were affected by infection on more than one occasion during the time interval evaluated. The hospital presents approximately 15 cases of HAIs per month. Of the 163 patients identified, 82 (50.3%) were female. Age ranged from 18 to 95 years, with a mean of 66.4 years (Standard Deviation–SD = 14.6) (Table 1).

Of these 163 patients, 108 (66.3%) were discharged and 55 (33.7%) died, and HAIs were directly related to approximately three-quarters of the number of deaths, affecting 39 (73.6%) patients. The age group with the highest number of HAIs cases was the elderly (more than 65 years), however, there was no significant association between age group and outcome. Infections correlated with risk factors occurred in 50 (28.1%) patients (Table 1). Moreover, comparing infected patients with associated risk factors with those without risk factors, a similar distribution in the rate of involvement of the types of bacterial agents were observed (Table 2).

Table 1. Characterization of the patients and hospitalizations

		Outcomes		
Variables	**Total n(%)**	**Discharge n(%)**	**Death n(%)**	**p-value**
Sex				
Female	82 (50.3)			
Male	81 (49.7)			
Age	66.4 (SD=14.6)			
	68.0 (55.5 – 78.0)			
Age group				0.176[Q]
18 to 44 years		6 (5.1)	6 (10.0)	
45 to 60 years		37 (31.6)	9 (15.0)	
61 to 75 years		41 (35.0)	24 (40.0)	
More than 76 years		33 (28.2)	21 (35.0)	
Surgery				
Yes	31 (19.0)			
No	119 (73.0)			
No information	13 (8.0)			
Outcome (n=162)				
Discharge	108 (66.7)			
Death	54 (33.3)			
Relationship with Death (n=53)				
Yes	39 (73.6)			
No	14 (26.4)			
Main site				
UTI	62 (34.8)			
BSI	58 (32.6)			
SSI	28 (15.7)			
TRAQ	16 (9.0)			
RTI	11 (6.2)			
SSTI	3 (1.7)			

Specific Site	
CAUTI	40 (22.5)
CRBSI	33 (18.5)
NCVC	25 (14.0)
FAUTI	22 (12.4)
DI	18 (10.1)
TRAM	13 (7.3)
BONE	7 (3.9)
PNEM	7 (3.9)
PNEC	4 (2.2)
SUBC	3 (1.7)
TRAC	3 (1.7)
SI	2 (1.1)
MEDI	1 (0.6)
Material	
Blood	61 (34.3)
Urine	57 (32.0)
Surgical wound infection	26 (14.6)
Tracheal secretion	25 (14.0)
Catheter tip	5 (2.8)
Eschar	2 (1.1)
Bronchial aspirate	1 (0.6)
Bone biopsy	1 (0.6)
Service	
Internal Medicine	84 (47.2)
Intensive Care Unit	41 (23.0)
Orthopedics	30 (16.9)
Others	13 (7.3)
Nephrology	10 (5.6)
Risk Factor	
Yes	50 (28.1)
No	116 (65.2)
No information	12 (6.7)
Bacteria	
Klebsiella pneumoniae	34 (19.1)
Staphylococcus aureus	29 (16.3)
Escherichia coli	27 (15.2)
Proteus mirabilis	17 (9.6)
Pseudomonas aeruginosa	16 (9.0)
Enterococcus spp.	14 (7.9)
Klebsiella Aerogenes	14 (7.9)

Staphylococcus coagulase negat	13 (7.3)
Acinetobacter baumannii	8 (4.5)
Candida sp	3 (1.7)
Streptococcus spp.	3 (1.7)

n:sample; %: frequency; SD: standard deviation; [Q] Chi-square test

Table 2. Distribution of the bacteria found by evolution, sex, and risk factor

Bacteria	Outcome		Sex		Risk Factor		
	Discharge n(%)	Death n(%)	Female n(%)	Male n(%)	Yes n(%)	No n(%)	No information n(%)
Acinetobacter baumannii	3 (2.6)	5 (8.2)	2 (2.4)	6 (6.4)	1 (2.0)	6 (5.2)	1 (8.3)
Candida spp.	1 (0.9)	2 (3.3)	0 (0.0)	3 (3.2)	0 (0.0)	3 (2.6)	0 (0.0)
Enterococcus spp.	8 (6.8)	6 (9.8)	8 (9.5)	6 (6.4)	5 (10.0)	8 (6.9)	1 (8.3)
Escherichia coli	21 (17.9)	6 (9.8)	22 (26.2)	5 (5.3)	8 (16.0)	18 (15.5)	1 (8.3)
Klebsiella aerogenes	10 (8.5)	4 (6.6)	7 (8.3)	7 (7.4)	3 (6.0)	10 (8.6)	1 (8.3)
Klebsiella pneumoniae	26 (22.2)	8 (13.1)	12 (14.3)	22 (23.4)	8 (16.0)	23 (19.8)	3 (25.0)
Proteus mirabilis	12 (10.3)	5 (8.2)	10 (11.9)	7 (7.4)	3 (6.0)	12 (10.3)	2 (16.7)
Pseudomonas aeruginosa	9 (7.7)	7 (11.5)	3 (3.6)	13 (13.8)	7 (14.0)	7 (6.0)	2 (16.7)
Staphylococcus aureus	19 (16.2)	10 (16.4)	13 (15.5)	16 (17.0)	9 (18.0)	20 (17.2)	0 (0.0)
Staphylococcus coagulase negative	5 (4.3)	8 (13.1)	7 (8.3)	6 (6.4)	6 (12.0)	7 (6.0)	0 (0.0)
Streptococcus spp.	3 (2.6)	0 (0.0)	0 (0.0)	3 (3.2)	0 (0.0)	2 (1.7)	1 (8.3)

n:sample; %: frequency

The distribution of bacteria found in each type of material was presented in Table 3.

Table 3. Distribution of bacteria found in each type of material

Bacteria	Material							
	Blood n(%)	Urine n(%)	Surgical wound infection n(%)	Tracheal secretion n(%)	Catheter tip n(%)	Eschar n(%)	Bronchial aspirate n(%)	Bone biopsy n(%)
Acinetobacter baumannii	2 (3.3)	1 (1.8)	2 (7.7)	3 (12.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Candida spp.	3 (4.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Enterococcus spp.	5 (8.2)	6 (10.5)	1 (3.8)	2 (8.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Escherichia coli	4 (6.6)	20 (35.1)	3 (11.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Klebsiella aerogenes	3 (4.9)	3 (5.3)	4 (15.4)	3 (12.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)
Klebsiella pneumoniae	10 (16.4)	15 (26.3)	3 (11.5)	3 (12.0)	2 (40.0)	0 (0.0)	1 (100.0)	0 (0.0)
Proteus mirabilis	3 (4.9)	8 (14.0)	2 (7.7)	1 (4.0)	1 (20.0)	2 (100.0)	0 (0.0)	0 (0.0)
Pseudomonas aeruginosa	3 (4.9)	4 (7.0)	0 (0.0)	8 (32.0)	1 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)

Staphylococcus aureus	13 (21.3)	0 (0.0)	11 (42.3)	5 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Staphylococcus coagulase negative	13 (21.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Streptococcus spp.	2 (3.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)

n:sample; %: frequency

Regarding bacterial findings there was a considerable variation of organisms identified, among them the multidrug-resistant bacteria of the ESKAPE group, being the most prevalent *Klebsiella pneumoniae, Staphylococcus aureus,* and *Escherichia coli* (Table 1). In addition, there was a significant predominance of gram-negative bacteria.

The antibiotics that showed the highest numbers of bacterial resistance in raw numbers were cephalosporins, penicillin, and quinolones. The bacterial agent's *Klebsiella pneumoniae, Staphylococcus aureus*, and *Coagulase-negative staphylococcus* were those with the highest resistance rates for both specific antibiotics and a broader spectrum of antibiotics (Table 4).

When comparing the prevalence rate of the bacterial types present between the hospital services, a similarity was observed between the agents present in the Internal Medicine and the ICU, except for *Escherichia coli* and *Pseudomonas aeruginosa*. The Orthopedics sector presented a high rate of infection by *Staphylococcus aureus* (Table 5).

Regarding microorganisms, *Klebsiella pneumoniae* was the most prevalent involved in patients who were discharged from the hospital, and *Staphylococcus aureus* was the most frequently involved in the number of deaths. About a quarter of the infections found in females were due to *Escherichia coli*, affecting 22 patients (26.2%), and in males, there was a predominance of *Klebsiella pneumoniae* infections, corresponding to 23.4% of infections (Table 2).

Table 4. Distribution of the antibiotics to which the bacteria were resistant

ATB	*Acinetobacter baumannii*	*Enterococcus spp.*	*Escherichia coli*	*Klebsiella aerogenes*	*Klebsiella pneumoniae*	*Proteus mirabilis*	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	*Staphylococcus coagulase negat*	*Streptococcus spp.*
	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)
AC	5 (6.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.2)	3 (9.4)	0 (0.0)	0 (0.0)	0 (0.0)
AMP	0 (0.0)	8 (30.8)	14 (21.9)	4 (20.0)	14 (7.0)	7 (15.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
AZ	0 (0.0)	0 (0.0)	4 (6.2)	0 (0.0)	19 (9.5)	3 (6.5)	6 (18.8)	0 (0.0)	0 (0.0)	0 (0.0)
BC	8 (11.0)	0 (0.0)	7 (10.9)	1 (5.0)	21 (10.4)	4 (8.7)	0 (0.0)	3 (3.7)	10 (12.7)	2 (100.0)
CAZ	8 (11.0)	0 (0.0)	4 (6.2)	0 (0.0)	18 (9.0)	3 (6.5)	5 (15.6)	0 (0.0)	0 (0.0)	0 (0.0)
CD	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	15 (18.3)	12 (15.2)	0 (0.0)
CFP	8 (11.0)	0 (0.0)	4 (6.2)	0 (0.0)	19 (9.5)	3 (6.5)	5 (15.6)	0 (0.0)	0 (0.0)	0 (0.0)
CIP	8 (11.0)	10 (38.5)	9 (14.1)	0 (0.0)	14 (7.0)	2 (4.3)	1 (3.1)	8 (9.8)	11 (13.9)	0 (0.0)
CL	2 (2.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
CTX	7 (9.6)	0 (0.0)	4 (6.2)	1 (5.0)	19 (9.5)	3 (6.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
ERI	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	15 (18.3)	12 (15.2)	0 (0.0)
FOX	1 (1.4)	0 (0.0)	4 (6.2)	12 (60.0)	21 (10.4)	3 (6.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
GT	6 (8.2)	3 (11.5)	1 (1.6)	1 (5.0)	10 (5.0)	4 (8.7)	3 (9.4)	6 (7.3)	11 (13.9)	0 (0.0)
IPM	6 (8.2)	0 (0.0)	0 (0.0)	0 (0.0)	5 (2.5)	0 (0.0)	4 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)
LEV	7 (9.6)	0 (0.0)	1 (1.6)	0 (0.0)	3 (1.5)	0 (0.0)	1 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)
LN	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
MERO	7 (9.6)	0 (00)	0 (0.0)	0 (0.0)	5 (2.5)	0 (0.0)	4 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)
NET	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
NIT	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.0)	7 (3.5)	8 (17.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
NOR	0 (0.0)	0 (0.0)	7 (10.9)	0 (0.0)	8 (4.0)	2 (4.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
OX	0 (0.0)	1 (3.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (9.8)	10 (12.7)	0 (0.0)
PEN	0 (0.0)	2 (7.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	26 (31.7)	13 (16.5)	0 (0.0)
POLI	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
RC	0 (0.0)	0 (0.0)	5 (7.8)	0 (0.0)	18 (9.0)	3 (6.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
VC	0 (0.0)	2 (7.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.2)	0 (0.0)	0 (0.0)

n:sample; %: frequency

AC: Amicacine; AMP: Ampiciline; AZ: Aztreonam; BC: TMP-SMX; CAZ: Ceftazidime; CD: Clindamicine; CFP: Cefepime; CIP: Ciprofloxacin; CL: Cloranfenicol; CTX: Cefotaxima; ERI: Eritromicine; FOX: Cefoxitine; GT: Gentamicine; IMP: Imipenem; LEV: Levofloxacin; LN: Linezolid; MERO: Meropenem; NET: Netilmicin; NIT: Nitrofurantoine; NOR: Norfloxacin; OX: Oxacilin; PEN: Penicilin; POLI: Polymyxin B; RC: Ceftriaxone; VC: Vancomicine

Table 5. Distribution of bacteria found in each service

Bacteria	Services				
	Internal Medicine	Intensive Care Unit	Orthopedics	Others	Nephrology
	n(%)	n(%)	n(%)	n(%)	n(%)
Acinetobacter baumannii	4 (4.8)	2 (4.9)	2 (6.7)	0 (0.0)	0 (0.0)
Candida spp.	3 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Enterococcus sp	6 (7.1)	3 (7.3)	1 (3.3)	1 (7.7)	3 (30.0)
Escherichia coli	17 (20.2)	5 (12.2)	3 (10.0)	2 (15.4)	0 (0.0)
Klebsiella aerogenes	7 (8.3)	0 (0.0)	6 (20.0)	1 (7.7)	0 (0.0)
Klebsiella pneumoniae	15 (17.9)	9 (22.0)	5 (16.7)	3 (23.1)	2 (20.0)
Proteus mirabilis	8 (9.5)	5 (12.2)	3 (10.0)	1 (7.7)	0 (0.0)
Pseudomonas aeruginosa	4 (4.8)	9 (22.0)	0 (0.0)	2 (15.4)	1 (10.0)
Staphylococcus aureus	10 (11.9)	5 (12.2)	10 (33.3)	1 (7.7)	3 (30.0)
Staphylococcus coagulase negat	9 (10.7)	3 (7.3)	0 (0.0)	0 (0.0)	1 (10.0)
Streptococcus spp.	1 (1.2)	0 (0.0)	0 (0.0)	2 (15.4)	0 (0.0)

n:sample; %: frequency

DISCUSSION

In this study, several variables available in the medical records of the patients studied were evaluated, helping to describe the epidemiological profile of bacteria isolated in a public hospital. The study seeks to identify and analyze the characteristics of healthcare-associated bacterial infections in clinical samples from patients seen in this hospital, such as their prevalence, distribution by bacterial species, sensitivity to antimicrobials, anatomical site of infection, and hospital ward with the highest infection rate, among others. By providing detailed information about the bacteria present in the hospital environment, the study aims to contribute to the understanding of the epidemiology of bacterial infections in the evaluated population. These data may be useful for the development of infection prevention and control strategies, the improvement of antimicrobial treatment protocols, and evidence-based decision-making for healthcare management at the hospital in question.

When comparing the prevalence of HAIs between genders, we saw that the majority was in female patients. In contrast to this, we found that men as opposed to women have an odds ratio of 1.56 for acquiring HAIs[4], however, other studies showed that the relationship between gender and HAIs rate depends on the reason for hospitalization and the anatomical site involved in the infection[5]. Thus, the high rate of UTIs found justifies these data, since women are more susceptible to these infections because their urethra is shorter and closer to the anus[6]. Moreover, for being a university hospital that is part of the Brazilian SUS network and for not selecting patients according to gender, it is expected to find homogeneous proportions between genders as seen in other university hospitals in the country[7].

Regarding age, we found an expressive prevalence of HAIs rate in the elderly (patients older than 65 years) when compared to younger patients, which was similarly found in the study[8]. A possible explanation is immunosenescence, which consists of the decrease in immune response due to aging, like reduced T-cell expression, fewer cytokines circulating, and decreased neutrophil function that make this population more prone to bacterial infection. In addition to this, some other characteristics present in older patients, such as

reduced mobility, need for a urinary catheter, diabetes mellitus, sarcopenia, and heart failure, among others increase this chance too[9].

As for mortality, we obtained different findings from those found in research[10,11]. We saw that the mortality rate was approximately 24% for patients with HAIs in the university hospital, different from the numbers found in their respective studies[10,11], with 34.6% and 38.4%. We believe that these data are justified by the low prevalence of healthcare-associated pneumonias and ventilator-associated pneumonias found in this university hospital when compared to high mortality levels in other institutions, which are associated with bad outcomes[12]. Furthermore, findings in studies[10,11] showed a high mean length of hospital stay, which is highly correlated with increased mortality rates due to more chances of multidrug-resistant bacteria colonization.

Our findings about the most affected anatomical site are aligned with those found by studies[13,14] in which there was a predominance of UTI and SSTI, in which a significant portion was correlated to the use of catheters because of the predisposition to the formation of a bacterial biofilm on their intraluminal and extra luminal surfaces[14]. Although, they differ from the data found by other studies, in which there was a significant predominance of airway infections, followed by SSI and gastrointestinal infections, and UTI and SSTI had the lowest rates of infections[4]. There is a large variation in the proportion of involvement rates of anatomical sites in the studies available in the literature, thus we did not identify any significant correlation to justify this inconsistency in data, showing that the distribution and incidence of HAIs may vary according to the individual profile of each institution.

It is important to emphasize that the risk factors associated with patients affected by HAIs are due to the use of devices, such as mechanical ventilation, foley urinary catheter, and central venous catheter, among others, and not due to clinical factors, which contribute to the isolation, proliferation and presence of pathogens at the tip of the catheter and tracheal secretion, in line with the fact that all the bacteria evaluated in our study have a greater number of infections in patients with risk factors who presented device-associated infection. Similar to some studies[15,16] *Staphylococcus aureus* was the most prevalent agent in patients with risk factors found in our study, corresponding to 18% of infections in this group. Thus, a greater control strategy should be implemented to limit the indication and duration of use of invasive devices and restrict the use of broadly spectrum antibiotics only in strictly necessary cases, aiming to avoid the development of methicillin-resistant *Staphylococcus aureus* (MRSA).

The internal medicine service had the highest HAIs rates, approximately 50% of all infections found in our hospital, which is in contrast with most studies available in the literature[17], in which the intensive care unit is the sector where the highest infection rates are described, with an incidence 2 to 5 times higher than in other hospital areas, often due to the compromised clinical condition of these patients, excessive use of antimicrobials and the risk factors associated with the use of devices[18]. We believe that this finding is due to the higher volume of patients in the internal medicine ward of the hospital when compared to the intensive care unit. The presence of *Pseudomonas aeruginosa, Klebsiella spp., and Staphylococcus aureus* in the hospital ICU is highly consistent with the data disclosed in the patient safety bulletins made available by Anvisa in 2017[19], evidencing a national difficulty in several institutions of the country in controlling these agents.

Bacteria from the ESKAPE group are responsible for the vast majority of HAIs cases worldwide, and according to the American Society of Infectious Diseases, the main bacterial agents are *Enterococcus faecium*, *Staphylococcus*

aureus, *Klebsiella pneumoniae*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa*[3]. Although in recent years we have seen a change in the pattern of bacterial agents toward gram-positive bacteria, we still see that most studies show that most HAIs are caused by gram-negative bacteria[20], as found in our study. Studies in the literature attribute this fact to the presence of mutations in the porins of the outer membrane of gram-negative bacteria, making it difficult for the antibiotic to enter the nucleus and, therefore, not being able to exert the desired effects, creating a resistance pattern[21]. Thus, HAIs profiles may vary by region and with variations in each population studied.

Two 2021 studies[13,22] reported findings similar to those found in this paper. It was observed that in recent years, from 2016 to 2020, there was an increase in the rate of resistance of *Staphylococcus aureus* and *Klebsiella pneumoniae* to beta-lactam antibiotics, most notably Methicillin, and carbapenems and cephalosporins, which have a beta-lactam ring in their structural core. In our data we found that for these same bacteria, there was greater resistance to beta-lactams, such as penicillin and oxacillin, for *Staphylococcus aureus*; and for *Klebsiella pneumoniae*, the use of cephalosporins was the least effective. It is possible to see in the literature that, since the early 2000s, there have been studies pointing to the existence of beta-lactamase-producing strains of *Klebsiella pneumoniae* emerging in several countries around the world[23]. However, 5 years ago, there was an exponential increase in the distribution of these agents, showing that it was already expected to find this pattern of resistance in the hospital.

The present study has some limitations. First, there was a small sample size of infected patients when compared to the large multicenter studies conducted on the topic. In addition, data collection was carried out in only one hospital, presenting only the profile of infections found there, which does not necessarily represent the same pattern of infections in other institutions. It was a retrospective study with only one-year follow-up. Unlike some other studies on the subject, data on the length of stay of patients was not collected.

CONCLUSION

Through the analyses performed, we can conclude that the study provided detailed information about the bacteria present in the hospital environment, contributing to the understanding of the epidemiology of bacterial infections in the evaluated population. These data can be used for developing infection prevention and control strategies, improving antimicrobial treatment protocols, and making evidence-based decisions for health management in the hospital in question. Furthermore, the need for specific prevention and control measures for the most prevalent bacterial species and those with the highest resistance to antimicrobials is observed. Moreover, the identification of hospital sectors with higher incidences of infections can direct efforts to implement interventions directed to these areas, aiming to reduce the spread of healthcare-associated bacterial infections.

In summary, the findings of this study highlight the importance of monitoring the epidemiology of bacterial infections in hospital settings and the ongoing need for effective interventions for prevention and control. This information can contribute to improving the quality of care, reducing morbidity and mortality associated with healthcare-associated bacterial infections, and promoting more efficient management of healthcare resources in the hospital studied.

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