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Original Article

Clinical factors associated with infection and antimicrobial resistance in hospitalized adult patients

Fatores clínicos associados à infecção e resistência antimicrobiana em pacientes adultos hospitalizados
Factores clínicos asociados a la infección y resistencia antimicrobiana en pacientes adultos hospitalizados

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ABSTRACT

Background and Objectives: Infections caused by multidrug-resistant microorganisms increase healthcare costs, prolong hospital stays, and raise mortality rates. Therefore, this study aimed to analyze the clinical factors associated with infections and antimicrobial resistance in hospitalized adult patients. **Methods:** Retrospective, cross-sectional, and descriptive study with a quantitative approach, conducted in a tertiary hospital in southern Brazil. Patients aged 18 years or older, hospitalized between January 2018 and December 2023 for more than 72 hours in clinical, surgical, or Intensive Care Unit (ICU) wards with positive bacterial cultures were included. Data were analyzed using IBM SPSS Statistics® 20. **Results:** A total of 546 patients with positive microbiological cultures were analyzed, of whom 74.2% had resistant microorganisms (RM). Resistance was associated with advanced age (p=0.055), male sex (p=0.036), use of invasive devices (p<0.001), prolonged hospitalizations in general wards and ICU (p<0.001), and multiple acquired infections (p=0.013). Patients with RM had a median hospital stay of 26 days, compared to 17 days for those with susceptible bacteria. In the ICU, the median stay was 15 days for patients with RM and 6 days for those with susceptible microorganisms, representing a significant increase of 9 days (p<0.001). The number of hospital-acquired infections doubled the likelihood of antimicrobial resistance. The highest incidence of resistance was observed in the carbapenem class (63.9%), followed by cephalosporins, fluoroquinolones, aminoglycosides (14.6%), and polymyxins (11.5%). **Conclusion:** Antimicrobial resistance was associated with clinical factors such as advanced age, male sex, use of invasive devices, prolonged hospitalizations, and multiple acquired infections. Patients with resistant microorganisms had significantly longer hospital stays, especially in the ICU.

Keywords: *Multidrug Bacterial Resistance. Hospital Infection. Risk factors. Microbial Drug Resistance.*

RESUMO

Justificativa e Objetivos: Infecções por microrganismos multirresistentes elevam os custos aos sistemas de saúde, prolongam internações e aumentam a mortalidade. Diante disso, este estudo objetivou analisar os fatores clínicos associados às infecções e resistência antimicrobiana em pacientes adultos hospitalizados. **Métodos:** Estudo retrospectivo, transversal e descritivo, com abordagem quantitativa, realizado em hospital terciário no sul do Brasil. Incluiu pacientes com 18 anos ou mais, internados entre janeiro de 2018 e dezembro de 2023 por mais de 72 horas em setores clínicos, cirúrgicos ou Unidade de Terapia Intensiva com culturas bacterianas positivas. Os dados foram analisados no IBM SPSS Statistics® 20. **Resultados:** Foram analisados 546 pacientes com culturas microbiológicas positivas, dos quais 74,2% apresentaram microrganismos resistentes (MR). A resistência se associou à idade avançada (p=0,055), sexo masculino (p=0,036), uso de dispositivos invasivos (p<0,001), hospitalizações prolongadas em unidades gerais e UTI (p<0,001) e múltiplas infecções adquiridas (p=0,013). Pacientes com MR tiveram mediana de permanência hospitalar de 26 dias, comparada a 17 dias para bactérias sensíveis. Na UTI, a mediana foi de 15 dias para os com MR e 6 dias para microrganismos sensíveis, com aumento significativo de 9 dias (p<0,001). O número de infecções hospitalares dobrou a chance de resistência antimicrobiana. A maior incidência de resistência foi observada na classe dos carbapenêmicos (63,9%), seguida por cefalosporinas, fluoroquinolonas, aminoglicosídeos (14,6%) e polimixinas (11,5%). **Conclusão:** A resistência antimicrobiana foi associada a fatores clínicos como idade avançada, sexo masculino, uso de dispositivos invasivos, hospitalizações prolongadas e múltiplas infecções adquiridas. Pacientes com microrganismos resistentes apresentaram internações significativamente mais longas, especialmente em UTI.

Descritores: *Farmacorresistência Bacteriana Múltipla. Infecção Hospitalar. Fatores de Risco. Resistência Microbiana a Medicamentos.*

RESUMEN

Justificación y Objetivos: Las infecciones por microorganismos multirresistentes aumentan los costos de los sistemas de salud, prolongan las hospitalizaciones y elevan la mortalidad. Por ello, este estudio tuvo como objetivo analizar los factores clínicos asociados a las infecciones y a la resistencia antimicrobiana en pacientes adultos hospitalizados. **Método:** Estudio retrospectivo, transversal y descriptivo, con enfoque cuantitativo, realizado en un hospital terciario en el sur de Brasil. Se incluyeron pacientes de 18 años o más, hospitalizados entre enero de 2018 y diciembre de 2023 por más de 72 horas en áreas clínicas, quirúrgicas o en la Unidad de Cuidados Intensivos (UCI) con cultivos bacterianos positivos. Los datos se analizaron con IBM SPSS Statistics® 20. **Resultados:** Se analizaron 546 pacientes con cultivos microbiológicos positivos, de los cuales el 74,2% presentaron microorganismos resistentes (MR). La resistencia se asoció con edad avanzada (p=0,055), sexo masculino (p=0,036), uso de dispositivos invasivos (p<0,001), hospitalizaciones prolongadas en unidades generales y UCI (p<0,001) y múltiples infecciones adquiridas (p=0,013). Los pacientes con MR tuvieron una mediana de estancia hospitalaria de 26 días, en comparación con 17 días para bacterias sensibles. En la UCI, la mediana fue de 15 días para los pacientes con MR y 6 días para microorganismos sensibles, con un aumento significativo de 9 días (p<0,001). El número de infecciones nosocomiales duplicó la probabilidad de resistencia antimicrobiana. La mayor incidencia de resistencia se observó en la clase de los carbapenémicos (63,9%), seguida por cefalosporinas, fluoroquinolonas, aminoglucósidos (14,6%) y polimixinas (11,5%). **Conclusión:** La resistencia antimicrobiana se asoció con factores clínicos como edad avanzada, sexo masculino, uso de dispositivos invasivos, hospitalizaciones prolongadas y múltiples infecciones adquiridas. Los pacientes con microorganismos resistentes presentaron hospitalizaciones significativamente más largas, especialmente en la UCI.

Palabras Clave: *Farmacorresistencia Bacteriana Múltiple. Infección Hospitalaria. Factores de Riesgo. Resistencia Microbiana a Medicamentos.*

INTRODUCTION

Healthcare-associated infections (HAIs) are one of the leading causes of morbidity and mortality in hospital settings and are often associated with the clinical severity of patients, medical and surgical interventions, and complications arising from these procedures.[1]

Among the etiological agents of these infections, bacteria stand out, as they can play a significant pathogenic role in certain circumstances. When these bacteria threaten human health, the use of antimicrobials becomes indispensable in treatment. However, the progressive increase in bacterial resistance to these drugs has become a critical and growing problem, complicating the control of HAIs and posing significant challenges to health systems globally.[2]

Although the increase in bacterial resistance is a natural phenomenon resulting from the interaction between microorganisms and the environment, European studies show a worrying increase in its incidence in recent years. It is estimated that 67.6% of deaths from infections are associated with bacteria that are multi-resistant to available antimicrobials, highlighting the impact of these infections on global health.[3,4]

This scenario is aggravated by risk factors related to the acquisition of HAIs, which can be endogenous, such as advanced age, use of immunosuppressants, compromised nutritional status, and chronic diseases, or exogenous, including cross-infection, prolonged hospitalizations, invasive procedures, and inadequate hygiene and disinfection practices. The combination of these factors contributes both to the increased prevalence of HAIs and to the emergence and spread of multidrug-resistant bacteria.[1,5]

The hospital environment favors the selection and spread of resistant microorganisms, mainly due to the inappropriate use of antimicrobials and the concentration of individuals with varying degrees of vulnerability to infection. In addition, the high number of invasive procedures performed in this context significantly increases the risk of HAIs. The institutional profile also influences these rates, since teaching hospitals tend to have higher rates of HAIs, associated with the greater complexity of the cases treated and the higher volume of interventions.[1,5]

Studies indicate that infections caused by multidrug-resistant organisms (MDROs) are associated with increased hospital costs, greater complexity of care, and prolonged hospitalization. These conditions increase patients' exposure to new infectious events and contribute to unfavorable clinical outcomes. Comparatively, patients infected with resistant pathogens have higher mortality rates than those infected with susceptible microorganisms.[6]

Despite advances in scientific knowledge, infections caused by multidrug-resistant microorganisms remain a major clinical challenge, especially in Brazilian hospitals, where epidemiological profiles, antimicrobial resistance patterns, and factors associated with infections may differ from other international contexts. Local analysis of these aspects is essential to support surveillance actions, guide policies for the rational use of antimicrobials, and improve strategies for the prevention and control of HAIs.

Thus, the objective of this study was to analyze the clinical factors associated with infection and antimicrobial resistance in hospitalized adult patients.

METHODS

A retrospective cross-sectional study with a quantitative approach was conducted to compare the clinical indicators and microbiological profile of cultures from adult patients hospitalized and infected with microorganisms resistant and sensitive to antimicrobials.

The study was conducted in a high-complexity tertiary philanthropic hospital located in southern Brazil, with a capacity of 274 beds, 48 of which are in the intensive care unit (ICU). The institution was a reference in robotic surgery and in the care of trauma patients, providing assistance to adults with clinical and surgical needs. The hospital had a Hospital Infection Prevention and Control Service (HIPCS) and a computerized system for managing the use of antimicrobials, which allowed the analysis of medical prescriptions recorded in the electronic medical records, with automatic blocking in cases of non-compliance. In addition, it had a clinical pharmacy service operating in an integrated manner in the care units.

All patients aged 18 years or older, hospitalized from January 2018 to December 2023 for more than 72 hours, in clinical, surgical, or intensive care unit (ICU) sectors, who had a positive microbiological diagnosis for the following bacteria: *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa,* and *Enterococcus*.

These microorganisms were selected due to their clinical relevance and high incidence of infections at the institution where the research was conducted, most of which belong to the ESKAPE group (*Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter spp.*), pathogens recognized for their resistance to multiple antimicrobials and their significant impact on nosocomial infections.[7] The diagnosis was made by blood culture, and the results were analyzed using the following criteria: *Pseudomonas aeruginosa*, and *Enterobacter spp.*),

pathogens recognized for their resistance to multiple antimicrobials and their significant impact on nosocomial infections.[7] The diagnosis was made through blood cultures, urine cultures, and tracheal secretion cultures collected previously, considering the potential impact of these infections on the morbidity and mortality of hospitalized patients.

Patients with incomplete medical records, absence of essential microbiological or clinical information, inconsistencies regarding length of stay, or absence of laboratory confirmation of the etiological agent were excluded.

The clinical variables analyzed included gender, age, race, period of hospitalization, length of stay in the ICU, type of admission (clinical or surgical), and clinical outcome (discharge or death); microbiological variables based on the identification of the bacterial species and the antimicrobial sensitivity profile; microbiological cultures were classified as multidrug-resistant in the following cases: methicillin-resistant *S. aureus (Oxacillin-resistant S. aureus*), vancomycin-resistant *Enterococcus spp*. (Vancomycin-resistant Enterococcus), and Gram-negative bacteria resistant to at least one class of antimicrobials, such as carbapenems, cephalosporins, fluoroquinolones, aminoglycosides, and polymyxins, according to the protocol adopted by the study institution.

Cases of healthcare-associated infections (HAIs) were obtained from the monthly bulletin prepared by the institution's Hospital Infection Prevention and Control Service (HIPCS). The diagnosis of HAIs followed the criteria established by the Brazilian Health Regulatory Agency (ANVISA), according to its current updates.

Blood cultures, urine cultures, and tracheal secretion cultures were collected according to institutional standards. Blood cultures were processed by the BACTEC® automated system (bioMérieux – Brazil) for microbial growth detection.

Urine cultures and tracheal secretion cultures were seeded in appropriate culture media and incubated to obtain isolated colonies. Microbiological confirmation was defined by cut-off points of $\geq 10^5$ CFU/mL for urine cultures and $\geq 10^6$ CFU/mL for tracheal secretion cultures.

Microorganism identification and antimicrobial susceptibility profiling were performed using the MicroScan® automated system (Siemens).

Data were extracted from electronic medical records using the Business Intelligence® platform, organized in Microsoft Excel®, and analyzed using IBM SPSS Statistics software, version 20.

Patients were classified according to their antimicrobial susceptibility profile and divided into two groups: susceptible and resistant, according to the criteria of the Brazilian Committee on Antimicrobial Susceptibility Testing.[8] Categorical variables were described by absolute and relative frequencies and compared using Fisher's exact test or Pearson's chi-square test, as applicable. The normality of the numerical variables was assessed using the Shapiro-Wilk test; as they did not show a normal distribution, they were described by median and interquartile range. A significance level of $p<0.05$ was adopted.

This research was part of a project entitled "Clinical and economic impact of antimicrobial resistance on hospital costs," approved by the institution's Human Research Ethics Committee through an amendment (Opinion No. 5,632,608; CAAE No. 24711718.8.0000.0099) on September 9, 2022, and was conducted in accordance with Resolutions No. 466/2012, No. 510/2016, and No. 580/2018 of the National Health Council.

RESULTS

The study population consisted of 546 patients who tested positive in blood culture, urine culture, and/or tracheal secretion culture during hospitalization; of these, 74.2% had antimicrobial-resistant microorganisms in at least one microbiological culture.

The results showed a predominance of older adult, male, white patients and hospitalizations for clinical reasons (Table 1).

Table 1. Association of clinical and demographic variables of patients admitted to a tertiary hospital according to the sensitivity profile of microbiological cultures. Londrina-PR, Brazil, 2018 - 2023 (N=546).

Variables	Total N=546 N %	Resistant n=405 N%	Sensitive n=141 N%	OR*	†95%CI	‡*p*-value
Sex						
Male	329 (60.3%)	255 (77.5)	74 (22.5)	1.53	1.04-2.26	0.036
Female	217 (39.7%)	150 (69.1)	67 (30.9)			
Age group						
≥ 20 - 29 years	15 (2.7)	12 (80.0)	3 (20.0)			
30 - 59 years	206 (37.7)	164 (79.6)	42 (20.4)			
≥ 60 years	325 (59.5)	229 (70.5)	96 (29.5)			0.055
Skin color¨						
White	447 (82.9)	320 (71.6)	127 (28.4)	0.45	0.24-0.82	0.009
Not white	92 (17.1)	78 (84.8)	14 (15.2)			
Reason for admission						
Surgical	222 (40.7)	171 (77.0)	51 (23.0)			
Clinical	324 (59.3)	234 (72.2)	90 (27.8)	1.29	0.86-1.91	0.233

continue

Variables	Total N=546 N %	Resistant n=405 N%	Sensitive n=141 N%	OR*	†95%CI	‡*p*-value
Invasive Devices						
OIT	363 (66.5)	287 (79.1)	76 (20.9)	0.48	0.32-0.71	<0.001
IUC	391 (71.6)	295 (75.4)	96 (24.6)	0.79	0.52-1.20	0.281
CVC	467 (69.3)	361 (77.3)	106 (22.7)	0.36	0.22-0.65	<0.001
Topography of HAIs						
PNM	186 (34.1)	145 (78.0)	41 (22.0)	0.73	0.48-1.11	0.151
BSI	267 (48.9)	202 (75.7)	65 (24.3)	0.85	0.58-1.26	0.494
UTI	207 (37.9)	155 (74.9)	52 (25.1)	0.94	0.63-1.40	0.840
Number of HAIs						
1 infection	442 (81.0)	318 (71.9)	124 (28.1)	1.99	1.14-3.49	0.013
≥ 2 infections	104 (19.0)	87 (83.7)	17 (16.3)			
Length of stay						
≥ 30 days	203 (37.2)	173 (85.2)	30 (14.8)	2.75	1.76-4.32	<0.001
< 30 days	343 (62.8)	232 (67.6)	111 (32.4)			
Stay in the ICU						
Yes	465 (85.2)	356 (76.6)	109 (23.4)	2.13	1.30-3.49	0.004
No	81 (14.8)	49 (60.5)	32 (39.5)			
Length of stay in the ICU						
< 15 days	224 (48.2)	147 (65.6)	77 (34.4)			
≥ 15 days	241 (51.8)	209 (86.7)	32 (13.3)	3.42	2.15-5.43	<0.001
Outcome						
Discharge	243 (44.5)	175 (72.0)	68 (28.0)			
Death	303 (55.5)	230 (75.9)	73 (24.1)	1.22	0.83-1.79	0.326

The '≥ 60 years' group was used as the reference category.
Percentages were calculated excluding 7 cases with missing information on skin color¨.
Abbreviation: OR*: Odds Ratio; †CI: Confidence Interval, ‡Pearson's Chi-square ‡‡Fisher's Exact; CVC: Central Venous Catheter; IUC: Indwelling urinary catheter; OIT: Orotracheal intubation; PNM: Pneumonia; BSI: Bloodstream Infection; UTI: Urinary Tract Infection.

Antimicrobial resistance was associated with the use of invasive devices, as well as prolonged periods of hospitalization, including stays in wards and ICUs exceeding 15 days.

Regarding length of hospital stay, patients infected with resistant bacteria had a median of 26 days (IQR: 22), significantly higher than those with sensitive bacteria, whose median was 17 days (IQR: 15). Regarding ICU stay, the group with resistant bacteria had a median of 15 days (IQR: 18), while the group with sensitive bacteria had a median of 6 days (IQR: 13). Infection with resistant bacteria was associated with a 9-day increase in the median length of stay in the ICU (p=0.004).

The number of infections acquired during hospitalization was significantly associated with antimicrobial resistance, increasing the probability of infections caused by resistant microorganisms by almost twofold.

A total of 616 microbiological cultures were analyzed, of which 76.5% were resistant to antimicrobials and 23.53% were sensitive. The class of antimicrobials with the highest resistance rate was carbapenems, followed by cephalosporins, fluoroquinolones, aminoglycosides, and polymyxins. The most prevalent microorganism was *K. pneumoniae*, followed by *A. Baumanni* and *P. aeruginosa* (Table 2).

Table 2. Prevalent microorganisms and antimicrobial resistance profile in adult patients admitted to a tertiary hospital. Londrina-PR, Brazil, 2018 - 2023 (N=616).

Microorganism	Resistant N (%)	Sensitive N (%)	Total N (%)
	471 (76.4)	145 (23.5)	616
Escherichia coli	31 (6.6)	32 (22.1)	63 (10.2)
Staphylococcus aureus	38 (8.1)	30 (20.7)	68 (11.0)
Klebsiella pneumoniae	183 (38.9)	25 (17.2)	208(33.8)
Acinetobacter baumannii	162 (34.4)	4 (2.8)	166 (26.9)
Pseudomonas aeruginosa	51 (2.8)	21 (14.5)	72 (11.7)
Enterococcus spp	6 (1.3)	33 (22.8)	39 (6.3)

The results of the study identified that *A. baumannii* had the highest resistance rate to the carbapenem class, with a rate of 52.8%, followed by *K. pneumoniae*, with 28.9% resistance. Regarding the cephalosporin, fluoroquinolone, and aminoglycoside classes, *K. pneumoniae* stood out as the most prevalent microorganism, with 58.6% resistance, followed by *E. coli*, which showed 27.1% resistance.

In the polymyxin class, often used as rescue therapy for infections caused by multidrug-resistant microorganisms, *K. pneumoniae* showed a high rate of antimicrobial resistance, reaching 98.1%. This finding is alarming, considering that polymyxins are often the last therapeutic resource available. The distribution of the antimicrobial resistance profile is illustrated (Figure 1).

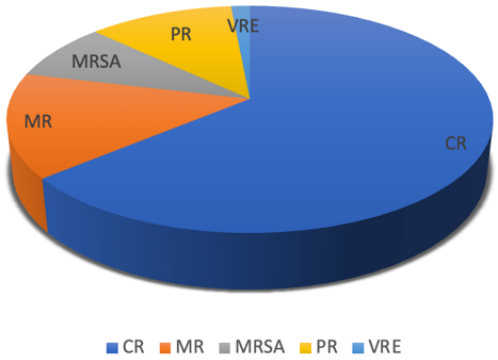

Figure 1. Distribution of resistance profiles by antimicrobial class in a tertiary hospital. Londrina-PR, Brazil, 2018 to 2023 (N=616).
Abbreviation: CR - carbapenem-resistant; MR - cephalosporin-, fluoroquinolone-, and aminoglycoside-resistant; PR - polymyxin-resistant; MRSA - oxacillin-resistant *Staphylococcus aureus*; VRE - vancomycin-resistant *Enterococcus* spp.

Although most patients who died had infections caused by resistant microorganisms, antimicrobial resistance was not significantly associated with clinical outcome in the study population. Among patients who died, 230 (75.9%) had infections caused by resistant microorganisms, and 73 (24.1%) had infections caused by sensitive microorganisms (p = 0.326).

DISCUSSION

The results showed that antimicrobial resistance was present in more than half of the patients with positive microbiological cultures for bacteria. The patients most affected by HAIs were male, older adult, and white.

The predominance of male patients diagnosed with HAIs observed in the present study (60.03%) is consistent with data from previous studies, both in Brazil, with 58.7% of cases in men, and in Europe, where 58.1% of infections were recorded in male patients.[9,10] The prevalence can be explained by biological, behavioral, and hospital factors. Biologically, men have less efficient immune responses due to the modulating effects of androgens, making them more susceptible to serious infections. Behaviorally, studies indicate that men tend to use fewer preventive health services and seek care later, increasing the likelihood of infections and exposure to multidrug-resistant microorganisms. In addition, hospital factors, such as greater clinical severity, greater need for invasive procedures, and prolonged hospitalization, contribute to colonization and infection by multidrug-resistant pathogens. [11,12,13,14]

In addition, it is important to note that advanced age also plays a significant role as a risk factor for these infections. Older adult patients have immune changes that make them more susceptible to these infections.[15]

Infectious diseases are among the most prevalent in this population, accounting for about 30% of hospitalizations and mortality. [16] In addition, antimicrobial resistance, often related to recurrent infections, excessive use of antimicrobials, reduced immune response, invasive procedures, hospitalization in ICUs, septic shock, comorbidities, and the severity of clinical conditions, represents a significant challenge in the treatment of infections in this age group.[17]

Among bacterial isolates, most cases of multidrug resistance (MDR) were attributable to Gram-negative bacteria (GNB), accounting for approximately 83% of cases. The predominance of Gram-negative bacteria among cases of multidrug resistance can be explained by their structural and genetic characteristics that favor antimicrobial resistance. These bacteria have an outer membrane that hinders the penetration of antibiotics and have a high capacity to acquire and transfer resistance genes through plasmids and other mobile genetic elements. In addition, in hospital settings, the frequent use of antibiotics and the presence of invasive devices create strong selective pressure, facilitating the spread of multidrug-resistant strains. Thus, biological and contextual factors contribute to Gram-negative bacterial infections accounting for the majority of cases of resistance observed.[18,19,20,21]

This finding is similar to that of a Brazilian study that analyzed the occurrence of bacterial infections and the profile of antimicrobial resistance, which identified that 59.4% of bacterial isolates were resistant to at least one class of antimicrobials, of which 21.8% were classified as multidrug resistant.[22]

Among the infections studied, the most frequent was bloodstream infection, followed by urinary tract infections and pneumonia. Among these, pneumonia was the infection most frequently associated with antimicrobial resistance, followed by bloodstream and urinary tract infections. The higher prevalence of antimicrobial resistance among pneumonia cases observed in this study can be explained by factors widely described in the literature. Hospital-acquired pneumonia, especially that associated with mechanical ventilation, occurs predominantly in critically ill patients, who are often exposed to broad-spectrum antimicrobials and subjected to invasive devices, such as endotracheal tubes and ventilators, which favor the colonization and spread of multidrug-resistant microorganisms. In addition, the pulmonary environment has characteristics that hinder bacterial eradication, such as biofilm formation, accumulation of secretions, and reduced tissue penetration of antimicrobials. International studies reinforce this trend, pointing to the predominance of Gram-negative bacilli, such as Acinetobacter baumannii, Klebsiella pneumoniae, and Pseudomonas aeruginosa, among the most frequent etiological agents of resistant nosocomial pneumonia.[23,24,25]

Most patients had only one infection, of which 71.9% showed resistance to antimicrobials. This resistance was particularly relevant in infections associated with the

presence of invasive devices, such as orotracheal tubes and central venous catheters. Although the presence of an indwelling urinary catheter did not show a statistically significant association, it was observed that more than half of the patients used this device. Among them, the majority developed infections caused by resistant microorganisms, suggesting a possible correlation between prolonged use of urinary catheters and an increased risk of infections caused by resistant pathogens. In addition, it is estimated that approximately 80% of urinary tract infections are associated with the use of urinary catheters.[26]

In this context, invasive devices generally represent a significant risk factor for hospital infections, as they break down the body's natural defense barriers and promote the colonization and spread of microorganisms. Venous catheters, urinary catheters, endotracheal tubes, and other devices provide surfaces conducive to the formation of microbial biofilms, which hinder the action of antimicrobials and the host's immune response. In addition, frequent handling of these devices and prolonged dwell time increase the risk of cross-contamination and infection by multidrug-resistant pathogens. Studies indicate that the use of invasive devices is associated with a significant proportion of healthcare-associated infections, including bloodstream infections, ventilator-associated pneumonia, and catheter-associated urinary tract infections.[27,28,29] Given this scenario, it is essential to implement effective preventive strategies to minimize the impact of these adverse events on patients. [30,31]

An integrative review conducted in Brazil between 2018 and 2021 analyzed data from six studies, highlighting the most prevalent infections in hospitalized adults. Urinary tract infection (UTI) was the most common, followed by bloodstream infection, surgical site infection, and ventilator-associated pneumonia.[32]

A European study conducted in Spain assessed the impact on morbidity, mortality, and length of hospital stay of hospital-acquired infections caused by resistant microorganisms, where the most prevalent infections were urinary tract infections (39.5%), respiratory infections (18.4%), and bloodstream infections (8.3%). In terms of the etiology of the infection, E. coli was the most common microorganism (39.4%), followed by *S. aureus (25.6%)* and *P. aeruginosa* (18.2%).[33]

The divergence between the findings of the present study, with a higher prevalence of bloodstream infection, and other studies, which point to urinary tract infection as more common, can be explained by the characteristics of the population studied and the healthcare context. Critical patients undergoing central catheterization and invasive procedures are at greater risk of hospital-acquired bacteremia, while the predominance of urinary tract infections in other studies reflects greater exposure to bladder catheterization. Thus, the profile of hospital-acquired infections varies according to the type of device, clinical severity, and healthcare setting.

In this study, the most prevalent infections were caused by K. pneumoniae (33.8%), A. baumannii (26.9%), and P. aeruginosa (11.7%). Among the microorganisms with the highest resistance to antimicrobials, K. pneumoniae (38.9%), A. baumannii (34.4%), and S. aureus (8.1%) stood out. The classes of antimicrobials with the lowest sensitivity profile were carbapenems, cephalosporins, fluoroquinolones, aminoglycosides, and polymyxins. These findings highlight the severity of antimicrobial resistance in clinically relevant microorganisms, especially in nosocomial infections. This data is alarming, considering that polymyxins are often the last therapeutic resource available for the treatment of HAIs.[34]

Another Brazilian study, conducted in a teaching hospital, found divergent data, highlighting surgical site infections as the most prevalent, followed by ventilator-associated pneumonia and primary bloodstream infection.[35] These data may vary depending on the context in which they are inserted, such as the type of hospital, the population served, the infection prevention protocols adopted, and the use of available technologies and medical devices.

Although often originating during hospitalization or hospital procedures, HAIs can worsen after discharge. Despite advances in technology and care practices, there is still a high probability of complications that harm patients' health.[36]

Although HAIs can occur in various hospital areas, the incidence is particularly high in the ICU, where patients often have compromised immune systems and are exposed to intensive use of antimicrobials. In addition, many of these patients require invasive devices such as catheters and mechanical ventilators. Contamination of catheters can result in the formation of biofilms, which increases the risk of local and systemic infections such as bacteremia and sepsis.[36,37]

Antimicrobial resistance in microorganisms isolated from adult patients was associated with factors such as length of hospitalization and length of stay in the ICU. In the present study, 37.2% of patients diagnosed with HAIs remained hospitalized for more than 30 days, with an average overall hospital stay of 30 days in cases of antimicrobial-resistant microorganisms. A European study presented similar data, reporting an average stay of 29.8 days.[33]

In this study, 85.2% of patients were admitted to the ICU, with a prevalence of hospitalizations lasting more than 15 days. The average length of stay in this sector was 9 days for patients with sensitive infections and 18 days for those with antimicrobial-resistant infections.

A Brazilian study reviewed the factors that influence the length of stay of patients in the ICU and observed that hospitalization for more than 72 hours is associated with a significant increase in the development of serious conditions, with a mortality rate that can exceed 53.3% and prolong hospitalization by up to 14.1 days.[38] These findings highlight how prolonged ICU stays can worsen clinical outcomes.

Another Brazilian study found data similar to this study, identifying a mean general hospitalization time of 25.9 ± 23.6 days, with a mean of 15.11 days in the ICU. Patients with hospital-acquired infections had a mean hospital stay of 28 days and a mean of 20.5 days in the ICU.[39]

These results reinforce the relationship between length of stay and severity of infections, especially in patients with HAIs and resistant microorganisms, but the causal direction should be interpreted with caution. Patients may remain hospitalized for longer periods due to clinical severity, increasing exposure to risk factors for acquiring HAIs; on the other hand, the occurrence of these infections can significantly prolong hospitalization due to the need for prolonged antimicrobial therapies, intensive monitoring, and management of complications. Thus, length of stay and the presence of HAIs influence each other, forming a cycle that increases clinical severity and the risk of adverse outcomes, reinforcing the importance of effective preventive strategies and strict surveillance of the use of invasive devices and antimicrobials.

In this study, mortality was not significantly associated with hospital infections caused by multidrug-resistant microorganisms; however, evidence from another study indicates that cases involving resistant organisms had a 1.7 times higher risk of mortality compared to infections caused by sensitive microorganisms.[33]

These findings reinforce the impact of infections caused by resistant microorganisms on the clinical evolution of patients, particularly in critical environments such as ICUs. In these situations, factors such as the presence of comorbidities, previous health status, and the severity of underlying conditions can significantly amplify the risks of unfavorable outcomes, such as higher mortality and prolonged hospitalization.

In this context, the main actions that contribute to the containment of antimicrobial resistance become even more essential, including appropriate prescribing, which can be optimized with the use of Artificial Intelligence, in addition to the interface with intelligent medical prescription systems. These systems are parameterized to block the escalation of inappropriate antibiotics, facilitate dispensing monitoring, and ensure continuous surveillance of infections caused by multidrug-resistant microorganisms. In addition, strict compliance with legislation on the use and dispensing of antimicrobials is essential to minimize risks and improve clinical outcomes.

Although this study provided relevant information on the clinical factors associated with infection and antimicrobial resistance in hospitalized adult patients, some limitations should be considered. Restricting the sample to a single hospital may compromise the representativeness of the findings, since different hospital settings and geographic regions have distinct profiles of infection and antimicrobial resistance. In addition, the classification of multidrug-resistant microorganisms adopted by the institution during the study period may have influenced the results. Thus, future research adopting the World Health Organization's categorization of priority pathogens classified as critical, high, and medium priority and the criteria for antimicrobial resistance in MDR (multidrug-resistant), XDR (extensively drug-resistant), and PDR (pan-drug-resistant) may contribute to a more comprehensive understanding of the clinical factors associated with infection and antimicrobial resistance.

Despite these limitations, the findings of the present study provide important evidence on the clinical factors that influence the occurrence of infections and antimicrobial resistance in hospital settings. It was observed that male gender, advanced age, white race, prolonged hospitalization, especially in intensive care units, and the use of invasive devices, such as catheters and mechanical ventilators, increase the risk of HAIs and antimicrobial resistance. The number of infections acquired during hospitalization was also found to be relevant, reinforcing the need for effective preventive strategies to reduce the spread of resistant pathogens and improve clinical outcomes for hospitalized patients.

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AUTHORS' CONTRIBUTIONS

Nayane Laine Paglione Dias contributed to the bibliographic research, writing of the abstract, introduction, methodology, discussion, interpretation and description of results, preparation of tables, conclusions, review, and statistics. **Sidnei Dias Silva** contributed to the literature review, writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics. **Susany Franciely Pimenta** contributed to the writing of the abstract, methodology, interpretation of results, conclusions, review, and statistics. **Rosângela Aparecida Pimenta** contributed to the writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics. **Maria do Carmo Fernandez Lourenço Haddad** contributed to the writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics. **Marcia Regina Eches Perugini** contributed to the writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics. **Danielly Negrão Guassú Nogueira** contributed to the writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics. **Adriana Zilly** contributed to the writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics.

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