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Microbiological and epidemiological profile of patients in an isolation unit at a university hospital in Paraná

Perfil microbiológico e epidemiológico de pacientes em unidade de isolamento em hospital universitário do Paraná

Perfil microbiológico y epidemiológico de pacientes en unidad de aislamiento en un hospital universitario de Paraná

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ABSTRACT

Introduction: Healthcare-Associated Infections (HAIs) represent a public health problem due to their impact on the quality of care and morbidity and mortality. This study analyzed the microbiological and epidemiological profile of HAIs in a hospital isolation unit, identifying the prevalence of resistant microorganisms and its relationship with demographic factors and clinical outcomes, from January 2021 to June 2024. Design: This is a descriptive, retrospective, and quantitative research, carried out with secondary data from patients admitted to a Multidrug-Resistant Organisms (MDROs) isolation unit of a university hospital in Paraná, Brazil. Results: 468 patients were analyzed, mostly male (68.16%), with a predominant age range between 60 and 79 years (38.30%). Colonization by MDRO was higher than infection, respectively, 63.02% and 36.95%). High rates of resistance to carbapenems (20.30%) and meropenem (18.80%) were notable. Rectal swabs were the main microbiological sample (63.68%). The mortality rate reached 19.01%. Implications: These findings reinforce the need for effective infection control and microbiological surveillance strategies to minimize the spread of resistant pathogens and reduce mortality, highlighting the importance of appropriate antibiotic management in the hospital setting.

DESCRIPTORS

Infection control. Health Profile. Patient isolation. Drug Resistance, Microbial. Asymptomatic Infections.

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INTRODUCTION

Healthcare-Associated Infections (HAIs) encompass all infections acquired by patients during healthcare, whether in a hospital, outpatient setting, or at home. It is important to note that HAIs can manifest locally or systemically, arising as a result of the body's immune response to the invasion of pathogenic microorganisms or the toxins they produce[1-3].

For conceptual purposes, the term HAI is used to designate any clinical manifestation of infection occurring more than 72 hours after hospital admission or discharge, provided the incubation period of the etiological agent is unknown and there is no clinical or laboratory evidence of infection at the time of admission. Infections are also considered to be those that occur within 72 hours of hospitalization, provided they are associated with diagnostic or therapeutic procedures performed during this period and are related to interventions performed in the context of healthcare[1,3,4].

Healthcare-Associated Infections (HAIs) are caused by bacteria, viruses, fungi, or other microorganisms found, for example, in the hospital environment, on the skin of patients, or on the hands of healthcare professionals[13]. Due to the significant consequences for morbidity and mortality and the population's quality of life, they are a global public health concern and represent one of the most frequent adverse events in healthcare services.

It is estimated that for every 100 patients undergoing intensive care, seven patients in high-income countries and 15 patients in low- and middle-income countries will develop at least one HAI during their hospitalization[5]. The probability of a patient acquiring at least one type of HAI is estimated to be approximately 7% in developed countries and 10% in developing countries[6].

These infections pose a significant risk to patient safety, as they can prolong hospital stays, increase treatment costs, and, in severe cases, lead to death. On mean, one in 10 affected patients will die from this infection[5-6].

Additionally, HAIs also involve the use of expensive antibiotics and the need for readmissions, in addition to generating significant social burdens, such as lost income and reduced productivity[3].

The literature shows that HAIs can be prevented through a series of measures involving both healthcare professionals and patients. These include adequate nutrition, as well-nourished patients have a lower risk of developing infections, effective implementation of infection control practices, and the adoption of rigorous hand hygiene protocols, such as cleaning surfaces and equipment[7-9].

Furthermore, standard precautions are essential, such as rational antimicrobial management, constant monitoring, continuing education of healthcare professionals, and strict supervision of compliance with protocols, especially in Intensive Care Units (ICUs). Therefore, it is imperative that everyone involved in patient care be knowledgeable about the essential aspects of HAIs, including their epidemiology and appropriate preventive measures. This understanding is essential to interrupt the chain of transmission and mitigate the damage caused by these infections[3,10,11].

It is important to highlight that HAI topographies include Urinary Tract Infections (UTIs), Bloodstream Infections (BSIs), Respiratory Tract Infections, especially Ventilator-Associated Pneumonia (VAP), Infections in surgeries involving implants and prostheses, and Surgical Site Infections (SSIs)[1,12-14].

In this context, infections caused by Multidrug-Resistant Organisms (MDROs) stand out. Undoubtedly, microorganisms, especially bacteria, have a remarkable capacity for mutation and acquisition of resistance genes, a factor that compromises the effectiveness of antimicrobials[15]. This process occurs because such drugs create selective pressure, allowing more resistant strains to survive, proliferate, and accumulate multiple resistance mechanisms over time[15,16]. Examples of MDRO include Staphylococcus aureus, Pseudomonas aeruginosa, Enterobacter, and Acinetobacter baumannii, which are widely associated with infections and colonization[12,17,18].

Given the growing concern about infections, it is essential that more rigorous control strategies be implemented, especially in the hospital environment, where the risk of spreading MDRO is high. Therefore, this study asks: What is the epidemiological and microbiological profile of HAIs in a hospital isolation setting? Based on this, this research analyzed the microbiological and epidemiological profile of HAIs in a hospital isolation environment, identifying the prevalence of MDRO and its associations with demographic factors (age, sex, race) and clinical outcomes (infection, colonization, antimicrobial resistance and death).

METHODS

This is a descriptive, retrospective, and quantitative study, conducted based on secondary data from patients admitted to an isolation unit at a teaching hospital in the state of Paraná, from January 2021 to June 2024.

Data collection took place between August and September 2024 and was obtained from the following sources: the Hospital Infection Control Service (HICS) database and electronic medical records. To characterize the sample, the following variables were included: age, sex, and race, type of microorganism, antimicrobial resistance, collection material, colonization or infection, and topography, totaling 468 patients.

To ensure the accuracy and consistency of the information analyzed, the following inclusion criteria were established: patients admitted to the isolation unit for the entire period of the MDRO, patients with complete data in the electronic medical record and in the HICS data spreadsheet.

The exclusion criteria included patients whose medical records and spreadsheet were incomplete or had insufficient data for analysis, patients who were discharged, transferred, or died before laboratory confirmation of MDRO, patients with duplicate records and laboratory samples in the spreadsheet, and patients whose microbiological results did not meet the institution's isolation protocol.

The study site is a teaching hospital located in the state of Paraná, with 100% of its beds allocated to patients of the Unified Health System (SUS). It serves as a referral center for 25 municipalities within the Regional Health System, in addition to serving four macro-regional health units within the state of Paraná[19].

Offering medium- and high-complexity services, this institution has: an adult ICU; a neonatal ICU; a pediatric ICU; a neurology and orthopedics unit; a surgical center; an obstetrics and maternity center; a pediatric rooming-in facility, an emergency room (ER), and outpatient services. Regarding the MDRO isolation unit, in November 2021, the need to implement additional contact isolation measures was identified. This phenomenon was particularly observed in the post-pandemic period, when there was a significant increase in the number of patients hospitalized for prolonged periods, substantially increasing the risk of acquiring MDRO. In response to this situation, hospital management, together with the HICS, designated a dedicated unit for the isolation of MDRO patients, aiming to reduce transmission and prevent the spread of these microorganisms.

Initially, 11 beds were made available for isolation per cohort of these patients. However, with increased demand, in January 2022, the entire unit was allocated to patients with MDRO, totaling 21 beds. However, this unit is currently no longer operational, an aspect not discussed in this study.

Rstudio Team[20] software was used for statistical data analysis. The results were organized and presented in tables created in Microsoft Excel® (version 2408).

Because this was documentary research involving human subjects, the ethical precepts established by Resolution 466/2012 and Resolution 510/2016, both of the National Health Council (NHC), were strictly observed. Conducting the study was subject to obtaining formal authorization from the head of the HICS of the hospital studied.

Furthermore, this research is part of a broader project, entitled “Knowledge that Permeates Nursing Care Practice in the Hospital Context”, with due approval by the Research Ethics Committee (REC), of the State University of Western Paraná, under opinion number 6.287.135 and the Certificate of Presentation for Ethical Appreciation (CAAE) number 72943723.5.0000.0107.

RESULTS

The following are the results obtained from the search of the HICS database and electronic medical records. The data are organized as follows: Table 1 – Patient profile, considering sex, race, age, and microbiological profile (colonization and infection); Table 2 – Antimicrobial resistance profile; Table 3 – Sample materials.

Information regarding the epidemiological profile of deaths among patients admitted to the isolation unit due to MDRO, highlighting the comparison between cases of infection and colonization, is presented in a descriptive format immediately after Table 3.

Table 1. Characterization of patients admitted to the MDRO isolation unit according to sex, race, age and microbiological profile (colonization and infection) - period from 2021 to 2024, Cascavel, PR, Brazil. (n=468)

Sex	**Number**	**%**
Male	319	68.16
Female	149	31.84
Color		
White	324	69.24
Brown	134	28.63
Black	8	1.70
Yellow	2	0.43
Age		
≤ 18 years	4	0.85
19 – 39 years	77	16.87
40 – 59 years	157	34.80
60 – 79 years	181	38.30
≥ 80 years	49	9.18
Microbiological profile		
Colonization	296	63.05
Infection	172	36.95
Total	468	100.00%

Source: Survey data, 2024.

Table 2. Antimicrobial resistance profile in patients admitted to the MDRO isolation unit - period from 2021 to 2024, Cascavel, PR, Brazil. (n=468)

Antibiotic	**N**	**%**
Carbapenems (Imipenem/Meropenem)	95	20.30
Meropenem	88	18.80
4th-Generation Cephalosporins and Carbapenems	64	13.68
Cefepime and Meropenem	31	6.62
Cefepime (4th-Generation Cephalosporins)	20	4.27
Cefepime and Carbapenems	19	4.06
Carbapenems and Colistin	15	3.21
Cefepime, Carbapenems, and Colistin	14	2.99
Vancomycin	11	2.35
Intermediate Resistance	63	13.46
Other Resistances	48	10.26
Total	468	100.00%

Source: Survey data, 2024.

Table 3. Distribution of microorganisms in various clinical materials - period from 2021 to 2024, Cascavel, PR Brazil. (n=468)

Material	Microorganism	Number	%
Rectal Swab		298	63.68
	Klebsiella pneumoniae	156	33.33
	Acinetobacter baumannii complex	90	19.23
	Pseudomonas aeruginosa	19	4.06
	Other microorganisms	33	7.05
Protected tracheal aspirate		56	11.97
	Pseudomonas aeruginosa	21	4.49
	Acinetobacter baumannii complex	17	3.63
	Klebsiella pneumoniae	14	2.99
	Other microorganisms	4	0.85
Other materials		114	24.36
	Pseudomonas aeruginosa	26	5.56
	Klebsiella pneumoniae	18	3.85
	Acinetobacter baumannii complex	11	2.35
	Other microorganisms	59	12.61
Total		468	100.00%

Source: Survey data, 2024.

Based on the analysis of the epidemiological profile of deaths among patients admitted to the MDRO isolation unit between 2021 and 2024 in the municipality of Cascavel, Paraná, Brazil (n=468), 89 deaths were recorded, corresponding to an overall lethality of 19.01%. When stratifying the deaths between infection and colonization, it was found that 34 (7.26%) occurred among patients with MDRO infection, while 55 (11.75%) were recorded in only colonized patients.

DISCUSSION

As shown in Table 1, there was a predominance of male patients (68.16%), considerably higher than the percentage of female patients (31.84%). These data are consistent with other studies[14,16,21], which also demonstrated a male prevalence.

This difference may be associated with men's possible reluctance to seek healthcare, as well as their tendency to seek care only in advanced stages of illness, when the condition is already worsened. This attitude may result in a reduced demand for healthcare services, which consequently affects the increase in morbidity and mortality rates in this population. Furthermore, this resistance contributes to the lack of preventive measures and neglect in the management of risk factors and complications associated with diseases[22].

Another factor may be related to the fact that men often hold positions in activities with greater levels of unhealthiness and physical exertion, increasing their exposure to workplace accidents and occupational diseases. Furthermore, harmful habits, such as a sedentary lifestyle and excessive alcohol and tobacco consumption, contribute to this situation. Studies indicate that men seek health care less frequently, usually in emergency cases, a situation aggravated by the incompatibility of health care facility opening hours with their work schedules[23-24].

The literature reinforces that the reduced presence of men in health services is deeply rooted in historical sociocultural constructs that associate health care with characteristics perceived as incompatible with traditional masculinity, such as weakness and insecurity. Factors such as lack of time, lack of concern

for prevention, fear of diagnosis, and delays in care also contribute to this reality[21,23]. It is believed that the lack of preventive care, combined with delays in treating diseases, can worsen men's health conditions, resulting in late diagnoses and more severe complications. Regarding the race variable, the data presented in Table 1 indicate a significant predominance of self-identified White patients (69.24%), followed by the proportion of brown race (28.63%) and, to a lesser extent, Black (1.7%) and Asian (0.43%).

Analysis of the data related to the race variable in this study reveals a discrepancy in relation to the racial distribution of the Brazilian population. The predominance of self-identified White patients (69.24%) in this study is significantly higher than the 43.5% of the Brazilian population who self-identified as White[25]. This may suggest that, in the sample studied, the representation of White people is higher than the national mean.

The proportion of self-identified brown patients in this study, 28.63%, is 16.67% compared to the national distribution, given that 45.3% of the Brazilian population identifies as brown. However, the representation of Black individuals (1.7%) is substantially below the 10.2% indicated by the Demographic Census. On the other hand, the percentage of self-identified Asian patients (0.43%) adequately reflects the distribution of this population in Brazil, according to the Census, which records 0.4%[25].

This discrepancy may be influenced by several factors, including inequalities in access to health services. Furthermore, urbanization and historical migration movements may have influenced the racial distribution in urban areas of the South of the country. In the 19th century, the region received a large number of European immigrants, marking a predominance of white individuals. However, internal migration flows and the search for better opportunities in urban centers may have increased the presence of brown-race individuals in cities, influencing the racial composition of patients treated in healthcare services[26,27].

Despite the social and racial inequalities that characterize Brazil, the relationship between race and health remains insufficiently explored in the literature, reflecting a significant gap in scientific production. This variable, however, is an essential indicator for understanding social disparities in health[28].

In this sense, Brazilian research has played a fundamental role in the formulation and implementation of public policies aimed at reducing racial inequalities in healthcare, promoting advances in the pursuit of a more equitable and inclusive healthcare system[26-28].

Another variable explored was age, as shown in Table 1. It can be seen that most patients are between 60 and 79 years old. Next, patients aged 40 to 59 stand out, followed by those aged 19 to 39.

These findings corroborate data from the Brazilian Institute of Geography and Statistics (IBGE) for 2022, in which the number of people aged 65 and over in Brazil increased by 57.4% between 2010 and 2022, going from 14 million (7.4% of the population) to 22.2 million (10.9%). This growth reflects the narrowing of the base of the age pyramid, a consequence of the decline in fertility and the number of births in the country. The fertility rate fell from 2.32 children per woman in 2000 to 1.57 in 2023, and the number of births per year decreased from 3.6 million in 2000 to 2.6 million in 2022[24].

This phenomenon is intrinsically linked to the demographic and epidemiological transition that Brazil has experienced in recent decades. Since 1970, the country has undergone a profound transformation in its demographic profile. Initially, Brazil was predominantly rural and traditional, with large families and high infant mortality rates. This change also impacted the age structure, with a decline in the young population and a significant increase in individuals aged 60 and over[29,30].

In the current context, the older Brazilian population is experiencing accelerated growth, with the demographic transition occurring more rapidly than in developed countries. It is estimated that by 2031, the older population will surpass the number of children aged 0 to 14. This population increase results in greater dependency among this age group, placing a significant burden on social security and healthcare systems. At the same time, there is a shift in the disease profile, with a growing prevalence of Chronic Non-Communicable Diseases (CNCDs), such as cardiovascular, neurological, and respiratory diseases[31].

Increased life expectancy has contributed to the growth of the older population, which often suffers from multiple chronic diseases. These conditions can worsen at certain times, requiring prolonged and intensive care. As a result, the older people are more vulnerable to hospitalizations than other age groups[32].

In this sense, HAIs pose a risk for this age group due to high morbidity and mortality rates, associated with more fragile clinical conditions and a slower immune response due to the aging process. This results in the need for more frequent hospitalizations, as well as greater exposure to invasive procedures[33] and increased hospital stays.

Therefore, the aging of the population should be considered one of the greatest challenges in

contemporary public health. Managing the complexity associated with this phenomenon represents a growing problem, requiring effective care strategies and adapting healthcare systems to meet the needs of an increasingly aging population[29,30,32]. Addressing these challenges requires a comprehensive and multidisciplinary approach that considers not only prevalent diseases but also the social, economic, and psychological aspects that impact the quality of life of older adults.

In this context, the health of older adults in hospital settings involves the risk of colonization and infection by MDRO, which further aggravates the clinical situation of these patients. To contextualize, the differentiation between colonization and infection involves not only the site of isolation of the microorganism but also the assessment of the patient's clinical conditions. Generally speaking, colonization refers to the presence of microorganisms without compromising the normal physiological functions of affected organs and/or tissues, nor triggering an inflammatory response from the immune system. On the other hand, the infection is characterized by the excessive proliferation of microorganisms, which causes functional changes in the affected tissues and organs, often accompanied by a significant immune response[34].

Multidrug-Resistant Organisms (MDROs) are a global public health problem, especially in hospital settings, where the risk of transmission is high due to procedures and the frequent use of invasive devices, such as central venous and urinary catheters, endotracheal tubes, and mechanical ventilators[31].

Table 1 also shows, in addition to data on the patients' demographic profile, the percentage distribution of colonization and infection cases. The analysis reveals a predominance of colonization over infections. These data indicate that, in more than half of the cases, the microorganisms identified did not cause infection but were present as colonizers.

It is noteworthy that bacteria, like other microorganisms, are not always responsible for infections and can establish transient or permanent colonization in different areas of the body[34]. Therefore, based on the findings of this study, the high colonization rate highlights the need for microbiological surveillance to identify potentially pathogenic microorganisms, while the infection rate highlights the importance of preventive interventions, such as hand hygiene, strict adherence to aseptic techniques, and the judicious use of antimicrobials.

Regarding infections, although less frequent, the 36.95% rate is significant, as these numbers indicate relevant clinical and epidemiological implications. This may be related to the increasingly complex adaptive mechanisms of microorganisms, favoring certain genera for the occurrence of multidrug-resistant intra-hospital infections[35].

These microorganisms have a significant capacity for survival on hospital surfaces, with survival times ranging from a few days to months, depending on the type of microorganism and environmental conditions[36].

This prolonged survival time increases the risk of HAIs and outbreaks, since eliminating MDRO in hospital settings is difficult, requiring rigorous disinfection and infection control protocols[37], as well as stewardship programs that manage and optimize antibiotic use, with the aim of minimizing the indiscriminate use of antimicrobials and reducing the selective pressure and proliferation of MDRO[38].

It is understood that the progression from colonization to infection in hospital settings poses a significant challenge to public health systems, directly affecting patients' health, prolonged hospital stays, and financial costs. Patients who stay for extended periods in hospital settings have an increased likelihood of developing HAIs.

This is due not only to increased exposure to MDRO, but also to the prolonged use of invasive devices, constant manipulation by healthcare professionals, and the decline in patient immune defenses over time. Increased hospital stays are directly related to the increased risk of transition from colonization to infection, especially in ICUs and critical care settings[17,34].

The clinical impact of infections, especially those caused by MDRO, can lead to a significant increase in morbidity and mortality. Infection can worsen the patients' clinical condition, increase resistance to conventional treatments, and prolong recovery. Furthermore, infections resistant to multiple antibiotics may require more aggressive and costly therapies, compromising the patient's overall prognosis[13,39].

Regarding the financial impact, infections cannot be underestimated, as they often result in prolonged hospitalizations and the need for more complex and expensive treatments, including broad-spectrum antibiotics and intensive supportive therapies. Furthermore, longer hospital stays can reduce bed turnover, increase the cost of intensive care, and require more resources, both financial and human. The increase in antimicrobial resistance can also increase costs for the development of new drugs and more specialized therapies, as well as extend treatment times and the risk of long-term complications[13,34,40].

To mitigate the impact of infections caused by MDRO, it is recommended that several strategies and best care practices be adopted. These include active microbiological surveillance, good hygiene and infection control practices, rational use of antibiotics, and education and ongoing training of healthcare staff[7,8,12,13].

Such approaches are essential[7,12], especially considering the worrying data presented in Table 2, which demonstrate growing antimicrobial resistance. These results indicate the urgency of implementing more effective strategies to control the indiscriminate use of antibiotics and improve infection management in hospital settings.

The data presented not only highlight the variety of emerging resistances but also the urgency of optimizing antibiotic use, considering that a portion of the patients presented microorganisms with intermediate resistance to the aforementioned antibiotics, which further aggravates the antimicrobial resistance situation in the study sample. This scenario reflects a growing global problem that significantly compromises therapeutic efficacy, especially in the treatment of HAIs caused by multidrug-resistant pathogens[41].

Regarding the predominance of carbapenem resistance, our research data indicate that the greatest resistance is associated with these antimicrobials. These drugs are widely used as a last-line treatment for serious infections caused by Gram-negative bacilli. The increase in resistance to these drugs significantly compromises available therapeutic options. Studies indicate that resistance to carbapenems is associated with the production of enzymes such as carbapenemases, which inactivate these antibiotics, as well as mechanisms such as alteration of porins and efflux pumps[42,43].

This suggests that the indiscriminate and inappropriate use of antibiotics contributes to the worsening of antimicrobial resistance, highlighting the need for effective control strategies, such as the implementation of rational antibiotic use policies, the education of healthcare professionals and patients, and investment in research to develop new therapeutic alternatives[42].

Resistance to fourth-generation cephalosporins is another relevant and concerning finding, representing 13.68% of the samples found in this study. These antibiotics are widely used in the treatment of HAIs. Resistance to 4th generation cephalosporins can be attributed to the production of extended-spectrum ß-lactamases (ESBLs) and the hyper-production of AmpC ß-lactamases, which hydrolyze cephalosporins[44].

Furthermore, fourth-generation cephalosporins, such as cefepime, also show resistance rates, with 4.27% of isolates resistant. The combination of cefepime and meropenem presents a resistance rate of 6.62%, suggesting the emergence of multidrug-resistant strains. Recent studies indicate that, without effective interventions, infections caused by drug-resistant bacteria could directly cause more than 39 million deaths between 2025 and 2050[5,45].

To reduce this threat, it is essential to implement effective strategies, such as optimizing the use of antimicrobials, as recommended by the National Health Surveillance Agency (ANVISA) through Collegiate Board Resolution (CBR) number 44/2010, which restricted the marketing of antimicrobials, requiring prescription retention and registration with the National Controlled Products Management System (SNGPC)[46].

The data from this study, combined with current evidence[41,42,45], highlight the urgent need for coordinated actions to monitor, prevent, and control antimicrobial resistance, ensuring the maintenance of the effectiveness of available treatments and global public health security. Another noteworthy result, as also highlighted by the data from this study, is the low proportion of microorganisms with associated resistance to other antibiotics, such as carbapenems and colistin, which remained at similar levels when combined with cefepime, carbapenems, and colistin.

Colistin is considered a last-line antibiotic in the treatment of infections caused by multidrug-resistant bacteria. The emergence of colistin resistance is particularly concerning because it further limits therapeutic options, especially in the context of severe and difficult-to-treat infections. Mechanisms of colistin resistance include modifications in the bacterial lipopolysaccharide membrane, which reduce the affinity for colistin, making bacteria less susceptible to the action of this antimicrobial[47].

This phenomenon can result in a vicious cycle, in which resistance to last-line antibiotics increases morbidity and mortality and complicates infection management, requiring the urgent implementation of antimicrobial resistance monitoring and control strategies[41]. Within the sample studied, a certain proportion of patients with resistance to Vancomycin was observed, which is alarming, considering its fundamental role as one of the last lines of defense against certain serious infections.

Vancomycin is a glycopeptide predominantly used to treat infections caused by Gram-positive

bacteria, such as Staphylococcus aureus, and plays an essential role in controlling multidrug-resistant infections. Vancomycin resistance, although less prevalent, poses a significant threat, especially in hospital settings. Resistance in enterococci, for example, is associated with the presence of the vanA and vanB genes, which alter vancomycin's target on the bacterial cell wall, compromising treatment efficacy[48].

Combined resistance was also identified, such as meropenem + colistin and ceftolozane/tazobactam, and colistin + ceftolozane/tazobactam + ceftazidime/avibactam. Furthermore, microorganisms with intermediate antibiotic resistance were considered, in accordance with the institutional precaution and isolation protocol in effect during the study period.

The spread of MDRO results in higher morbidity and mortality rates, in addition to prolonging hospital stays and increasing healthcare costs. To mitigate this problem, it is necessary to implement effective antimicrobial management programs, encourage continuous monitoring of bacterial resistance, and invest in research to develop new antimicrobials[5].

Such strategies[(5)] are essential to contain the spread of resistance and preserve the efficacy of existing therapies, ensuring treatment safety and long-term public health. In this context, analysis of the data presented in Table 3 reveals the distribution of different microorganisms in various clinical samples. Rectal swabs stood out as the most common material for collecting microorganisms. This reflects the importance of the gastrointestinal tract and perineal areas as primary sources of colonization and infection, especially in patients admitted to intensive care units, where the intestinal microbiota can be altered[49].

Within this sample, Klebsiella pneumoniae and Acinetobacter baumannii were the most prevalent species, both recognized for their high antimicrobial resistance, highlighting the importance of their detection in accessible samples such as rectal swabs. The presence of Pseudomonas aeruginosa, an opportunistic pathogen associated with invasive devices and hospital environments, was also observed. The "other microorganisms" category included species such as Enterococcus faecalis, Clostridium difficile, and Stenotrophomonas maltophilia, which, although less frequent, may be involved in clinical infections associated with the use of broad-spectrum antibiotics. Even to a lesser extent, these pathogens contribute to antimicrobial resistance and the complexity of HAIs[50-52].

The use of rectal swabs is widely documented as an essential tool for monitoring MDRO in hospitalized patients, particularly in the ICU. Recent studies highlight the role of carbapenemase-producing Klebsiella pneumoniae (KPC) and Acinetobacter baumannii complex as priority pathogens for surveillance, given their potential for horizontal spread and their high antibiotic resistance[49,50].

Furthermore, rectal colonization by these microorganisms is frequently associated with the risk of systemic infections, such as bacteremia and urinary tract infections, especially in immunosuppressed patients or those undergoing invasive procedures[51].

Rectal swabs are used as a monitoring tool and are typically linked to the patient's length of stay in healthcare facilities, their pre-existing clinical conditions, comorbidities, clinical management of antibiotic use, and care of devices inserted into the patient[52,53].

The high prevalence of Klebsiella pneumoniae and Acinetobacter baumannii complex is concerning, as both are associated with serious nosocomial infections and contain multiple mechanisms of antimicrobial resistance. The predominance of these pathogens in rectal swabs suggests significant intestinal colonization, which may serve as a reservoir for systemic infections, especially in immune-compromised patients[54].

Furthermore, these microorganisms frequently spread to other sites, such as the respiratory tract, as observed in protected tracheal aspirate samples. Although Acinetobacter baumannii and Pseudomonas aeruginosa were still prevalent in the samples, the presence of Klebsiella pneumoniae was lower, suggesting an infectious profile more closely related to mechanical ventilation. Tracheal aspirates are directly associated with Ventilator-Associated Pneumonia (VAP), with Pseudomonas aeruginosa being one of the main etiological agents, significantly affecting morbidity and mortality in ICUs[55-56].

These bacteria are known for their ability to survive in hospital environments and are frequently associated with severe respiratory infections in patients with pre-existing conditions or prolonged antibiotic use[54-56].

The "Other materials" category, which includes samples such as blood cultures, catheter tips, wound secretions, cerebrospinal fluid, and urine, represented a significant portion of the total analyzed. In this category, Pseudomonas aeruginosa and Klebsiella pneumoniae were the most frequently identified microorganisms, demonstrating their ability to colonize various sites of the human body and cause infections in different organs and systems. Furthermore, the group classified as "Other microorganisms" indicates the

presence of less frequent but still clinically relevant agents, such as Staphylococcus aureus, Escherichia coli, Enterococcus faecalis, Proteus sp., Enterobacter sp., and Clostridium difficile, which, although less frequent, may also be associated with HAIs.

These data reinforce the importance of a robust microbiological surveillance system, with an emphasis on early detection and appropriate management of infections caused by MDRO. Continuous monitoring of the predominant microorganisms, combined with strategies for rigorous control of antibiotic use and the implementation of good care practices, is essential to improve infection management and reduce the impact of antimicrobial resistance in the healthcare setting[7,8,12,13].

According to the data obtained in this study, the need for microbiological surveillance becomes even more evident given the mortality rate observed among the patients studied. Some of the deaths occurred in individuals with active infection, while others corresponded to patients colonized by multidrug-resistant microorganisms (MDRO). Therefore, we emphasize the importance of continuous monitoring and the adoption of control measures to prevent adverse clinical outcomes.

It can be inferred that these data may be associated with several factors, including the severity of infections caused by resistant pathogens, the clinical profile of patients (often immune-compromised or with multiple comorbidities), and therapeutic difficulties related to antimicrobial resistance. This study demonstrates that colonization by MDRO constitutes a significant risk factor for the development of serious infections and increased hospital mortality[57].

Between January and December 2023, a study conducted in Brazil analyzed more than 70,000 surveillance culture samples, identifying more than 5,000 MDRO-positive cases. Carbapenemase-producing Klebsiella pneumoniae (KPC) and carbapenem-resistant Acinetobacter baumannii were the predominant pathogens, both strongly associated with high mortality rates in hospital settings[58].

The COVID-19 pandemic contributed to the increase in bacterial resistance due to the uncontrolled use of antibiotics. In Brazil, between 2017 and 2022, there was a significant increase in the frequency of genes that confer resistance to carbapenems in species such as Klebsiella pneumoniae, Escherichia coli, and Acinetobacter baumannii. These microorganisms are associated with serious hospital-acquired infections and high morbidity and mortality rates[59].

Globally, antimicrobial resistance is a growing concern. In 2024, morbidity and mortality from bacterial infections surpassed that caused by HIV or malaria. It is estimated that if effective measures are not implemented by 2050, more than 39 million deaths could occur due to antibiotic-resistant infections[60].

Given this scenario, the predominance of deaths in patients colonized with Multidrug-Resistant Organisms (MDROs) reinforces the need for rigorous prevention and control measures. Implementing effective protocols for early identification, adequate isolation, and rationalization of antimicrobial use is essential to contain the spread of these pathogens.

Furthermore, strategies such as continuous microbiological surveillance, strengthening of good care practices, and the development of new antimicrobial therapies are necessary to minimize the impact of bacterial resistance and reduce the morbidity and mortality associated with Multidrug-Resistant Organisms (MDROs) infections.

Furthermore, considering the limitations inherent in retrospective data collection, we highlight the need for future research employing more robust methodologies capable of assessing the dynamics of antimicrobial resistance and the effectiveness of implemented interventions. Multicenter studies with longitudinal analyses and an integrated approach across different levels of healthcare can provide more accurate support for formulating public policies aimed at controlling the spread of MDRO and mitigating the clinical and epidemiological impacts of these infections.

CONCLUSION

The analysis of the microbiological and epidemiological profile of HAIs in an exclusive isolation setting identified the predominance of MDRO, with emphasis on Klebsiella pneumoniae, Acinetobacter baumannii, and Pseudomonas aeruginosa, as well as their associations with demographic factors and clinical outcomes. A higher frequency of cases was observed among male patients and those aged 60 to 79, highlighting the impact of population aging on the increased demand for long-term care and invasive procedures. This scenario, characteristic of Brazil's demographic and epidemiological transition, contributes to the increased risk of colonization and infection by MDRO, highlighting the importance of developing robust strategies to

control the spread of these pathogens.

Regarding race, the distribution of the patients analyzed reflects the demographic composition of the studied region, with a predominance of self-identified white individuals and a considerable representation of brown-race individuals. However, the need for future investigations into possible inequalities in access to and quality of healthcare is emphasized.

Regarding the resistance profile, it was observed that carbapenems, particularly imipenem and meropenem, stand out as one of the most alarming, severely limiting the efficacy of these antibiotics, widely used in the treatment of serious infections. Furthermore, resistance to fourth-generation cephalosporins and the emergence of combined resistance to colistin and other antimicrobial classes pose additional challenges to clinical practice and the control of HAIs.

In this sense, this study reinforces the importance of epidemiological and microbiological surveillance for the prevention and control of HAIs, highlighting the need for public policies aimed at reducing social inequalities and improving the quality of hospital care. Addressing this scenario requires a multidisciplinary approach, combining prevention measures, constant monitoring, and innovative therapeutic strategies to contain the spread of MDRO and reduce associated morbidity and mortality.

Prospective studies evaluating the effectiveness of preventive measures, containment strategies, and new therapeutic approaches in the management of MDRO infections are also recommended, with a view to supporting more effective and sustainable public health actions. It is therefore considered essential that health services implement systematic microbiological surveillance programs, intensify infection control actions and promote the rational use of antimicrobials, with the aim of reducing both the incidence and the clinical and epidemiological impacts of HAIs.

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AUTHOR CONTRIBUTIONS

Contributed to the conception or design of the study/research: Melo SE, Campos TA.
Contributed to data collection: Melo SE.
Contributed to the analysis and/or interpretation of data: Melo SE, Campos TA.

Contributed to article writing or critical review: Melo SE, Campos TA.
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CONFLICT OF INTEREST

The authors declare no conflict of interest.