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Epidemiological Profile of Primary Bloodstream Infections in Patients Hospitalized in an Intensive Care Unit

Perfil Epidemiológico das Infecções Primárias de Corrente Sanguínea em Pacientes Internados em uma Unidade de Terapia Intensiva

Perfil Epidemiológico de las Infecciones Primarias del Torrente Sanguíneo en Pacientes Hospitalizados en una Unidad de Cuidados Intensivos

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ABSTRACT

Introduction: Healthcare-Associated Infections (HAIs) represent a serious problem due to their negative impact on public health and patient care. This study aimed to outline the epidemiological profile of primary bloodstream infections in adult patients hospitalized in an Intensive Care Unit (ICU) between 2016 and 2023. **Methods:** A descriptive, retrospective, and quantitative study using data from patients admitted to an ICU in a teaching hospital in Paraná, Brazil. Data collection took place from February to August 2023 and was obtained from the Hospital Infection Control Service database and the electronic medical record. **Results:** A total of 236 patients were analyzed, of whom 67.4% were male and 32.6% female, with a predominance of ages between 60–79 years (37.7%). The main comorbidities were neurological impairment (35.6%) and cardiocerebrovascular conditions (23.7%). The most commonly isolated microorganisms were Acinetobacter baumannii (13.6%) and Staphylococcus epidermidis (13.6%). Regarding antimicrobial resistance, 22.9% were resistant to Oxacillin and 16.9% to Carbapenems. **Conclusion:** Primary bloodstream infections represent a significant challenge, resulting in prolonged hospital stays, increased costs, and high morbidity and mortality. This scenario demands rigorous infection control strategies, rational antibiotic use, and the implementation of bundles to improve clinical outcomes and reduce antimicrobial resistance.

KEYWORDS: Patient Safety; Hospital Infection; Intensive Care; Epidemiological Profile; Antimicrobial Stewardship.

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INTRODUCTION

Patient safety has emerged as a topic of growing concern and discussion within healthcare institutions and is widely recognized as a fundamental dimension for ensuring the quality of care. The absence of appropriate planning in this regard may result in significant harm to the population's health. Over a substantial period, however, discussions regarding various strategies for preventing adverse health events have been constant, particularly in relation to Healthcare-Associated Infections (HAIs)[1,2].

Also known as nosocomial infections, HAIs are infections that arise as a result of healthcare delivery and have been the subject of significant debate in public health due to their adverse impact on patient care. They are a source of concern because of the challenges they pose to healthcare systems, as they can lead to prolonged hospital stays, additional treatment costs, increased morbidity and mortality, and compromised patient safety[1,2].

HAIs may be attributed to a variety of pathogenic agents, such as bacteria, viruses, protozoa, and fungi. These infections affect different parts of the body and are defined as those acquired after patient admission and/or following invasive procedures, and may manifest during hospitalization or after discharge. Among the main topographies of HAIs are Ventilator-Associated Pneumonia (VAP), Urinary Tract Infections (UTI), Surgical Site Infections (SSI), and Primary Bloodstream Infections (PBSI)[1,3,4,5].

However, several risk factors contribute to the development of HAIs, such as hemodynamic instability, prolonged hospitalization, compromised immunity, inadequate hand hygiene practices, indiscriminate antimicrobial use, and invasive procedures[6,7].

Among the most frequent HAIs are PBSI. It is estimated that approximately 60% of bacteremias occurring in the hospital environment are associated with intravascular devices[8,4,9,5]. Nevertheless, it is worth emphasizing that the use of intravascular devices, such as central venous catheters (CVC), is necessary to enable certain therapeutic interventions, especially in critically ill or life-threatened patients.

The literature indicates that PBSI related to CVCs are among the HAIs with the greatest preventive potential, thus becoming the main type of infection that can be avoided[1,9,10]. This type of infection can be identified, and its microorganism isolated, through blood cultures collected from two different sites[11].

PBSI that arise due to the use of venous catheters constitute a significant complication, particularly prevalent among patients in clinically unstable conditions, who are generally allocated to Intensive Care Units (ICUs). Frequently, these patients undergo insertion of invasive devices to enhance clinical monitoring, administer pharmacological therapies, and infuse fluids for proper hydroelectrolytic balance management[12].

Despite the therapeutic benefits of these devices, the literature[13] indicates that the use of intravascular devices is one of the main factors associated with the development of healthcare-related bacteremias. As one of the predominant risk factors for PBSI, this situation underscores the imperative need for the implementation of rigorous preventive measures and infection-control strategies to promote patient safety.

Other studies reveal that surveillance and infection-control programs can achieve positive results by identifying HAIs and implementing intervention measures, such as training activities, aimed at reducing infection rates and curbing their spread[1,2,14].

In turn, the Brazilian Health Regulatory Agency (ANVISA), in 2010, established mandatory reporting of all PBSI cases in healthcare institutions with more than 10 beds designated for Intensive Care Units (Adult, Pediatric, or Neonatal)[15].

This requirement aims to strengthen epidemiological surveillance and monitoring of these infections, enabling early identification, the development of preventive strategies, and the adoption of appropriate control and intervention measures.

In this context, the Hospital Infection Control Service (HICS) plays an important role in the epidemiological surveillance of HAIs through systematic monitoring, thorough investigation, and infection control. In addition, HICS actively implements preventive measures aimed at reducing HAI incidence

Given the above, the following question arises: what is the epidemiological profile of PBSI and antimicrobial resistance specifically among patients receiving intensive care in a teaching hospital? From this perspective, the present study aimed to outline the epidemiological profile of Primary Bloodstream Infections (PBSI) and antimicrobial resistance in patients hospitalized in an Adult Intensive Care Unit (ICU).

It is evident that studies examining the epidemiological profile of PBSI and antimicrobial resistance are important for improving the quality of healthcare, preserving patient safety, guiding clinical decision-

making, and reducing the financial impacts of HAIs. Moreover, such studies contribute to the expansion of scientific knowledge in the field of infection control and to the development of effective health policies that foster the continuous advancement of care practices. Additionally, feasible and supplementary measures that influence the prevention and reduction of infections related to intravascular devices may also be considered.

METHODS

This is a descriptive, retrospective study with a quantitative approach, conducted using secondary data from patients hospitalized in an Adult Intensive Care Unit (ICU) in a teaching hospital in Paraná, covering the period from January 2016 to July 2023.

The hospital, which served as the study setting, is a public institution affiliated with a State University and located in Paraná, with 100% of its beds designated for patients of the Unified Health System (SUS). It serves a population of approximately 2 million inhabitants and functions as a referral center for 25 municipalities within its Health Region, in addition to four other macro-regions.

The hospital offers medium- and high-complexity services, including Adult and Pediatric Intensive Care Units; a Neonatal ICU; Neurology and Orthopedics Unit; Surgical Center; Obstetric Center and Maternity Ward; Pediatric Rooming-In Unit; and the Emergency Department (ED).

It is noteworthy that, during the study period, the hospital had three areas designated for Adult ICU beds: one annexed to the Emergency Department, with 5 beds; another located in a structure originally designed for the Burn Treatment Center (CTQ), designated as Adult ICU 2, with 30 beds; and ICU 1, with 25 beds, totaling 60 intensive care beds.

The data were collected from February to August 2023, referring to the period from January 2016 to July 2023. The data were obtained from the following sources: the Hospital Infection Control Service (HICS) database and the electronic medical record. To characterize the sample, the following study variables were included: age, sex, comorbidities/underlying conditions, type of microorganisms, and antimicrobial resistance.

The inclusion criteria for the study were: all confirmed Primary Bloodstream Infections (PBSI) from 2016 to July 2023, restricted exclusively to Adult ICU 1. The exclusion criteria included: notifications prior to 2016, cases that did not meet ANVISA's diagnostic criteria for Healthcare-Associated Infections (HAIs), and cases from other ICUs (Adult ICU 2, ICU annexed to the Emergency Department, Neonatal ICU, and Pediatric ICU). Thus, the sample totaled 236 patients.

The selection of Adult ICU 1 was due to the "Saúde em Nossas Mãos" ("Health in Our Hands") project, implemented by the hospital's HICS in 2021. This project is an initiative of the Ministry of Health, carried out under the Institutional Development Support Program of the Unified Health System (PROADI-SUS), in partnership with the hospitals Alemão Oswaldo Cruz, Beneficência Portuguesa de São Paulo, Hcor, Einstein, Moinhos de Vento, and Sírio-Libanês. Its objective is to reduce HAIs by up to 30% in SUS ICUs across Brazil, with a focus on the multidisciplinary team.

Subsequently, the collected data were subjected to descriptive statistical analysis and presented in tables using Microsoft Office Excel® version 2019.

It is important to emphasize that this research is part of a larger project entitled "Knowledge that Underpins Nursing Care Practices in the Hospital Context," approved by the Research Ethics Committee of the Western Paraná State University under opinion no. 6.287.135 and CAAE no. 72943723.5.0000.0107. Although this is a documentary study, data collection began only after authorization was granted by the head of the HICS at the aforementioned hospital.

RESULTS

Considering that Primary Bloodstream Infections (PBSI) represent a significant public health challenge due to prolonged hospitalization, increased treatment costs, and higher mortality rates among affected patients, an analysis was conducted using data obtained from the Hospital Infection Control Service (HICS) database and the electronic medical record of 236 patients with PBSI.

The profile of the patients, including data related to sex, age, underlying conditions, microorganism profile, and antimicrobial resistance, was organized into tables as follows:

Table 1. Profile of patients hospitalized in ICU 1 — 2016 to 2023, according to sex, Cascavel, PR, Brazil, 2024 (n = 236).

Sexo	**n°**	**%**
Male	159	67,4
Female	77	32,6
Total	236	100%

Source: Research data, 2024.

Table 2. Profile of patients hospitalized in ICU 1 — 2016 to 2023, according to age, Cascavel, PR, Brazil, 2024 (n = 236).

Age	**n°**	**%**
≤18 years	3	1,3
19 - 39 years	51	21,6
40 - 59 years	85	36
60 - 79 years	89	37,7
≥80 years	8	3,4
Total	236	100%

Source: Research data, 2024.

Table 3. Profile of patients hospitalized in ICU 1 — 2016 to 2023, according to underlying conditions/comorbidities, Cascavel, PR, Brazil, 2024 (n = 236).

Underlying conditions / comorbidities	**n°**	**%**
Cardiocerebrovascular impairment	56	23,7
Metabolic and/or endocrine impairment	9	3,8
Neurological impairment	84	35,6
Respiratory impairment	42	17,8
Other conditions	39	16,5
No underlying condition	6	2,5
Total	236	100%

Source: Research data, 2024.

Table 4. Distribution of microorganisms and corresponding age groups and predominant underlying conditions among patients hospitalized in ICU 1 — 2016 to 2023, Cascavel, PR, Brazil, 2024 (n = 236).

Microorganism	**n°**	**%**	**Age group with highest incidence (n/%)**	**Most frequent underlying conditions(n/%)**
Klebsiella pneumoniae	32	13,6	60-79 (12/37,5%)	Cardiocerebrovascular (14/43,8%)
Pseudomonas aeruginosa	15	6,4	60-79 (5/33,3%)	Neurological (7/46,7%)
Acinetobacter baumannii	32	13,6	40-59 (14/43,8%)	Other (12/37,5%)
Staphylococcus haemolyticus	23	9,7	60-79 (6/26,1%)	Neurological (9/39,1%)
Enterobacter cloacae	11	4,7	40-59 (4/36,4%)	Neurological (6/54,5%)
Staphylococcus epidermidis	32	13,6	60-79 (9/28,1%)	Neurological (16/50,0%)
Staphylococcus aureus	30	12,7	60-79 (13/43,3%)	Neurological (12/40,0%)
Sem microrganismo identificado	61	25,7		
Total	236	100%	100%	

Source: Research data, 2024.

Table 5. Antimicrobial resistance profile of patients hospitalized in ICU 1 — 2016 to 2023, Cascavel, PR, Brazil, 2024 (n = 236).

Antimicrobial resistance	**n°**	**%**
Carbapenems	40	16,9
Oxacillin	54	22,9
Vancomycin	2	0,8
No antimicrobial resistance identified	140	59,3
Total	236	100%

Source: Research data, 2024.

DISCUSSION

According to Table 1, it was observed that the proportion of male patients (67.4%) is significantly higher than that of female patients (32.6%). This predominance is consistent with other studies[16,17], which also demonstrated a higher prevalence of males.

According to the literature, diseases do not affect men and women equally. The literature[18] presents two explanations, physiological and behavioral, to clarify this observation, focusing on infectious diseases such as tuberculosis, hepatitis A, and dengue.

The physiological hypothesis emphasizes discrepancies in sex hormones and genetic structure, while the behavioral hypothesis highlights variations in exposure associated with gender [18]. It is important to note that the relationship between gender and infections is complex and multifactorial, as understanding gender differences in HAIs requires a detailed analysis that considers several factors, including social, biological, and behavioral aspects.

Furthermore, infection rates may vary depending on the specific type of HAI considered [1,3,4]. This disparity may be related to men's possible lack of interest in seeking healthcare, as well as a tendency to seek medical care late, when health conditions are already more severe. This behavior may lead to a reduced demand for healthcare services, which, in turn, contributes to higher mortality rates in this population group[19,20], as well as neglect in risk management and the lack of preventive measures for diseases and their complications[20].

Regarding age, the data presented in Table 2 indicate a notable concentration of patients between

60 and 79 years of age, totaling 37.7%, followed by the 40–59-year age group, which accounted for 36%, while the 19–39-year age group comprised 21.6% of the sample.

The findings of our study are consistent with those reported by research such as this one[21], in which 57% of patients admitted to the ICU were 60 years or older. Similarly, previous studies[22,23] also highlighted that the majority of patients hospitalized in ICUs are elderly individuals with comorbidities.

This trend results from the health conditions of older adults, who most often present multiple chronic diseases [24] that may, at some point, acutely worsen and require prolonged and intensive care, exposing them to a greater likelihood of hospitalization compared to other age groups.

In addition, this scenario may be correlated with the demographic and epidemiological transition occurring in the country. Studies[25,26] indicate that, starting in the 1970s, Brazil began—and continues—to undergo a transformation in its demographic profile. Initially characterized as a predominantly rural and traditional society, with large families and high infant mortality rates, the country transitioned to a predominantly urban configuration.

It is inferred that this shift has resulted in a significant reduction in the number of children per family and a reconfiguration of Brazilian family structures. The country, which previously had a predominantly young population not long ago, now shows a progressively larger contingent of people aged 60 years or older[23,25,26,27].

Thus, increased life expectancy and longevity are observed in several nations, including Brazil. Although aging does not automatically represent illness, it is evident that within the elderly population, there is an increase in clinical-functional decline, associated with a greater propensity for developing chronic noncommunicable diseases (NCDs). Such conditions are closely related to functional impairment and mortality, factors that may, in turn, increase healthcare costs and demand for services[23,28,29].

Regarding the main reasons for hospitalization identified in this study, as shown in Table 3, neurological disorders accounted for 35.6% of admissions, representing the leading cause of ICU admission in the hospital investigated. In this category, traumatic brain injury (TBI) stood out as the primary etiology, followed by other conditions such as Guillain-Barré Syndrome, Spinal Cord Trauma, Cerebral Meningioma, Brain Tumor, and Neuroleptic Syndrome. Cardiocerebrovascular conditions followed with an incidence of 23.7%, and respiratory conditions accounted for 17.8%. Other causes totaled 16.5%, complementing the spectrum of reasons for hospitalization identified in the study.

In Brazil, TBI emerges as the third leading cause of death[30]. This finding underscores the magnitude of the challenge faced by public policy managers in addressing the prevention and effective management of trauma. The critical nature of this public health issue highlights the need for comprehensive and diligent strategies to prevent and mitigate the impact of TBI on population morbidity and mortality[30,31,32].

Among patients hospitalized in the ICU during the study period, cardiocerebrovascular underlying conditions accounted for 23.7% of cases. It is noteworthy that this group includes cerebrovascular accidents (ischemic and hemorrhagic), systemic arterial hypertension (SAH), and heart diseases.

NCDs constitute the main determinant of global morbidity and mortality, accounting for approximately 70% of deaths worldwide, which corresponds to more than 38 million deaths annually. However, these conditions not only lead to premature deaths but also impose significant social and economic impacts, in addition to substantial losses in quality of life [28,33].

Among NCDs, cardiovascular diseases (CVD) represent a substantial proportion, accounting for about 45% of all deaths related to these conditions globally, which is equivalent to more than 17 million deaths. This reality is also observed in the Brazilian context, where 72% of deaths originate from NCDs, and of this percentage, 30% are attributed to CVD[34,35].

It is understood that the implementation of healthcare actions, monitoring of access, and the utilization of health services by people with NCDs, along with multiprofessional follow-up, are essential. These studies[28,36] indicate that individuals with NCDs seek healthcare services more frequently than adults without NCDs. Therefore, the increased demand for healthcare services requires the implementation of strategies aimed at planning, organizing, and adapting health policies and care delivery.

Regarding the group related to respiratory impairment, it accounts for 17.8%. This category includes Chronic Obstructive Pulmonary Disease (COPD), COVID-19, pneumonia, empyema, sepsis of pulmonary origin, pulmonary thromboembolism (PTE), and acute respiratory failure (ARF).

Respiratory system conditions rank second as the main cause of hospital admissions in Brazil, totaling 5,928,712 hospitalizations between 2013 and 2017 (37). Indeed, respiratory disorders can affect

all age groups, causing varying degrees of severity and morbidity and mortality, with pneumonia being one of the leading causes of death[37,38,39].

Furthermore, in relation to respiratory conditions[38,40], sepsis with a pulmonary focus also demonstrates a significant incidence in hospital settings. Additionally, chronic complications are widely observed, with COPD identified as one of the contributing factors to mortality. These aspects highlight the multifaceted complexity of respiratory diseases and reinforce the need for integrated clinical and public health approaches to effectively address these health challenges.

Regarding the "other" category, diseases that did not fit into the aforementioned groups were included, such as femoral fracture, perforated and obstructive acute abdomen, upper gastrointestinal bleeding (UGIB), firearm injury, Fournier's syndrome, splenic abscess, coumarin intoxication, alcoholic hepatitis and cirrhosis, pancreatitis, choledocholithiasis, suppurative appendicitis, and submandibular abscess, corresponding to 16.5% of cases, reflecting a wide range of health conditions that require hospitalization.

Given the above, it can be said that several justifications support the need for ICU admission, encompassing situations such as trauma, clinical emergencies, and diseases that may arise throughout life. In this sense, a deep understanding of this scenario is essential for the effective management of healthcare resources and for the development of appropriate care strategies for each situation, with the aim of maximizing positive clinical outcomes and mitigating related complications, such as HAIs.

Concerning the profile of microorganisms in ICU patients, which served as the basis for this study, it was observed that among the 236 patients analyzed, 66.3% presented some type of multidrug-resistant microorganism.

According to ANVISA, some of the main microorganisms screened in surveillance cultures for the prevention of multidrug-resistant organisms include *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus* (MRSA), extended-spectrum beta-lactamase (ESBL)-producing Enterobacterales, carbapenemase-producing Enterobacterales (KPC), and vancomycin-resistant *Enterococcus* spp. (VRE)[41].

It was observed that the most notable finding in this study was associated with *Acinetobacter baumannii*, with an incidence of 32 cases (13.6%). Following this, the presence of *Staphylococcus epidermidis* was identified in 32 cases (13.6%), followed by *Staphylococcus aureus* with 30 cases (12.7%), *Klebsiella pneumoniae* with 32 cases (13.6%), and *Staphylococcus haemolyticus* with an incidence of 23 cases (9.7%).

To contextualize, regarding the species *Acinetobacter baumannii*, it is important to highlight its clinical significance within the genus *Acinetobacter* spp. These organisms belong to the family *Moraxellaceae* and exhibit Gram-negative coccobacillus morphology. They are strictly aerobic, do not ferment glucose, do not require fastidious growth conditions, and are catalase-positive and oxidase-negative. They live as free-living saprophytes and are widely distributed in the environment, being isolated from water, soil, air, food, arthropods, as well as from the microbiota of animals and humans[42].

It is known that plasmids in *Acinetobacter baumannii* play a fundamental role in the dissemination of genes responsible for antimicrobial resistance, particularly to carbapenems. Additionally, several virulence-related genes are determinants of this bacterium's pathogenic effectiveness. Notably, *Acinetobacter baumannii* is included in the ESKAPE group of pathogens (*Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa*, and *Enterobacter* species)[41,42,43].

It is noteworthy that, both in our study and in another investigation[43], *Acinetobacter baumannii* was the most prevalent microorganism. Our study revealed that this microorganism was identified in 13.6% of PBSI-related cases, while that study[43] reported a prevalence of 22.6% (147/649), predominantly isolated from respiratory tract samples. In both studies, this prevalence was statistically associated with the hospitalization setting, specifically the ICU.

Infection by this microorganism[42,44] makes individuals susceptible to a range of clinical manifestations, including pneumonia, bloodstream infections, septicemia, urinary tract infections, and meningitis, especially in patients with compromised immune systems.

Staphylococcus epidermidis was identified in 32 cases, corresponding to 13.6% of the sample. The results obtained in this study align with the literature[45], demonstrating that among the microorganisms identified, *Staphylococcus epidermidis* had a frequency of 12.1%, in agreement with our findings.

These data underscore the importance of surveillance and control of HAIs in healthcare facilities. This finding emphasizes the imperative adoption of preventive measures to mitigate infection risks and, consequently, preserve patient health.

Regarding *Staphylococcus epidermidis*, this is a Gram-positive, coagulase-negative coccus that tends to form clusters. It is catalase-positive and facultatively anaerobic, and is one of the most prevalent species of coagulase-negative *Staphylococcus* that colonize human skin. Although usually harmless in its natural habitats, such as the skin or mucosa, it can invade the human body through devices, causing infections[46].

Infection prevention and control are essential[44], representing a practical, evidence-based approach aimed at preventing both patients and healthcare professionals from being harmed by avoidable infections.

This study[47], in which 150 microbiological cultures from various clinical samples were performed throughout 2019 in patients hospitalized in an ICU, found that 64% were negative, 30% were positive, and 6% were inconclusive. The genus *Staphylococcus* was the most prevalent, with 14 cases distributed among *Staphylococcus epidermidis, Staphylococcus aureus, Staphylococcus haemolyticus*, and others identified only at the genus level.

The findings of that survey converge with the results observed in this research. The literature indicates that beginning in 2019, a species of coagulase-negative *Staphylococcus* (CoNS), specifically *Staphylococcus epidermidis*, began to be individually identified. Regarding its incidence, it was found that in 2019 it represented 18% of all isolates, equivalent to the proportion of *Klebsiella pneumoniae*. However, in 2020, this incidence increased to 20%, surpassing *Klebsiella pneumoniae*, which remained at 18%[48].

Regarding the treatment of *Staphylococcus epidermidis* infection, its therapeutic approach is closely related to the type and severity of the infection. For patients with systemic infection, parenteral therapy is required. It is worth noting that methicillin resistance is present in more than 80% of CoNS isolates (46). Therefore, empirical therapy for *Staphylococcus epidermidis* infection generally includes intravenous vancomycin, as methicillin resistance should be presumed[46,49,50].

Primary bloodstream infections (PBSI) constitute a global challenge of complex resolution, influenced by multiple factors, such as impaired patient health and deficiencies in good care practices, including hand hygiene and strict adherence to aseptic techniques[2,4,8,9,10,12].

Another relevant finding of our study was the identification of *Staphylococcus aureus*, totaling 30 cases, which represents 12.7% of the sample. Our data are consistent with other findings in the literature[43], which indicate that *Staphylococcus aureus* was identified among the microorganisms with a frequency of 12.1%.

An additional study of relevance in this field[48] reports that between 2013 and 2021, in the State of São Paulo, *Staphylococcus aureus* was one of the most commonly detected microorganisms in blood cultures from Adult ICUs. This underscores the imperative need for active surveillance and the implementation of preventive measures as fundamental pillars for ensuring patient safety and well-being.

This microorganism, *Staphylococcus aureus*, is widely recognized as an opportunistic pathogen and is present in the commensal microbiota of the skin in an estimated 30% to 50% of the population. It is a Gram-positive bacterium and is considered one of the main causes of HAIs, given that its incidence is among the three most frequent[4,5,6,51].

From this perspective, the prevention of PBSI and the appropriate management of catheters[1,8,9,10,12,13] are of utmost importance for healthcare professionals, considering that these devices also represent an entry point for severe infections, such as catheter-associated bacteremia. Infection prevention requires the implementation of a set of measures known as “bundles,” which, when applied collectively, have demonstrated effectiveness in reducing infection rates.

These measures are recommended by the Centers for Disease Control and Prevention (CDC), which emphasizes the importance of using maximal barrier precautions during device insertion, including cap, mask, gown, and sterile gloves, in addition to large sterile drapes. These practices aim to reduce the likelihood of catheter contamination during insertion[9,10,13].

Given the complexity of PBSI, the standardization and incorporation of rigorous aseptic techniques into clinical practice are essential to prevent these infections. Proper catheter management and multidisciplinary surveillance must be priorities for the entire patient care team, demanding rigor and meticulous attention.

Regarding the microorganism profile in ICU patients during the period from 2016 to 2023, another important finding was the presence of *Klebsiella pneumoniae*, with 32 cases, representing 13.6% of the sample.

Klebsiella pneumoniae, a Gram-negative pathogen associated with infections in both community and healthcare settings, demonstrates a high mortality rate due to the clinical severity of patients and the presence of multidrug-resistant strains. Carbapenemase enzymes were first identified in the United States in 1996 in an isolate of *Klebsiella pneumoniae*, which became known as carbapenemase-producing *Klebsiella pneumoniae* (KPC)[52].

This bacterium presents a variety of characteristics, including capsule, lipopolysaccharides, fimbriae, membrane proteins, and siderophores, which contribute to its considerable resistance and pose challenges for infection control[52]. Consequently, in its most severe manifestations, it may cause urinary tract infections, respiratory infections, and septicemia.

Our data corroborate those of another study[53], in which *Klebsiella pneumoniae* was among the most prevalent microorganisms, accounting for 20.4% (n = 19). In this context, it is appropriate to agree with other authors[8,9,13,23,41] who state that healthcare and patient safety services require the implementation of effective care practices, preventive measures, accurate diagnoses, and actions to mitigate HAIs and their harmful effects on patients, available resources, and length of hospital stay.

This implies the need for the active presence of professionals specialized in HAI control within healthcare environments. Considering that these adverse events may occur, it is essential to conduct investigations to identify and correct any structural deficiencies or other factors that may pose risks to patient safety[1,14,54].

Still in relation to Table 4, which presents the distribution of microorganisms in patients hospitalized in the ICU between 2016 and 2023, an association is observed between the age groups with the highest incidence and the main underlying conditions. The results show that *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Staphylococcus epidermidis* each accounted for 13.6% of the cases, followed by *Staphylococcus aureus* (12.7%), *Staphylococcus haemolyticus* (9.7%), *Pseudomonas aeruginosa* (6.4%), and *Enterobacter cloacae* (4.7%).

Most occurrences were concentrated in the 60–79-year age group, particularly related to neurological comorbidities, although *Acinetobacter baumannii* and *Enterobacter cloacae* showed higher prevalence among patients aged 40 to 59 years.

This relationship between age group, cardiocerebrovascular diseases, and *Klebsiella pneumoniae* can be explained by different aspects. Changes in demographic composition have led to an increase in the incidence and prevalence of NCDs[55]. Studies such as this one (56) demonstrated that the prevalence of systemic arterial hypertension (SAH) among individuals aged 60 years or older was 80.4% in 2010, while the cumulative incidence over six years reached 36.1% among those who were normotensive at baseline.

These findings reinforce the high burden of NCDs in this age group, especially SAH, one of the main conditions that contributes to greater vulnerability to severe infections. Moreover[57], the immunological fragility inherent to aging, prolonged hospitalizations requiring invasive devices, the chronic inflammatory state, and endothelial dysfunction associated with cardiocerebrovascular diseases, combined with the frequent use of antibiotics throughout life, favor the selection and spread of resistant strains such as *Klebsiella pneumoniae*.

Next, *Staphylococcus haemolyticus* was identified in 9.7% of cases, predominantly among individuals aged 60 to 79 years (26.1%) and mainly associated with neurological conditions (39.1%). This relationship may be linked to a greater predisposition of this age group to develop neurological disorders, whether due to the natural aging of the nervous system or the accumulation of life-long risk factors, such as Traumatic Brain Injury (TBI)[58]. Additionally, it is important to consider that the hospital studied is a regional reference in traumatology and neurosurgery, which may influence the frequency and profile of neurological conditions observed in this age group.

Pseudomonas aeruginosa, in turn, accounted for 6.4% of cases, with the highest incidence among patients aged 60 to 79 years (33.3%) and predominantly associated with neurological conditions (46.7%). Meanwhile, *Enterobacter cloacae* was identified in 4.7% of cases, more often among patients aged 40 to 59 years (36.4%), also related to neurological comorbidities (54.5%).

These data highlight the importance of considering age group and underlying clinical conditions[59,60] in the evaluation and management of infections caused by these microorganisms. Moreover, they

emphasize the need for targeted prevention and control strategies, especially in vulnerable populations with specific comorbidities.

Moving to the analysis of antimicrobial resistance profiles, as presented in Table 5, a significant concern emerges in the healthcare field, as such resistance can negatively affect infection treatment and increase patient morbidity and mortality.

The emergence of antibiotic-resistant bacteria is a problem that has worsened over the years[61,62]. Antibiotic resistance results in substantial clinical and economic impacts. The absence of microbiological testing may limit accurate diagnosis, favoring empirical and often unnecessary therapies. This scenario contributes to prolonged hospitalization, increased mortality, and higher healthcare costs[61,62].

The results of our study revealed that a significant proportion of microorganisms were identified as resistant to different classes of antimicrobials. For example, regarding carbapenems—an important class of antibiotics—40 cases, corresponding to 16.9% of the sample, were identified as resistant.

It is noteworthy that the rise in ESBL (Extended-Spectrum Beta-Lactamase)-producing strains has driven the increased use of carbapenems as the primary therapeutic option for severe infections. As a result, the emergence of KPC (Klebsiella pneumoniae Carbapenemase) has conferred resistance to nearly all beta-lactams and their inhibitors. KPC-producing bacteria demonstrate the ability to hydrolyze cephalosporins, penicillins, monobactams, and carbapenems. This has led to a growing restriction in the therapeutic spectrum, with limited use of polymyxins, tigecycline, and aminoglycosides in combination with imipenem[63,64].

This issue is concerning, since carbapenems are frequently used as a last line of defense in the treatment of infections resistant to other antibiotics. Undoubtedly, this represents a complex scenario, as antimicrobial resistance is widely recognized as one of the greatest global threats to public health, with direct implications for the effectiveness of HAI treatment.

Estimates from the Review on Antimicrobial Resistance (O'Neill Report), supported by the World Health Organization (WHO), project that, without effective containment measures, bacterial resistance may be responsible for approximately 10 million deaths annually by 2050, making it one of the greatest contemporary challenges for healthcare systems[65].

This scenario reinforces the importance of strategies for controlling HAIs, the rational use of antimicrobials, and investments in research and public health policies to address this growing challenge.

A high rate of resistance to Oxacillin was also observed, with 54 cases, representing 22.9% of the sample. Oxacillin is commonly used to treat infections caused by Methicillin-Resistant *Staphylococcus aureus* (MRSA), making this resistance a significant therapeutic challenge.

MRSA has caused substantial problems, as this bacterium is one of the main agents responsible for HAIs. It is important to highlight that Oxacillin-Resistant *Staphylococcus aureus* (MRSA) constitutes one of the primary clinical and epidemiological concerns in the context of HAIs. Additionally, it is noteworthy that MRSA infections are not restricted to the hospital environment, as they may also be acquired in the community[51].

On the other hand, there was a low rate of resistance to Vancomycin, with only two cases identified as resistant, representing 0.8% of the sample. Vancomycin is an important antibiotic for the treatment of MRSA infections.

To contextualize, Vancomycin-Resistant *Enterococcus* (VRE) exhibits a remarkable capacity for dissemination in hospital settings, emerging as one of the main complications resulting from inadequate pharmacological treatments in hospitalized patients. Recognized as a multidrug-resistant bacterium, VRE is considered an important cause of opportunistic infections, ranking second among the bacteria most frequently associated with hospital infections in the United States. Its initial identification dates back to 1986 in Europe, followed by reports in several countries. The first case of VRE in Brazil was recorded in 1996[66].

Vancomycin is a glycopeptide antimicrobial agent, and its action is particularly directed toward Gram-positive bacteria, inhibiting cell wall synthesis by interfering with the incorporation of peptidoglycan. This mechanism disrupts cell wall metabolism, resulting in bacterial death due to osmotic instability[66,67]. It is important to note the existence of six phenotypes of glycopeptide resistance in *Enterococcus*, named VanA, VanB, VanC, VanD, VanE, and VanG. However, it is not the objective of this study to explore these phenotypes in depth.

Given the above, throughout this study, the importance of continuous surveillance of antimicrobial

resistance and the implementation of infection control strategies to prevent the spread of resistant strains became evident. This includes more cautious antibiotic prescribing practices, the promotion of hand hygiene, and the adoption of rigorous HAI prevention measures, especially in ICUs, to also mitigate the growing number of PBSI cases.

It is important to highlight, as a limitation of this study, that the period analyzed (2016–2023) encompassed the COVID-19 pandemic, which altered care workflows and increased the use of invasive devices and antimicrobials. This may have influenced both the rate and the microbiological profile of PBSI—an aspect not explored in this research.

CONCLUSION

Primary Bloodstream Infections (PBSI) represent a significant challenge for healthcare services, as they contribute to prolonged hospital stays, increased hospital costs, and higher morbidity and mortality rates. The findings of this study demonstrate a predominance of male and elderly patients with neurological, cardiocerebrovascular, and respiratory comorbidities, as well as the circulation of multidrug-resistant microorganisms, particularly *Acinetobacter baumannii*, *Staphylococcus epidermidis*, *Staphylococcus aureus*, and *Klebsiella pneumoniae*.

These findings reinforce the importance of targeted preventive strategies, continuous surveillance of antimicrobial resistance, and the implementation of bundles, combined with ongoing professional education. Such actions, associated with effective public policies, are essential to reduce PBSI incidence, enhance patient safety, and guide future research aimed at improving the quality of care in ICUs.

Furthermore, these findings highlight a challenging field for future investigations aimed at improving care, safety, and the quality of assistance provided to hospitalized ICU patients. Through a joint commitment and coordinated actions, it is possible to mitigate the risks associated with HAIs, especially PBSI.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to the conception, design, analysis, and writing of this manuscript.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.