Prevalence of healthcare-related infections in an intensive care unit of a teaching hospital in western Paraná

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ABSTRACT

Introduction: Health Care-Related Infection (HAI) is a worrisome event for global public health, due to its high level of morbidity and mortality. Objective: To identify the main bacteria that cause infection in an Intensive Care Unit (ICU) and their sensitivity profiles. Methodology: Retrospective observational cross-sectional study, conducted in patients admitted to the ICU of a Teaching Hospital in the city of Cascavel - PR, in 2021. Results: Most patients were male (70.96%) and the microorganisms were isolated mainly from tracheal secretion (49.46%). Of the total of 186 patients admitted to the ICU, 120 (64.51%) had co-infection with SARS-CoV-2, and of these, 78 (42.29%) died. Of the total of 22 species of bacteria isolated, there was a higher prevalence of Pseudomonas aeruginosa (20.22%), followed by Klebsiella pneumoniae (15.73%) and Staphylococcus aureus (9.55%). Regarding antimicrobial resistance, Pseudomonas aeruginosa presented an average of 65.37% resistance to the drugs tested, followed by Klebsiella pneumoniae (58.45%) and Staphylococcus aureus (37.05%). Conclusion: Pseudomonas aeruginosa was the main isolated bacterium, presenting high resistance to the drugs of the classes of quinolones, penicillins, cephalosporins, nitrofurans and sulfonamides, reaching up to 100% resistance to some antimicrobials tested.

Keywords: HAI, Intensive Care Units, Prevalence, Drug Resistance.

1 INTRODUCTION

The occurrence of infections in patients admitted to the intensive care unit (ICU) is frequent and considered a prerequisite for the development of sepsis, which can lead to death. This is due to the invasive nature of many treatments, such as mechanical ventilation and central venous access, both of which significantly increase the risk of healthcare-related infections (HAIs) in these individuals (Silva et al., 2022). These infections arose a long time ago, and it is stipulated that since the creation of health institutions in the nineteenth century, hospital infections were already present, possibly due to the high occurrence of numerous infectious diseases that developed at that time, due to the hygienic, health, social and sanitation conditions that surrounded not only the centers of care to the individual, but also the entire population (Ferreira et al., 2010).

The Intensive Care Unit (ICU) is the main nosocomial site where infections are commonly found (corresponding to 30% of infections), and this is mainly due to the conditions in which patients are exposed in this environment, such as the numerous invasive procedures routinely performed and also to their clinical condition. In addition to these procedures, long hospitalization, mechanical ventilation, age, use of immunosuppressants, use of catheters, underlying disease, immune status of the patient and even the submission of these individuals to surgeries are considered factors that corroborate to make this site conducive to infection by microorganisms (Arcanjo & Oliveira, 2017; Lima et al., 2007; ANVISA, 2007).

Contributing to the above scenario, its indiscriminate use of antimicrobials led numerous bacteria to become resistant to this class of drugs, increasing the morbidity and mortality of patients (Loureiro et al., 2016). Many bacterial strains have evolved to be resistant to various antimicrobials (Rigatti et al, 2010). The increased prevalence of bacteria that express resistance to β-lactams and carbapenemases, in addition to the alteration of the cell wall promoting resistance to methicillin, has compromised the therapeutic efficacy of current treatments. Patients hospitalized with infections caused by multidrug-resistant pathogens have a higher risk of receiving inadequate therapy and, consequently, of treatment failure, increasing the burden of disease in ICUs (Karam et al., 2016).

In Latin America, especially in Brazil, the most problematic strains regarding pharmacoresistance are: *Acinetobacter* spp., microorganisms of the *Enterobacteriaceae* family that produce broad-spectrum beta lactamases, *and Pseudomonas aeruginosa* (Oliveira et al, 2017). In addition to many bacteria causing infection, they enter the bloodstream, causing a state of bacteremia. When this state is reached, the patient's situation becomes severe. In this case, there is a high lethality, that is, approximately 35%, which contributes to the increase in hospital costs and the duration of hospitalization of the patient. (Guilarde et al., 2007).

It is worth mentioning that the mortality rate of patients who presented infection is high, reaching 27.88% in Paraná, and in some ICUs of Rio Grande do Sul, 48% (Leiser et al., 2007). Despite these data, in Brazil there are still few studies on HAI. In addition, these data are not consolidated by many hospitals, which makes it difficult to know the real dimension of the problem (Busato et al., 2012). Thus, the aim of the present study was to verify the prevalence of bacterial infection, as well as to analyze the profile of sensitivity to antimicrobials in patients admitted to the ICU of a teaching hospital located in the West of Paraná.

2 METHODOLOGY

This is a quantitative exploratory-descriptive study, based on a careful analysis of data obtained from 186 medical records of patients who were admitted to the ICU of a teaching hospital in Cascavel - Paraná. For data collection from medical records, the following criteria were considered: patient's age, gender, month of ICU admission, length of hospital stay, hospitalization diagnosis, isolated and identified microorganisms, patient evolution, cultures and blood cultures, type of infection and antibiogram result.

The inclusion criteria taken into account for analysis are the medical records in which the patients presented some type of bacterial infection, patients in whom the admission and hospital follow-up form contains elements that satisfy the data collection of the research and patients who have remained hospitalized in the ICU for more than 24 hours, these being of all age groups. Patients who did not present any health-related infection during their ICU stay or who did not contain complete information in order to be carefully analyzed were excluded from the study.

Data collection was performed by verifying documents related to indicators of health-related infection, bacterial cultures and antibiograms performed on hospitalized patients. These data were made available through the management software Tasy, which provides a computerized means of patient care and follow-up. The data were organized and tabulated in Microsoft Excel® and, subsequently, analyzed in SAS (Statistical Analysis Software), version 9.4. The results were expressed as means, standard deviations (± SD) or frequencies. The association between qualitative variables was verified using the Chi-Square or Fisher's Exact tests. Quantitative variables were analyzed using the Wilcoxon test. Statistical significance was set at $p<0.05$. Access to medical records, hospital infection control forms, microbiological examinations of the CCIH (Hospital Infection Control Center) of the Hospital were performed after approval by the Research Ethics Committee of the Assis Gurgacz Foundation - (CEP/FAG) number 5,566,206 of 08/05/2022, meeting the ethical precepts for research involving human beings recommended in Resolution 466/12 of the National Health Council.

3 RESULTS AND DISCUSSION

Of the total of 186 patients, 132 (70.96%) were male. Regarding the age groups, patients aged 0 to 17 years (16 belonged to males and 10 to females), 18 to 59 years (59 belonged to males and 25 to females) and older/equal to 60 years (57 belonged to males and 19 to females). When comparing the indexes of age group and sex, it was verified that these two variables did not have statistical significance ($p>0.05$). Other studies corroborate our findings (Oliveira et al., 2011; Lima et al., 2007).

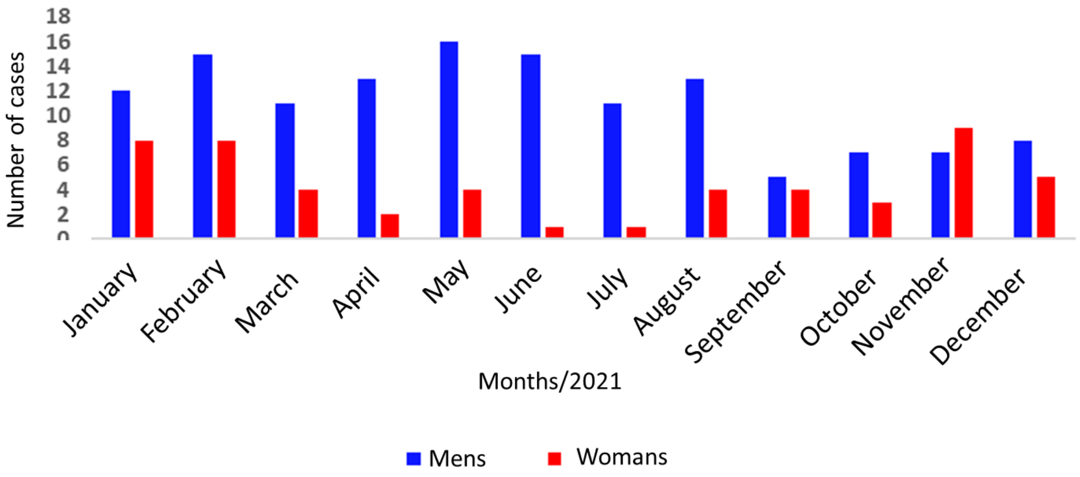
When analyzing the age groups of patients in relation to gender, there was no statistical association between these variables ($p=0.24$). The mean age of all patients admitted to the ICU was 55 years, the median 50.1 years, standard deviation 25.19, and the Inter-Quartile Ratio (RIQ) 26-69 years.

Regarding these same variables, but analyzing the sexes separately, there were male (mean = 51.38 years; median = 55.5 years; standard deviation = 24.87, RIQ = 31-71 years) and female gender (mean = 46.90 years; median = 55.0 years; standard deviation = 25.90 and RIQ = 8-52 years), respectively. Studies by Oliveira et al (2012) and Pereira et al (2016), showed that the mean age among patients admitted to ICUs was 57.3 and 58.3 years, respectively, close to the average found in this study.

During 2021, it was observed that cases of bacterial infection in the ICU in the analyzed hospital did not remain constant (Figure 1). There was an increase at the beginning of the year (January and February), but over the months the number of cases varied. This variability that has occurred can be attributed to the timing of the coronavirus disease (COVID-19) pandemic. A study conducted at the University Hospital of the city of São Paulo showed that healthcare-related infections (HAI) were higher in 2020 than in 2019, in the first year of the SARS-CoV-2 pandemic in the country (Fram et al, 2021).

Regarding the length of stay in the ICU, it was observed that the mean length of stay was 28.1 days, median of 23 days, standard deviation of 22.52 and RQI 12-38.5 days. Similar results in Brazil show that the length of stay was 19.3 days, with a median of 13 days, and 21.2 days for those who developed HAI (Oliveira et al., 2010; Pereira et al, 2016). Given the situation, studies indicate that during the period of the COVID-19 pandemic in Brazil there was an increase in the days of hospitalization due to SARS-CoV-2 infection in a hospital environment, abruptly increasing hospital expenses. In this sense, it is worth remembering that the high period of hospitalization in days in the ICU increases the chance of the hospitalized to acquire a multidrug-resistant pathogen, favoring infection in this environment (Santos et al., 2021; Lisbon & Nagel, 2011).

Figure 1. Number of cases per month of ICU patients divided by sex, in the year 2021

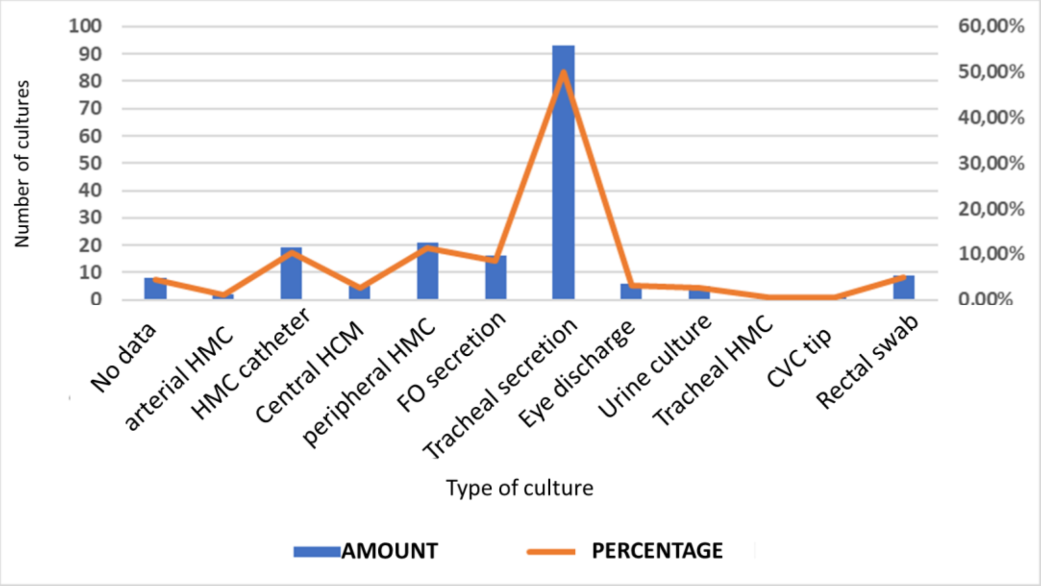


Source: authors (2023)

Regarding the sites of infection, the topography most recorded in the ICU was the respiratory tract (56.45%), followed by infection at the surgical site (15.05%) and catheter-associated bloodstream infection (12.9%). Other topographies such as urinary tract infection, associated bloodstream, skin and soft tissues, among others, did not show significant rates. A result close to that of this study was found in an ICU of the Hospital de Clínicas da Universidade Estadual de Campinas (UNICAMP), in which the most prevalent site of infection was also in the respiratory tract (59%) (Santos et al., 2015). Another study that evaluated the secondary infections that affected patients hospitalized for COVID-19, pointed to the topography of the respiratory tract as the predominant in relation to the other studies. A plausible explanation for this fact is that patients admitted to the ICU receive more intense and invasive management (Baptista, Sousa & Ramos, 2022).

Regarding cultures to identify microorganisms, it was found that tracheal secretion was the most used in relation to the samples analyzed (92; 49.46%), followed by catheter blood culture (19; 10.21%) and peripheral blood culture (18; 9.67%). It is important to emphasize that 8 medical records of patients (4.30%) did not indicate which type of culture was performed for bacterial identification, because the diagnostic criteria used by the Hospital follow the technical norm of ANVISA, since the fact of not having a culture or being negative, does not prevent the professional from the clinical diagnosis of the infection (ANVISA, 2023). According to a study produced in Recife (PE), the main routine cultures for the identification of the pathogen in the ICU are blood cultures, tracheal secretion and rectal swab, the latter being performed when there is no knowledge of the patient's infection (Pires, Nascimento, Siqueira & Silva, 2020). Such data then according to the findings in this study, as illustrated in Figure 2. Blood culture samples and respiratory tract samples deserve special attention, since they are related to bacteremia of high lethality and great importance in terms of morbidity and mortality, respectively (Barros et al, 2012; Calcagnotto et al., 2011).

Figure 2. Cultures performed to isolate the pathogens that infected patients admitted to the ICU in the period of 2021.

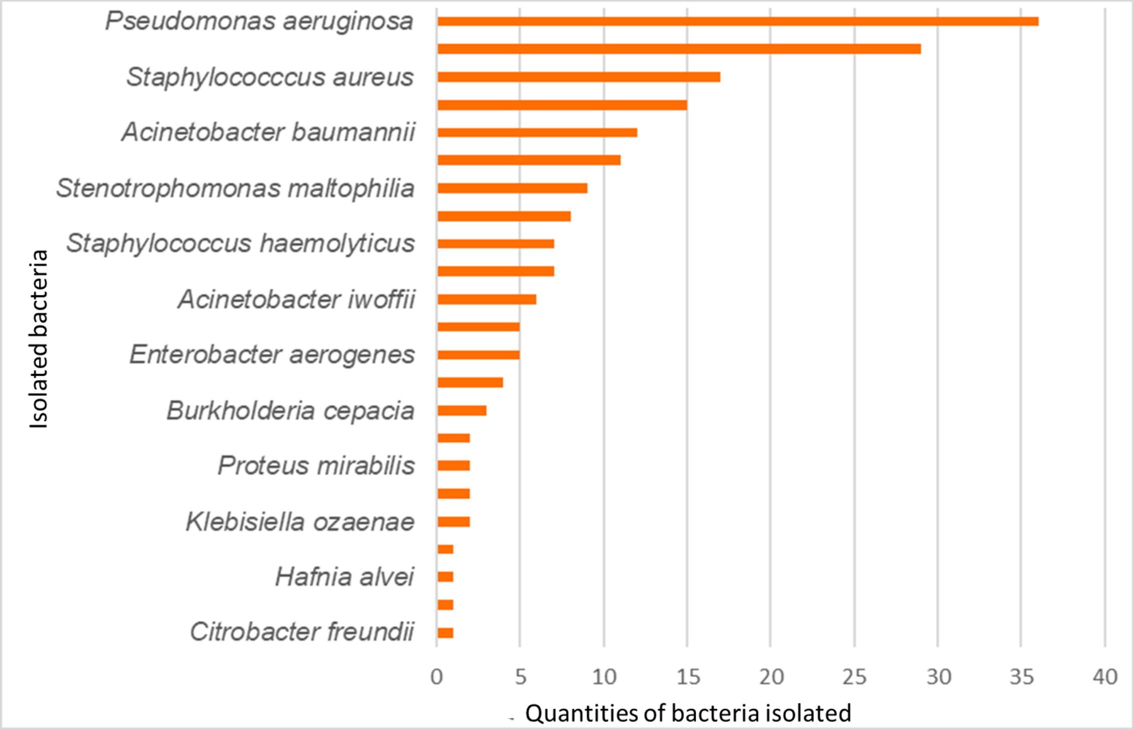


Legend: HMC - Blood Culture, FO Secretion - Surgical Wound Secretion, CVC TIP - Central Venous Catheter Tip;
Source: authors (2023)

Of the 178 microorganisms isolated, the most prevalent were *Pseudomonas aeruginosa* (36; 20.22%), Klebsiella *pneumoniae (28; 15.73%) and* Staphylococcus aureu*s (17; 9.55%)*. Other species and subspecies of bacteria were found and are illustrated in Figure 3. A similar result was observed in a study in the ICU of a hospital in Santa Catarina, which recorded a prevalence of 27.9% for *Pseudomonas aeruginosa* and 26.7% for *Klebsiella pneumoniae* (Farias & Gama, 2020). Contributing to the findings, *Pseudomonas aeruginosa* was also the most common pathogen found in another study done at the University Hospital of Fortaleza (Pereira et al., 2015).

Regarding the diagnoses of patients before being admitted to the ICU, it was analyzed that 55 (29.56%) had COVID-19, followed by respiratory tract infections and prematurity, both with 13 (6.98%). A study conducted at the Intensive Care Center of the Public Hospital of the South of Minas Gerais found different results from those observed in our study, with the predominant pathologies: cardiovascular (50%), digestive and genitourinary (41.7%) and respiratory (33.3%) (Cândido et al., 2013). It is important to note that the underlying pathology acts as a favorable factor for the development of infections, suppressing the immune system and facilitating the invasion of pathogens into the host's body (Silva & Rodrigues, 2015).

Figure 3. Prevalence of bacteria isolated from positive biological samples, taken from patients admitted to the ICU, in 2021.

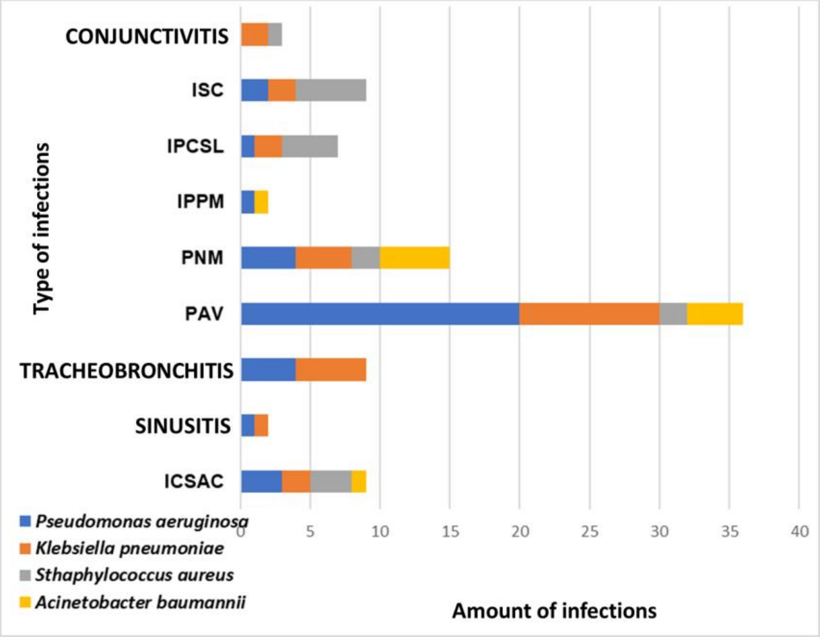


Source: authors (2023)

Regarding the infections caused by the most prevalent bacteria found in our study, it was found that there is a higher prevalence of infections that affect the respiratory tract, as well as ventilator-associated pneumonia, tracheobronchitis and pneumonia were the most frequently found, as shown in Figure 4. According to other results, a research conducted in an intensive care unit of a general and teaching hospital showed that respiratory tract infections were also the ones that most affected individuals hospitalized in this environment (Sousa et al., 2016). Another study points out that more than 94% of those admitted to the ICU of a hospital in Fortaleza (CE) had pneumonia, and of these, 60% were due to mechanical ventilation, data such as these corroborate the finding of this study, and reaffirm the importance of care and management with such individuals so that the mortality rate does not remain high (Bezerra et al., 2012).

Of all the medical records analyzed, 120 (64.51%) and 64 (34.40%) patients were admitted to the ICU with and without SARS-Cov-2 infection, respectively. Two (1.07%) patients' medical records did not contain information about them. Researchers report that ICU patients with a previous diagnosis of the novel coronavirus have increased chances of bacterial, viral, and also fungal co-infections and superinfections, which can lead to severe health conditions and poor prognosis during their hospitalization (Fernandes et al., 2021). Figure 5 illustrates the dynamism of hospitalizations of patients hospitalized for COVID-19 in the hospital unit under study, in which an exponential increase can be observed at the beginning of the year, this fact can be attributed to some factors, such as: high and intense dissemination, viral transmissibility and also by the lack of effectiveness of vaccination (Covre et al., 2022).

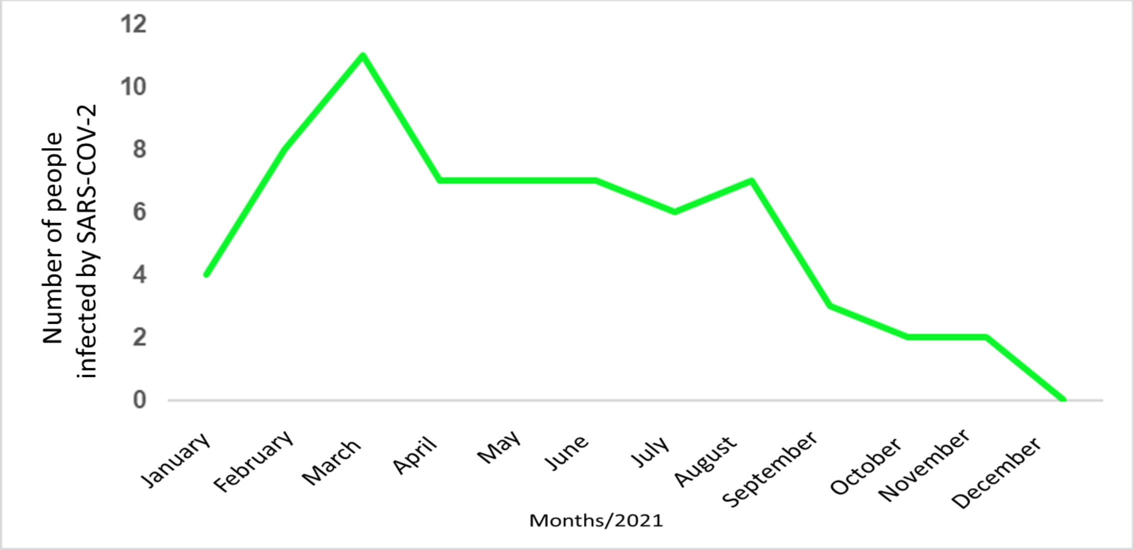
Figure 4. Infections caused by the most prevalent bacteria in ICU patients in 2021.



Legend: Mechanical Ventilation, PNM - Pneumonia, IPPM - Skin and Soft Tissue Infection, IPCLS - Primary Laboratory Bloodstream Infection, SSI - Confirmed Surgical Site Infection**.**

Source: authors (2023)

Figure 5. Number of hospitalizations of SARS-CoV-2 infected patients in ICU patients in 2021



Source: authors (2023)

Regarding the hospital evolution of those admitted to the ICU of the hospital, it was analyzed that 93 (50.54%) people were discharged from the hospital, that is, they recovered from the infectious process and/or the reason that led to hospitalization. 78 (42.29%) people died due to their clinical conditions, 10 (5.43%) people remained hospitalized and 3 (1.63%) were transferred to other health institutions for reasons not ascertained. It is worth mentioning that two medical records did not contain necessary information that would indicate the clinical outcome of the patient during hospitalization. Studies show that the mortality rate is high in patients who are under ICU care and can vary from 9 to 38% (Rodrigues & Pereira, 2016).

Pseudomonas aeruginosa was the most prevalent bacterium in the present study.

Regarding the P. aeruginosa *susceptibility test* to antimicrobial drugs, there was an average of 65.37% of resistance to the antimicrobials tested (Table 1), a value higher than that found in a medium-sized hospital in Rio Grande do Sul, which was 50% (Basso et al., 2016). In another study conducted in a reference hospital in infectology in Amazonas, it was found that the resistance of *P. aeruginosa* to carbapenems was 33.3% (Gima et al., 2020). These data differ from our study, because this same bacterium presented a low rate of resistance to this class of antimicrobials, a factor that may be linked to the intrinsic means of the bacterium itself, through mutation during its cell cycle and even acquired by adding genetic material from another microorganism (Costa & Junior, 2017).

It can be verified that the average resistance to the antibiotics tested for *Klebsiella pneumoniae* was 58.45%. Table 1 shows that for some antimicrobials this strain is highly resistant such as aztreonam, cefepime, ceftriaxone and ampicillin and strongly sensitive to amikacin. Similar results were found in a study conducted in western Pará (Gato et al., 2022), *Klebsiella pneumoniae* is capable of producing extended-spectrum β-lactamases (ESBL), a class of enzyme that leads to resistance to many antibiotics, thus becoming highly resistant, generating alerts in units that provide intensive care (Perna et al., 2015).

With an average resistance of 37.05% to the drugs tested, it was possible to verify, according to Table 1, a high rate of resistance, especially for the penicillin class. The findings of this study corroborate those found in a review study with data from several hospitals in Brazil that found that *Staphylococcus aureus* has high resistance to drugs of the penicillin class, including oxacillin (Bôtelho et al., 2022). The reason for this finding is explained by the ability of *Staphylococcus aureus* to inactivate β-lactam antibiotics. This process involves the action of β-lactamase enzymes, which break down the β-lactam ring of penicillins and cephalosporins. It is important to note that some strains of this bacterium have developed resistance to certain antimicrobials, even those that are not necessarily inactivated by β-lactamase. This is due to the presence of an extra β-lactam-binding protein, which is encoded by a mutated chromosomal gene (Cussolim et al., 2021).

4 CONCLUSION

The most prevalent bacteria in the ICU of the hospital under study were *Pseudomona aeruginosa* and *Klebsiella pneumoniae*, as well as the respiratory tract was identified as the main site of infection. In addition, there was a high number of SARS-CoV-2 infected patients who were infected by various bacteria, contributing to the high mortality rate observed. Regarding the antimicrobial resistance of the most prevalent bacteria, *Pseudomonas aeruginosa* with resistance of 65.37% to the drugs tested, as well as *Klebsiella pneumoniae* (58.45%) and *Staphylococcus aureus* (35.07%). It is worth mentioning that the bacterial and antibiogram profile found of the infections is particular to the hospital under study, and may even be extrapolated to other hospitals, but with due care. In addition, our results can draw a microbiological profile specific to the ICU, and it is possible to guide which antimicrobials should be empirically instituted. Thus, it is possible to obtain a greater therapeutic effect and less tendency to the emergence of multidrug-resistant microorganisms, as well as a reduction in the length of stay and hospital costs of patients hospitalized in this environment. Further research should be done on this topic and clinical considerations should be undertaken for the rational use of antimicrobials in the ICU in order to maintain the effectiveness of such treatments and prevent the emergence of microbial resistance.

Table 1. Sensitivity profile of microorganisms to different drugs

Pseudomonas aeruginosa	***Klebsiella pneumoniae***	***Staphylococcus aureus***						
Antibiotic (class)	**Number of samples evaluated n (%)**	**Resistant isolates in the evaluated samples n (%)**	**Antibiotic (class)**	**Number of samples evaluated n (%)**	**Resistant isolates in the evaluated samples n (%)**	**Antibiotic (class)**	**Number of samples evaluated n (%)**	**Resistant isolates in the evaluated samples n (%)**
quinolones	10 (27,77)	10 (100)	Aminoglycoside	25 (86,20)	1 (4)	Penicillin / β-lactamase Inhibitor	14 (82,35)	7 (50)
Aminoglycosides	31 (86,11)	9 (39,03	Penicillin / β-lactamase Inhibitor	8 (27,58)	5 (62,5)	penicillin	14 (82,35)	13 (92,85)
Penicillin / β-lactamase Inhibitor	10 (27,77)	10 (100)	Penicillin / β-lactamase Inhibitor	8 (27,58)	8 (75)	Cephalosporin	14 (82,35)	7 (50)
Penicillin / β-lactamase Inhibitor	10 (27,77)	10 (100)	penicillin	25 (86,20)	25 (100)	fluoroquinolone	14 (82,35)	5 (35,71)
penicillin	23 (63,88)	23 (100)	Monobactams	25 (86,20)	21 (84)	lincomicidal	14 (82,35)	6 (42,85)
Monobactams	19 (52,77)	17 (89,47)	Cephalosporin	8 (27,58)	6 (75)	Cyclic lipopeptide	10 (58,82)	0 (0)
Cephalosporin	10 (27,77)	10 (100)	Cephalosporin	24 (82,75)	19 (79,16)	macrolide	14 (82,35)	9 (64,28)
Cephalosporin	30 (83,33)	22 (73,33)	Cephalosporin	8 (27,58)	6 (75)	Aminoglycoside	14 (82,35)	5 (35,71)
Cephalosporin	11 (30,55)	11 (100)	Cephalosporin	8 (27,58)	5 (62,5)	fluoroquinolone	14 (82,35)	5 (35,71)
Cephalosporin	10 (27,77)	10 (100)	Cephalosporin	15 (51,72)	12 (80)	Oxazolidinone	14 (82,35)	0 (0)
Cephalosporin	31 (86,11)	19 (61,29)	Cephalosporin	25 (86,20)	20 (80)	penicillin	14 (82,35)	7 (50)
Cephalosporin	10 (27,77)	10 (100)	Cephalosporin	8 (27,58)	6 (75)	penicillin	14 (82,35)	13 (92,85)
Quinolone	29 (80,55)	11 (37,93)	fluoroquinolone	23 (79,31)	16 (69,56)	Glycopeptides	14 (82,35)	1 (7,14)
Polymyxin	30 (83,33)	0 (0)	Polymyxin	25 (86,20)	0 (0)	Tetracycline	14 (82,35)	1 (7,14)
Carbapenem	4 (11,11)	0 (0)	Carbapenem	25 (86,20)	10 (40)	Sulfonamide	14 (82,35)	4 (28,57)
Phosphonate	31 (86,11)	27 (87,09)	Phosphonate	25 (86,20)	14 (56)	Glycopeptides	14 (82,35)	0 (0)
Aminoglycoside	31 (86,11)	18 (58,06)	Aminoglycoside	25 (86,20)	13 (52)			
Carbapenem	31 (86,11)	1 (3,22)	Carbapenem	25 (86,20)	9 (36)			
Quinolone	31 (86,11)	13 (41,93)	fluoroquinolone	25 (86,20)	17 (68)			
Carbapenem	31 (86,11)	1 (3,22)	Carbapenem	25 (86,20)	11 (44)			
nitrofuran	10 (27,77)	10 (100)	nitrofuran	5 (17,24)	3 (60)			

Quinolone	9 (25)	3 (33,33)	fluoroquinolone	7 (24,13)	4 (57,14)			
Penicillin / β-lactamase Inhibitor	31 (86,11)	20 (64,52)	Penicillin / β-lactamase Inhibitor	25 (86,20)	15 (60)			
Aminoglycoside	31 (86,11)	13 (41,93)	Glycylcycline	8 (27,58)	0 (0)			
Sulfonamide combined with Trimetropine	10 (27,77)	10 (100)	Aminoglycoside	24 (82,75)	14 (58,33)			
			Sulfonamide	9 (31,03)	6 (66,66)			

Source: authors (2023)

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