

Surveillance of multi-resistant microorganisms and epidemiological investigation of intensive care unit patients

Análise de parâmetros relevantes em culturas de vigilância epidemiológica de pacientes internados no centro de tratamento intensivo e colonizados por microrganismos multirresistentes

DOI:10.34117/bjdv8n12-204

Recebimento dos originais: 14/11/2022

Aceitação para publicação: 19/12/2022

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ABSTRACT

It is of great importance to detect the presence of microorganisms in healthcare services. On this basis, strategies should be developed to maintain safety inside the hospital environment by preventing the transmission of microorganisms, thus preventing healthcare-associated infections (HAI). In the Intensive Care Unit (ICU), the precocious detection of infection and/or colonization by multidrug-resistant (MDR) microorganisms is key. For this reason, the routine monitoring of patients that are infected or colonized by MDR microorganisms is mandatory. In this context, this study aimed to evaluate the performance of epidemiological surveillance swabs and microbiological cultures in ICU patients in a university public hospital in Belo Horizonte, Minas Gerais State, Brazil. Medical records of patients admitted to the ICU from January 1st, 2018 to December 31st, 2020, submitted to epidemiological surveillance cultures, and presenting factors correlated to the development of HAI were evaluated. This was a descriptive, retrospective and observational, non-interventional study. The study population was composed mainly of male patients (66.3%), with a mean age of 59 years, coming from the Medical Clinic department, and septicemia was the main cause of hospitalization in the ICU. The analyses showed that 9.5% of the patients were colonized by MDR microorganisms. The samples were collected at the ICU, and a higher frequency of gram-negative bacteria was observed, including *A. baumannii*, *P. aeruginosa*, *K. pneumoniae*, and carbapenem-resistant Enterobacteriaceae. The most frequently prescribed antimicrobials were β -lactams and glycopeptides, and the same patient was treated using more than one class of antimicrobials. The surveillance culture is key to understanding the microbiological profile of the institution. The collection of swabs and microbiological cultures from different sites could be used to adopt routines and recommend measures aimed at controlling and reducing the HAI rates as well as the emergence of MDR outbreaks. These procedures could contribute to the creation and maintenance of a safe and effective healthcare service.

Keywords: health care-related infections, active surveillance cultures, multidrug-resistant microorganisms, intensive care center.

RESUMO

A detecção de microrganismos nos serviços de atenção à saúde é componente importante para a gestão em saúde. A partir desta informação podem ser desenvolvidas estratégias para a manutenção de um ambiente hospitalar mais seguro por eliminação de prováveis pontos de contato e transmissão de agentes biológicos e, assim, prevenir as Infecções

Relacionadas à Assistência à Saúde (IRAS). Nos Centro de Terapia Intensiva (CTI) a infecção e/ou colonização por microrganismos multirresistentes (MR) se destacam, sendo relevante a utilização rotineira de ferramentas que permitam o monitoramento dos pacientes portadores. Neste contexto, este estudo objetivou avaliar a realização de culturas microbiológicas e *swabs* de vigilância epidemiológica em pacientes do CTI em um hospital de grande porte da rede pública de Belo Horizonte, Minas Gerais, Brasil. Desta forma, foram avaliados prontuários de pacientes internados no CTI no período de 01/01/2018 a 31/12/2020 e submetidos à culturas de vigilância epidemiológica e que possuíam fatores relacionados ao desenvolvimento de IRAS, caracterizando-se como um estudo descritivo, retrospectivo e observacional, não intervencionista. A população de estudo mostrou predominância de pacientes do sexo masculino (66,3%), idade média de 59 anos, egressos da Clínica Médica, sendo a septicemia a principal causa de internação. As análises demonstraram a colonização por MR em 9,5% das amostras coletadas no CTI, sendo observada maior frequência de bactérias Gram negativas, entre elas *A. baumannii*, *P. aeruginosa*, *K. pneumoniae* e Enterobactérias resistentes aos carbapenêmicos. Os antimicrobianos mais frequentemente prescritos foram os β -lactâmicos e os glicopeptídeos, sendo que um mesmo paciente utilizou mais de uma classe de antimicrobianos. A cultura de vigilância é de extrema relevância para conhecer o perfil microbiológico da instituição através da coleta do *swab* de diferentes sítios e culturas microbiológicas que permitem regulamentar rotinas e adotar ações e medidas que visam o controle e a redução das taxas de IRAS, bem como a seleção de microrganismos resistentes, no intuito de criar e manter um ambiente de atenção à saúde mais seguro e eficiente.

Palavras-chave: infecções relacionadas à assistência à saúde, culturas de vigilância, microrganismos multirresistentes, centro de tratamento intensivo.

1 INTRODUCTION

Healthcare-associated infections (HAI) are linked to healthcare services and have an epidemiological evolution over time (LACERDA, 2003; CDC, 2016, 2019). HAI could represent a serious threat to patients' lives worldwide (ANVISA, 2017, 2021; CDC, 2019). According to National Healthcare Safety Network, HAI could be shown as an adverse outcome associated with one or more infectious agents that are absent or incubating at the time of admission to a hospital (ANVISA, 2017; 2021). These infections usually increase morbidity and mortality rates, enhance medical assistance costs, and bring several consequences to patients' quality of life (CDC, 2016, 2019; KWIECINSKI, HORSWILL, 2020; MOUSTAFA *et al.*, 2020).

Hospital environments are considered a reservoir of potentially pathogenic microorganisms, and HAI could affect not only immunocompromised patients but also visitors and hospital employees (COSTA, 2016). Several conditions could be associated with HAI, such as previous hospitalizations in the intensive care units (ICU), preceding

antimicrobial use, long-term hospitalization and staying in long-term care institutions, the existence of comorbidities, homecare treatments, mechanical ventilatory support, the use of indwelling devices, and microbial colonization (COLLIGNON, MCEWEN, 2019; JACKSON *et al.*, 2019).

Strategies for cross-infection control measures recommended by the Centers for Disease and Control and Prevention (CDC) are transmission-based precautions, including contact, droplet, and airborne precautions (LIU *et al.*, 2018; ANVISA, 2019; COLLIGNON, MCEWEN, 2019). Microbial transmission can occur by different modes: direct or indirect contact, on droplets, or airborne. The most frequent routes of transmission are by person-to-person contact and contact with surfaces, fomites, and contaminated hands. After being exposed to an exogenous or endogenous infectious agent, the patient can remain asymptomatic and colonized or can evolve to an infection exhibiting signs and symptoms. Interestingly, some microbial components of the indigenous microbiota can be associated with HAI (ANVISA, 2017; OLIVEIRA *et al.*, 2017; COLLIGNON, MCEWEN, 2019).

Asymptomatic carriers can harbor and spread multidrug-resistant (MDR) microorganisms and can be reservoirs and sources of transmission. In 2003, the Society for Healthcare Epidemiology of America published guidelines recommending the use of Active Surveillance Cultures (ASC) in combination with other measures in an attempt to identify colonized patients in advance (ANVISA, 2017; 2019). This procedure could help the healthcare services to better understand the microbial resistance profile of each institution (HARRIS *et al.*, 2010; ANVISA, 2017, 2019). Thus, ASC are used inside hospitals to identify patients colonized or infected by MDR during admission. From this analysis, healthcare institutions could establish cross-infection control strategies to diminish cross contamination and decrease the occurrence of HAI (PIRES *et al.*, 2007; WHO, 2009).

Controlling and monitoring HAI is a huge challenge for healthcare professionals and institutions due to their consequences to patients' life, social impact, rising costs, and the increase in the morbidity and mortality rates. To control and minimize HAI damage, it is important to organize and perform an effective HAI surveillance system, especially inside ICUs (FERREIRA *et al.*, 2014). On this basis, this study aimed to evaluate some epidemiological aspects of patients submitted to ASC and colonized by MDR bacteria.

2 MATERIAL AND METHODOLOGY

This was an observational, retrospective, non-interventional, and descriptive study. The sample was composed of patients admitted to the intensive care unit (ICU) of a public hospital. The hospital is classified as a medium-sized (100–499 beds), non-profit, and philanthropic hospital and is a public teaching institution with 315 beds including 30 beds in the ICU. The ICU is a clinical and surgical unit for adults and receives approximately 120 admissions per month. Most patients come from the emergency room, the surgical ward, the medical and surgical clinic department, and the maternity ward (HRTN, 2022). All included patients were submitted to active surveillance cultures (ASC) and possessed factors related to the development of healthcare-associated infection (HAI). All medical records that identified the presence of MDR microorganisms during the execution of ASC procedures, inside the ICU from January 1st, 2018 to December 31st, 2020 were included.

2.1 PATIENTS AND SAMPLING

The present study included data collected from the medical records of patients submitted to ASC according to the hospital criteria. All patients were admitted to the ICU and attended the inclusion (≥ 18 years old, hospitalized between January 1st, 2018 and December 31st, 2020) and exclusion criteria (< 18 years old, patients that were not admitted to the ICU during the studied period, patients that were not MDR or had no epidemiological relevant microorganism colonization or infection, according to the hospital's criteria). After hospital admission to the ICU and compliance with the ASC institutional protocols, culture results were analyzed to identify the presence of infection/colonization by relevant microorganisms, according to hospital guidelines.

2.2 ACTIVE SURVEILLANCE CULTURE (ASC) COLLECTION

Institutional protocols recommend that axillar, nasal, or rectal swabs and microbiological cultures (urinary sites, respiratory specimens [sputum, mini bronchoalveolar lavage – MINIBAL, endotracheal aspirate, and bronchoalveolar lavage fluid], blood samples [1st, 2nd, and 3rd blood culture samples], deep tissues, and other sites should be performed as ASC. Sample collection took place up to 48 h after admission to the ICU. The nurse in charge was responsible for requesting the swabs and for leading and instructing the correct sampling technique performed by the nursing technical support team. The frequency of nasal and rectal swabs was of every

10 days. Samplings were performed every 10 days until hospital discharge or death or during outbreaks, according to the Infection Control Committee criteria.

2.3 DESCRIPTIVE STATISTICAL ANALYSIS

Data from the total number of ASC performed inside the hospital and in the ICU during the study period were obtained. The epidemiological characteristics of the patients and the main group of recovered microorganisms and prescribed antimicrobials were collected from medical records and described using descriptive statistics.

2.4 ETHICAL ASPECTS

Ethical approval was obtained in advance from the Research, Educational and Extension Center of the Risoleta Tolentino Neves hospital (NEPE n° 22/2018) and the Ethics and Research Committee of the Federal University of Minas Gerais (CEP/UFMG - CAAE: 39871820.1.0000.5149).

3 RESULTS AND DISCUSSION

3.1 TOTAL NUMBER OF ACTIVE SURVEILLANCE CULTURES (ASC)

According to the hospital protocol, the ASC swabs were performed mainly in the nasal and rectal sites. In all, 6,491 (48.2%) nasal swabs, 6,556 (48.7%) rectal swabs, and 427 (3.1%) axillar swabs were obtained (Table 1). Axillar swabs were recommended only for cardiac patients. From the number of surveillance swabs during the study period, it was possible to observe that the annual number decreased over time. This reduction could be due to the characteristics of the patients attended in this public hospital and also to the possibility of fluctuation in the number of patients per year. The decrease could also be due to modifications in financial investments, changes in the number and qualification of healthcare personnel or leadership, and to the COVID-19 pandemic, among others. In the ICU, another 8,080 swabs were obtained and distributed as demonstrated in Table 1.

Table 1: Number of swabs collected in one Brazilian university public hospital from 2018 to 2020, considering all hospital departments and the intensive care unit.

| Place of sampling | SWAB | 2018 | 2019 | 2020 | Total |
|---------------------|------------------------|--------------|--------------|--------------|---------------|
| All Hospital Units | AXILLAR | 236 | 100 | 91 | 427 |
| | NASAL | 2,443 | 2,126 | 1,922 | 6,491 |
| | RECTAL | 2,464 | 2,144 | 1,948 | 6,556 |
| | Subtotal / year | 5,143 | 4,370 | 3,961 | 13,474 |
| Intensive Care Unit | AXILLAR | 236 | 26 | 24 | 79 |
| | NASAL | 2,443 | 1,482 | 1,280 | 4,023 |
| | RECTAL | 2,464 | 1,470 | 1,282 | 3,978 |
| | Subtotal / year | 5,143 | 2,978 | 2,586 | 8,080 |

Following medical recommendations, different sites should be sampled to detect the presence of microorganisms and to determine if there is an infectious disease in progress inside ICUs. Considering the period of the present study, 8,632 microbiological cultures were also taken from urinary sites, respiratory specimens, blood samples, deep tissues, and other sites (Table 2). Our results demonstrated that inside the ICU 4,104 (47.5%) blood cultures (including 1st, 2nd, and 3rd samplings) were obtained (Table 2). In our research, as in other studies, it was possible to confirm that the presence of fever among other signs and symptoms associated with blood cultures are the main parameters investigated to diagnose sepsis (VINCENT, J. L., 2016).

Table 2: Number of microbiological cultures performed inside the Intensive Care Unit of a Brazilian university public hospital from 2018 to 2020.

| CULTURES | 2018 | 2019 | 2020 | TOTAL |
|-----------------------------|--------------|--------------|--------------|--------------|
| URINARY | 401 | 418 | 225 | 1,044 |
| RESPIRATORY SPECIMENS | 441 | 440 | 376 | 1,257 |
| BLOOD CULTURE | 1,487 | 1,533 | 1,084 | 4,104 |
| TISSUES | 730 | 857 | 640 | 2,227 |
| Total cultures/ year | 3,059 | 3,248 | 2,325 | 8,632 |

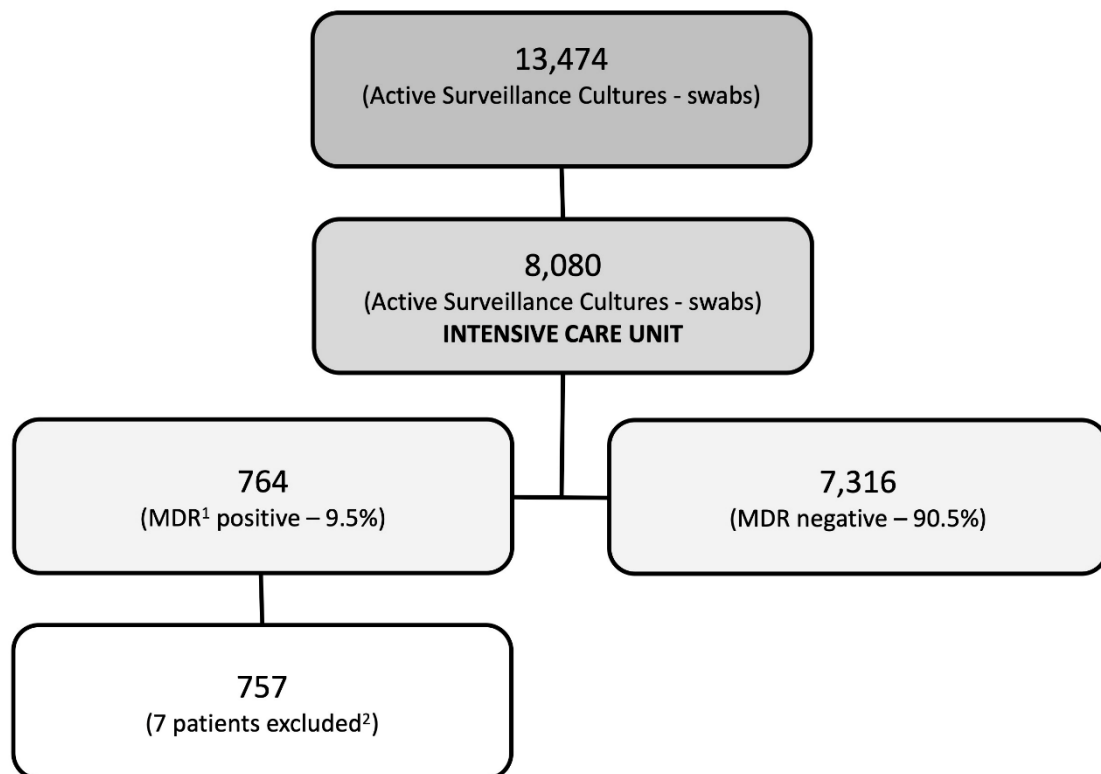
During 2018, 3,059 microbiological cultures were taken from different sites corresponding to 35.5% of all samplings inside the ICU. Similar numbers were obtained in 2019 (3,248 microbiological cultures, corresponding to 37.6%), but a decrease was noted in 2020 (2,325 cultures representing 26.9% of all tests performed during the study period). As mentioned above, the variation in numbers could be attributed to several details including the new institutional policies implemented during the COVID-19 pandemic of 2020. The literature did not establish a consensus about which is the leading site of infection and mentioned bloodstream infections associated with central venous catheters, urinary tract infections attributed to the use of an indwelling urinary catheter,

ventilator-associated pneumonia, and surgical site infection among them (PARAJULI et al., 2017; ANVISA, 2021).

3.2 CHARACTERIZATION OF PATIENTS

Our results highlighted that 764 surveillance cultures were positive for MDR microorganisms inside the studied hospital from 2018 to 2020. This result corresponds to a total of 521 sampled patients. It is important to highlight that sometimes more than one surveillance swab from the same patient is necessary. Besides that, occasionally the same patient was admitted to the ICU more than once in different periods of time. For statistical analysis, the data were presented as positive results for MDR microorganisms. Figure 1 exhibits the numbers of ASC performed, and 757 analyses were considered as the final result.

Figure 1: Flowchart of the surveillance swabs performed in a Brazilian public university hospital from 2018 to 2020.



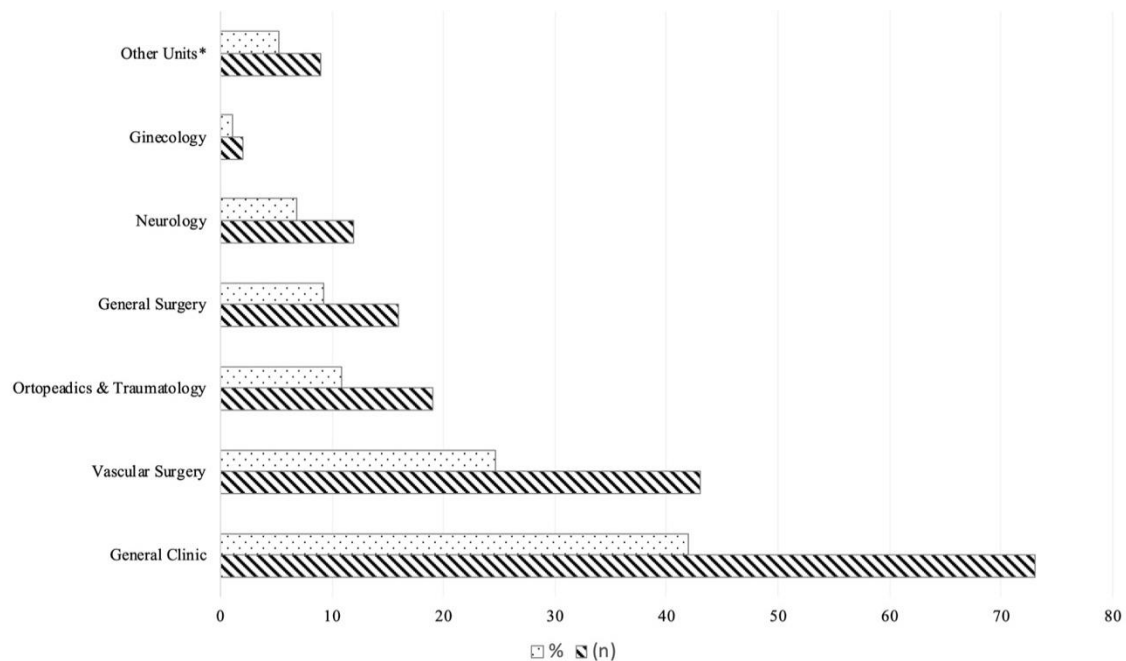
¹:MRD - multidrug resistant microorganism; ²: seven patients were excluded due to missing information inside medical records.

The majority of the studied population was composed of male patients (n = 502; 66.3%), of which 259 died during hospitalization (34.2%). There were 255 female patients (33.7%), corresponding to one third of the final sample. Mortality rates among

female patients were lower (141 deaths – 18.6%). Among the patients whose age was disclosed, a higher frequency of individuals in the age group 60–80 years was observed (mean age of 59.02 ± 16.13). The mean age found agrees with other studies performed in ICUs (LIMA-COSTA, VERAS, 2003; ALMEITDA, LOURENÇO, 2007). One quarter of the sample (25%) were over 50 years old, half were up to 71 years old, and the last quarter were over 71 years old. Our results also showed that colonized patients were mostly male. This is in accordance with other published studies (OLIVER *et al.*, 2008; MARKOGIANNAKIS *et al.*, 2009).

It was observed that 174 patients (33.4%) were previously admitted to the ICUs of other healthcare institutions or other departments/units of the studied hospital at different moments. The most prevalent previous hospitalizations (Figure 2) were from the general clinic (n = 73; 41.9%), followed by vascular surgery (n = 43; 24.7%). As a general hospital, the studied institution receives patients for general clinic treatment, admitted at the emergency services sector, or transferred from other healthcare institutions. The procedures performed in the department of vascular surgery have become more prominent due to the treatment of diabetic patients with recommended amputation.

Figure 2: Number of the prevalence of previously hospitalized patients attended in the intensive care unit in a Brazilian public university hospital from 2018 to 2020, considering the medical specialty of hospitalization.



* Other units: neurology, plastic surgery, surgical clinic, infectology, anesthesiology.

Studies disclosed that patients coming from general units represent 13 to 54% of the total admitted. Their clinical condition varies from light to mild, but severely ill patients could also be found among them due to a lack of ICU beds in hospitals. Therefore, the treatment of these critically ill patients involves more equipment and technology and requires invasive procedures and the use of antimicrobials. All these necessities reinforce the epidemiological importance of the patients previously hospitalized in general units (MARDANI, 2009; OLIVEIRA et al., 2017).

The reason for hospitalization was determined based on the International Classification of Diseases (ICD-10). The main cause of admission to the ICU was sepsis (ICD-A41), representing 13.5% of the studied sample, followed by respiratory failure (ICD-J96) with 10.4% (Table 3).

Table 3: Main reasons for admission to the intensive care unit of a Brazilian public university hospital from 2018 to 2020, considering the International Classification of Diseases.

| International Classification of Diseases (ICD-10) | Code | n ¹ | % |
|--|-------|----------------|-------|
| Sepsis | A41 | 102 | 13.5 |
| Respiratory failure | J96 | 79 | 10.4 |
| Other postprocedural states | Z98 | 41 | 5.4 |
| Cardiac arrest | I46 | 36 | 4.8 |
| Other symptoms and signs involving cognitive functions and awareness | R41 | 30 | 3.9 |
| Intracranial injury | S06 | 23 | 3.0 |
| Traumatic amputation | S88 | 23 | 3.0 |
| Arterial embolism and thrombosis | I74 | 20 | 2.6 |
| Shock | R57 | 14 | 1.8 |
| Complications of procedures | T81 | 14 | 1.8 |
| Abdominal and pelvic pain | R10 | 12 | 1.6 |
| Chronic kidney disease | N18 | 11 | 1.5 |
| Gastrointestinal hemorrhage | K92-2 | 10 | 1.3 |
| cerebrovascular diseases | I67 | 9 | 1.2 |
| Subtotal | | 424 | 56.0 |
| Other ICD codes | | 333 | 44.0 |
| Total | | 757 | 100.0 |

¹: n = number of patients.

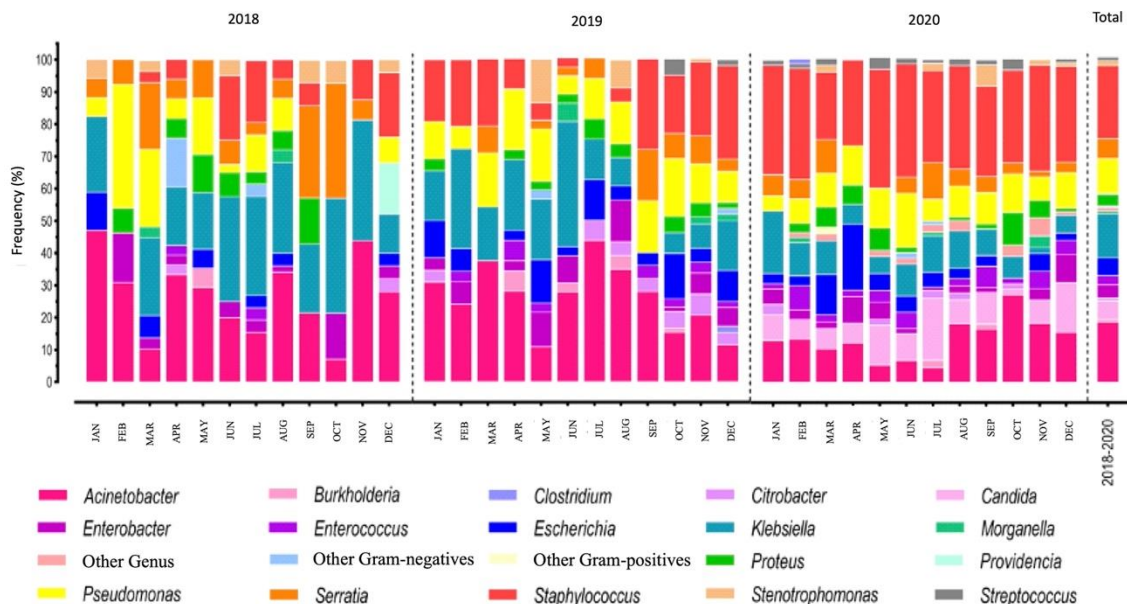
3.3 ISOLATED MICROBIAL GROUPS

The results of the microbiological culture performed inside the hospital are presented as the frequency of each microbial group per month during the three years of research. The microbial profile sampling highlighted that the group of gram-negative

bacteria prevailed (67.8% of all infections), with a predominance of non-fermenting organisms (31.5%). The second most frequent group was that of gram-positive bacteria led by enterobacteria (24.2%) and followed by the group composed of *Citrobacter*, *Enterobacter*, *Serratia*, and *Proteus* (12.1%). *Candida* spp. represented 5.9% of the total microorganisms recovered (Figure 3).

In an analysis of the microbial distribution, it was observed that from the end of 2019 and during the year 2020, an increase in gram-positive bacteria and yeasts occurred. One significant increase observed was in the species *Staphylococcus aureus*, whose prevalence increased from 7.9% (2018) to 15% (2019) and achieved 30.6% in 2020. Yeast strains were not recovered in the first year of the present study but represented 2% in 2019, increasing to 9% in 2020 (Figure 3). The genus *Streptococcus* spp. almost tripled their numbers from 2019 (0.6%) to 2020 (1.7%). In the meantime, the frequency of *A. baumannii* dropped by almost 50% from 2018 (26.7%) and 2019 (26.1%) to 2020 (13.4%). In the beginning of 2020, the COVID-19 pandemic was declared, and this event changed the profile of hospitalization, with a higher prevalence of severely ill patients.

Figure 3: Frequency¹ of the microorganisms recovered from microbiological culture performed at different anatomical sites of hospitalized patients in the intensive care unit of a Brazilian public hospital from 2018 to 2020.



¹: A frequency distribution of the data is shown in this Figure. The monthly percentual over the year and the total percentual during the study period of clinical isolates are represented. Each color of the legend illustrates one of the microbial groups isolated and collected from medical records.

The isolation and increasing levels of MDR *A. baumannii* in ICUs is of great concern. The species is also resistant to chemical disinfectants and could remain viable

for long periods of time on hospital surfaces. This bacterium can reproduce and grow in matrix-enclosed biofilms adherent to host and/or to environmental surfaces (KEMPF, ROLAIN, 2012). The mechanisms of resistance used by *A. baumannii* should be attributed to alteration of the target site of bacteria, enzymatic inactivation by the production of β -lactamases which hydrolyze the carbapenems, active efflux pumps and a decrease in the antimicrobial or biocidal intake. The mechanism of resistance should be intrinsic, such as the production of chromosomally encoded cephalosporinases and reduction of membrane permeability, or acquired after gene transference or mutation in regulated or constitutive genes (LIU *et al.*, 2015; LIU *et al.*, 2018). Polymyxins (polymyxin B and colistin) have been used as a last-line therapeutic option for the treatment of severe infections caused by MDR bacteria. Despite that, the indiscriminating use of these drugs could lead to the selection of resistant bacterial strains (LIU *et al.*, 2015; GIRARDELLO *et al.*, 2017).

Oxacillinase-type carbapenemases (OXA) are recognized worldwide as the main mechanism of resistance in the genus *Acinetobacter* spp., especially inside hospitals. The main difficulty encountered in Brazil treating infections caused by MDR bacteria, including *Acinetobacter baumannii*, is the production of β -lactamases that hydrolyze carbapenems such as imipenem, meropenem, ertapenem, doripenem, and broad-spectrum cephalosporins such as ceftazidime and cefepime. The excessive and inappropriate use of these best-choice medications has increased the rates of resistance from 12.6 to 71.4% (KEMPF, ROLAIN, 2012; LABARCA *et al.*, 2014).

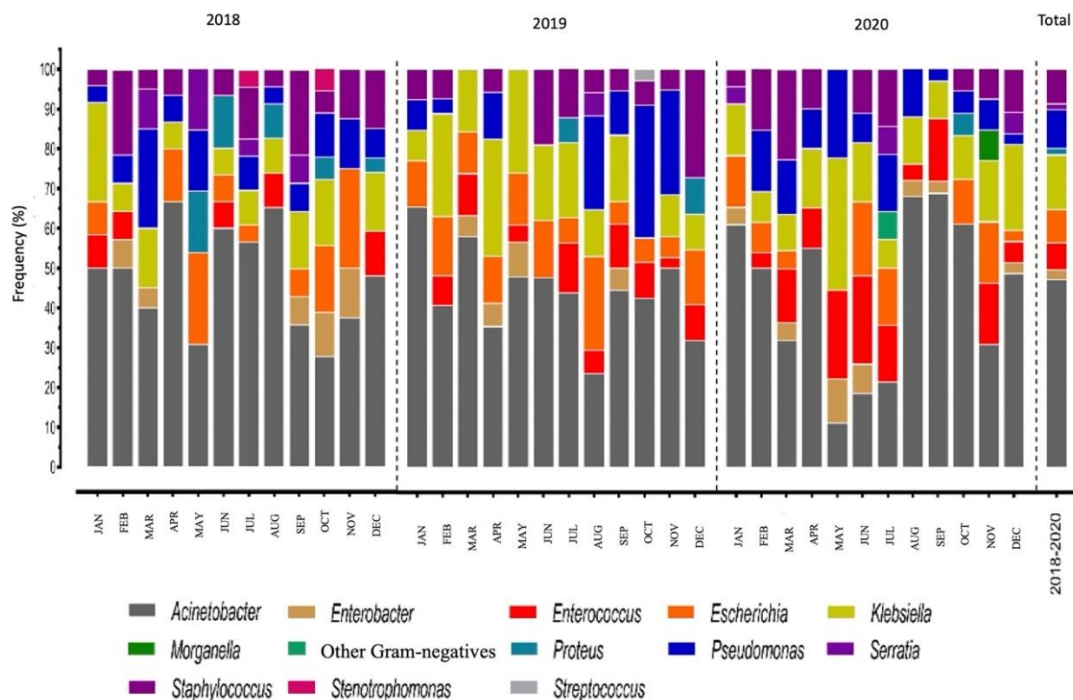
Among the gram-positive bacteria, MDR bacteria are the leading microorganisms related to infections and outbreaks in hospital institutions, especially methicillin-resistant *S. aureus* (MRSA), which represent around 29% of all events in Brazil (JONES *et al.*, 2013; MARZEC, BESSESEN, 2016). MRSA infections and outbreaks represent a great clinical and epidemiological challenge and are considered the main etiological agents of healthcare-associated infections (HAI) (MARZEC, BESSESEN, 2016; MURRAY, 2017; BUTLER-LAPORTE *et al.*, 2018; ANVISA, 2021).

Nasopharyngeal colonization with *S. aureus* can affect 20%–40% of global population, and MRSA could reach 6%–18%. Some studies demonstrated that 80% of bacteremia cases are caused by *S. aureus*, and the invasive strain is genetically identical to those recovered from nasopharynx. These findings reinforced the epidemiological importance of nasopharyngeal colonization. Therefore, the risk factor commonly associated with developing an infectious disease caused by MRSA is previous

colonization. So, colonized patients, and especially colonized healthcare personnel, could represent a silent reservoir for future transmission. Colonized people have an increased risk of developing MRSA infections when compared to those not colonized by this bacterium (MURRAY, 2017; BUTLER-LAPORTE *et al.*, 2018; ANVISA, 2021).

The results of surveillance swabs highlighted the circulation of non-fermenting gram-negative bacteria (n = 427, 56.4%); enterobacteria (n = 181, 23.9%); the group composed of *Citrobacter*, *Enterobacter*, *Serratia*, and *Proteus* (n = 31, 4.1%); and also, gram-positive bacteria (n = 117, 15.5%) (Figure 4). The most prevalent microorganism was the non-fermenting *Acinetobacter* spp. (n = 352, 46.5%), followed by *Klebsiella pneumoniae* (n = 104, 13.74%) and *P. aeruginosa* (n = 73, 9.64%). Considering the group of gram-positive bacteria, *S. aureus* prevailed (n = 65, 8.59%) and was followed by *Enterococcus* spp. (n = 51, 6.7%). Another study presented a similar profile of microbial colonization in patients living in long-term care institutions (ARCANJO *et al.*, 2014). When the results of the microbiological culture and the surveillance swabs were compared, a similar distribution was observed over time. Nevertheless, the observed increasing in gram-positive bacteria in the surveillance swabs that occurred in 2020 was not perceived with the culture of anatomical sites.

Figure 4: Microbial profile¹ obtained from positive surveillance swabs performed on hospitalized patients in the intensive care unit of a Brazilian public hospital from 2018 to 2020



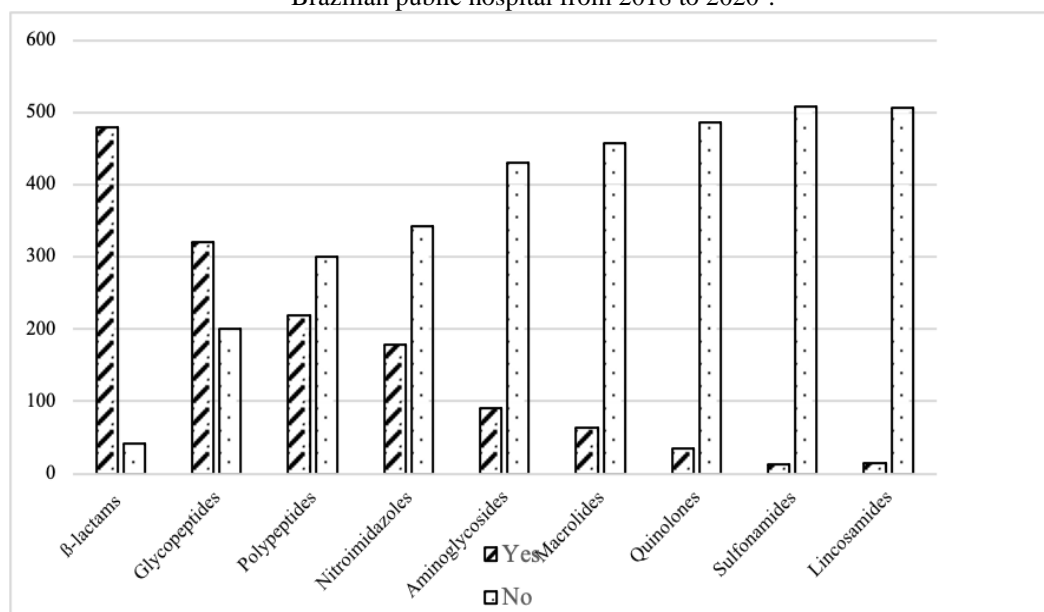
¹: A frequency distribution of data can be shown in this Figure. The monthly percentual over the year and the total percentual during the study period of clinical isolates are represented. Each color of the legend illustrates one of the microbial groups isolated and collected from medical records.

The frequency of gram-negative rods and gram-positive cocci are similar to those of other national and international studies performed with surveillance cultures in ICUs (MORAES et al., 2013; GOMES *et al.*, 2014; HESPANHOL *et al.*, 2018). Some studies investigated colonization by MDR microorganisms in ICUs and also found *A. baumannii* as the prevailing agent (KEMPF, ROLAIN, 2012; FORTALEZA *et al.*, 2013). Another non-fermenting bacterium recovered was MDR *P. aeruginosa* followed by *K. pneumoniae*, and the use of invasive devices, the severity of the associated disease, and the presence of chronic wounds represented critical factors for microbial colonization and, consequently, HAI (BABADY *et al.*, 2012; KEMPF, ROLAIN, 2012; VIDERMAN *et al.*, 2018). Regarding gram-positive bacteria, some studies mentioned that *E. faecalis* poses the highest colonization rates, in contrast to the United States, where *E. faecium* prevailed (FURTADO *et al.*, 2011; ZHANG *et al.*, 2013). Concerning oxacillin-resistant *S. aureus* (ORSA), a frequency of 45.8% of nasal swabs was observed, and the highest prevalence was observed in those patients with long-term hospitalization, surgical procedures, and the use of invasive devices (MARDANI, 2009).

3.4 Class of antimicrobials used

The most frequently used antimicrobial classes in hospitalized patients were the β -lactams (94.0%) and the glycopeptides (61.4%). It is important to highlight that the same patient was treated with more than one class of antimicrobial (Figure 5).

Figure 5: Main class of antimicrobials used on hospitalized patients in the intensive care unit of a Brazilian public hospital from 2018 to 2020¹.



¹: The colored bars represent the total number of prescribed antimicrobials, according to the hospital files.

Since their discovery in the 40s, antimicrobials have been the most used medications to treat infectious diseases in both hospital and community settings. Approximately 40%–50% of hospitalized patients receive these drugs for therapeutic or prophylactic use. The indiscriminate use of antimicrobials has been contributing to the emergence of resistant microorganisms and interfering in the hospital environment by modifying the microbial ecology (PHILMON *et al.*, 2006; ANVISA, 2021).

β -lactams are the first choice of treatment in medical practice due to their pharmacodynamics and to their effect against gram-negative bacteria (ROMANO *et al.*, 2020). When we compared the microbial profile recovered in the present study with the prescribed antimicrobials it was possible to observe an interesting relationship between the use of β -lactams, especially the carbapenem meropenem, and the polypeptides, particularly colistin and polymyxin B, and the high frequency of gram-negative bacteria, predominantly *A. baumannii* and carbapenemase-producing Enterobacteriaceae. On the other hand, glycopeptides are prescribed to treat infections caused by gram-positive bacteria and in this study, a high frequency of *S. aureus* and *Enterococcus* was also observed colonizing ICU hospitalized patients (ROMANO *et al.*, 2020; ANVISA, 2021).

4 CONCLUSION

Nowadays, HAI represents a relevant public health challenge, always requiring epidemiological surveillance and a convergence of actions among national and international regulations, healthcare personnel, the hospital administration, and the hospital infection control committee. The management and constant monitoring of the microbial load and their respective antimicrobial profiles are of great importance, especially the performance of active surveillance cultures. Based on our results it was possible to attest that 9.5% of all patients admitted to the ICU were positive for clinically relevant microorganisms. The most frequently recovered group was gram-negative bacteria, and *A. baumannii* was the most prevalent species, followed by *P. aeruginosa*, *K. pneumoniae*, and carbapenem-resistant Enterobacteriaceae. Among the gram-positive group, vancomycin-resistant *Enterococcus* and oxacillin-resistant *S. aureus* were the most frequently isolated bacteria. The antimicrobial resistance profile showed a higher prevalence of meropenem-resistant bacteria and carbapenem-resistant enterobacteria. The most commonly prescribed antimicrobials in the ICU were those of the β -lactam and glycopeptide class, and the same patient was treated with more than one class of antimicrobial. Data on frequencies and antimicrobial resistance observed in the present

study are in accordance with other national and international studies where MDR resistant, mainly gram-negative, organisms prevailed in the hospital environment. The impact on the worldwide circulation of MDR microorganisms is of great importance and could represent a threat to humanity. Thereby, the results of the present study reinforce the importance of performing active surveillance cultures in an attempt to define the institutional microbiological profile by the sampling of swabs and culture from different anatomical sites. The respective results should be used to propose rules and to adopt preventive measures focused on the reduction of HAI rates and the emergence of MDR microorganisms, maximizing the safety of the hospital environmental and the effectiveness of medical procedures.

5 CONFLICTS OF INTEREST STATEMENT

All authors declare that there are no conflicts of interest.

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