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Original Article

Analysis of the resistance profile of microorganisms in the pre-pandemic and Covid-19 pandemic period

Análise do perfil de resistência de microrganismos em Unidades de Terapia Intensiva do Amazonas no período pré-pandêmico e pandêmico de Covid-19

Análisis del perfil de resistencia de microorganismos en el periodo prepandémico y pandemia de Covid-19

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Corresponding author:
E-mail: adb.med23@uea.edu.br
Address: Cosme Ferreira Avenue, 5787, São José Operário, Manaus, Amazonas, Brazil.

Esther Pereira Abensur[1]
Adriany da Rocha Pimentão[1]
Vinícius Moura de Araújo[1]
Albe Dias Batista[1]
Eidie Souza de Queiroz[1]
Maria Luiza Silva dos Santos[1]
Pedro Eduardo Garcia de Andrade[1]
Elielza Guerreiro Menezes[1]
Evelyn Cesar Campelo[2]
Timóteo Tadashi Watanabe[2]

[1]University of the State of Amazonas, Manaus, Amazonas, Brazil.
[2]Amazonas Health Surveillance Foundation “Dr. Rosemary Costa Pinto”, Manaus, Amazonas, Brazil.

ABSTRACT

Background and Objectives: With the pandemic caused by SARS-CoV-2, the intense empirical use of antibiotic therapy endorsed selective pressure driving microbial resistance. Understanding the profile of this resistance in the hospital environment generates support for the rational use of antimicrobials. This study aimed to analyze the resistance profile of microorganisms in patients admitted to intensive care units of Amazonas before and during the Covid-19 pandemic. **Methods:** This is a quantitative, observational, and retrospective study conducted between 2019 and 2021. Based on the database provided by Dr. Rosemary Costa Pinto Health Surveillance Foundation, it was possible to identify the isolated microorganisms, compare the microbial resistance profile during the research period, and relate it to the main types of mandatory notification infections found in blood cultures and urine cultures. The data were organized in Microsoft Excel® spreadsheets and subjected to a descriptive analysis according to their epidemiological significance. **Results:** 26 microorganisms were classified over the three years, with a higher prevalence of carbapenem-resistant and cephalosporin-resistant gram-negative bacteria; however, there was a higher incidence of oxacillin-resistant gram-positive bacteria. **Conclusion:** Empirical antimicrobial treatment was used to minimize the high mortality in health services during the coronavirus pandemic, but its approach lacked good clinical reasoning from the professionals of the multidisciplinary team. By avoiding the indiscriminate use of antibiotics, the cost and expenses of unnecessary public and private resources are also avoided, also slowing down the speed of spread of microbial resistance.

Keywords: *Drug Resistance. Covid-19. Cross Infection. Intensive Care Units.*

RESUMO

Justificativa e Objetivos: Com a pandemia causada pelo SARS-CoV-2, o intenso uso da antibioticoterapia endossou uma pressão seletiva impulsionando a resistência microbiana. Compreender o perfil dessa resistência no ambiente hospitalar fornece subsídios para o uso racional de antimicrobianos. O presente estudo teve como objetivo analisar o perfil de resistência dos microrganismos em pacientes internados em Unidades de Terapia Intensiva do Amazonas antes e durante a pandemia de Covid-19. **Métodos:** Trata-se de um estudo quantitativo, observacional e retrospectivo, realizado entre 2019 e 2021. A partir do banco de dados disponibilizado pela Fundação de Vigilância em Saúde Drª Rosemary Costa Pinto, foi possível identificar os microrganismos isolados, comparar o perfil de resistência microbiana durante o período da pesquisa e relacionar com os principais tipos de infecção de notificação obrigatória encontrados em hemoculturas e uroculturas. Os dados foram organizados em planilhas do *Microsoft Excel®* e submetidos a uma análise descritiva de acordo com sua importância epidemiológica. **Resultados:** Foram classificados 26 microrganismos durante os três anos, com maior prevalência das bactérias gram-negativas resistentes a carbapenêmicos e a cefalosporinas, entretanto houve maior incidência das bactérias gram-positivas resistentes à oxacilina. **Conclusão:** O tratamento empírico de antimicrobianos visou minimizar a alta mortalidade nos serviços de saúde durante a pandemia do coronavírus, mas sua abordagem careceu de um bom raciocínio clínico dos profissionais da equipe multidisciplinar. Evitando o uso indiscriminado de antibióticos, evita-se também o custo e despesas de recursos públicos e privados desnecessários, desacelerando também a velocidade de propagação da resistência microbiana.

Descritores: *Resistência Microbiana. Covid-19. Infecção Hospitalar. Unidades de Terapia Intensiva.*

RESUMEN

Justificación y Objetivos: Con la pandemia causada por el SARS-CoV-2, el uso empírico intensivo de la terapia antibiótica respaldó una presión selectiva que impulsó la resistencia microbiana. Entender el perfil de esta resistencia en el ámbito hospitalario genera subsidios para el uso racional de los antimicrobianos. El presente estudio tuvo como objetivo analizar el perfil de resistencia de microorganismos en pacientes ingresados en unidades de cuidados intensivos del estado de Amazonas antes y durante la pandemia de Covid-19. **Métodos:** Se trata de un estudio cuantitativo, observacional y retrospectivo, realizado entre los años 2019 y 2021. A partir de la base de datos puesta a disposición por la Fundación de Vigilancia de la Salud Dra. Rosemary Costa Pinto, fue posible identificar los microorganismos aislados, comparar el perfil de resistencia microbiana durante el período de investigación y relacionarlos con los principales tipos de infecciones de notificación obligatoria encontradas en hemocultivos y urocultivos. Los datos se organizaron en hojas de cálculo de Microsoft Excel® y se sometieron a un análisis descriptivo de acuerdo con su importancia epidemiológica. **Resultados:** Se clasificaron un total de 26 microorganismos a lo largo de los tres años, con mayor prevalencia de bacterias gramnegativas resistentes a carbapenémicos y cefalosporinas, sin embargo, hubo una mayor incidencia de bacterias grampositivas resistentes a oxacilina. **Conclusión:** El tratamiento empírico de antimicrobianos se utilizó para minimizar la alta mortalidad en los servicios de salud durante la pandemia del coronavirus, pero su enfoque careció de un buen razonamiento clínico por parte de los profesionales del equipo multidisciplinario. Al evitar el uso indiscriminado de antibióticos, también se evitan costos y gastos innecesarios de recursos públicos y privados, desacelerando además la velocidad de propagación de la resistencia microbiana.

Palabras Clave: *Farmacorresistencia Microbiana. Covid-19. Infección Hospitalaria. Unidades de Cuidados Intensivos.*

INTRODUCTION

Since the beginning of the Covid-19 pandemic caused by SARS-CoV-2, along with the evolution of technology, there has been an acceleration in the transmission of information around the world about treatment possibilities, and the impact of empirical treatment has been a proven problem.[1] This challenge was also experienced in the state of Amazonas, which experienced two waves of exponential growth in infections in early and late 2020, totaling more than 10,400 deaths from the beginning of the pandemic until February 2021.[2] The widespread use of antibiotic therapy has caused selective pressure so that the most resistant strains have persisted, accumulated resistance mechanisms, and spread.[1]

On the other hand, research involving the development of new antibiotics has not progressed at the same speed as pathogens have developed resistance mechanisms, compromising treatment options for some infections.[3,4]

According to the Pan American Health Organization (PAHO), Microbial Resistance (MR) occurs when microorganisms undergo changes when exposed to antimicrobials, acquiring resistance to a wide range of drugs, thus jeopardizing the effectiveness of prevention and treatment of an increasing number of infections.[5,6]

With the possible increase in multidrug-resistant (MDR) microorganisms in hospital services with a wider range of resistance to the most used antimicrobials and increasingly restricted therapeutic treatments due to the lack of rapid development of new drugs, it is becoming increasingly difficult to treat and recover patients affected by MDR.[4]

It is illusory to believe that the development of new drugs will keep pace with the development of MR, so it is necessary to understand the resistance profile of microorganisms present in hospitals to have subsidies for the rational use of antimicrobials, in addition to emphasizing preventive measures.

Given the above, the objective of this study was to analyze the resistance profile of microorganisms in Intensive Care Units (ICUs) in the state of Amazonas during the pre-pandemic and pandemic periods of Covid-19.

METHODS

This is a quantitative, observational, retrospective study conducted using data provided by the Amazonas Health Surveillance Foundation – Rosemary Costa Pinto. The research involved the analysis of microorganisms isolated in blood cultures and urine cultures, as well as their antimicrobial resistance profiles, in all ICUs in the state of Amazonas, from 2019 to 2021, considering January 2019 to December 2021.

Sample

All blood cultures and urine cultures from intensive care units (ICUs) in the state of Amazonas were processed by the Central Public Health Laboratory (LACEN). This laboratory strictly follows the criteria established by Technical Standards No. 01, 02, and 03 of the Health Services Surveillance and Monitoring Management (GVIMS) of the National Health Surveillance Agency (ANVISA), regarding the diagnosis of Healthcare-Associated Infections (HAIs) subject to mandatory national notification for the year 2023.

The standards define the diagnostic criteria according to the type of infection, with specific categorization for adult, pediatric, and neonatal patients. After processing, the data were forwarded to the State Commission for Infection Prevention and Control in Health Services, of the Amazonas Health Surveillance Foundation – Dr. Rosemary Costa Pinto (CECISS/FVS-RCP), where they created the annual database.[7-9]

Selection criteria

To define the types of infection considered in the study, the classifications established by the Technical Standards of the Health Services Surveillance and Monitoring Management of the National Health Surveillance Agency (GVIMS/ANVISA), 2023 edition, were adopted. The following healthcare-associated infections were included in the scope of the study: Laboratory Primary Bloodstream Infection (LPBI) associated with the use of Central Venous Catheters (CVC); Urinary Tract Infection (UTI) associated with the use of Indwelling Urinary Catheters (IUC).

These infections were selected based on their epidemiological relevance and the availability of consolidated blood and urine culture data in the surveillance system of the Amazonas Health Surveillance Foundation – Rosemary Costa Pinto (FVS-RCP). On the other hand, the following conditions were excluded from the study: Ventilator-Associated Pneumonia (VAP); Surgical Site Infections (SSI); Infections associated with dialysis services. Both are also described in ANVISA's Technical Standards and are included in the records of the State Coordination of Infection Control in Health Services (CECISS/FVS-RCP), but were not considered in this analysis because they did not fit the specific objectives of this study.[7-9]

Data collection instruments

Initially, a comprehensive literature review was conducted using the Scientific Electronic Library Online (SciELO), Virtual Health Library (VHL), National Center for Biotechnology Information (NCBI), and

PubMed databases between August 2022 and June 2023.

The purpose of the review was to contextualize local findings within the national and international landscape, identify patterns and trends related to MR in intensive care settings, and provide a theoretical basis for the choice of microorganisms and infections prioritized in the research. In addition, it allowed the identification of gaps in the scientific literature that justify and reinforce the relevance of the present study to the Amazonian reality.

At the same time, between November 2022 and March 2023, secondary data were collected from the MR database on Healthcare-Associated Infections (HAIs), made available by the State Commission for Infection Prevention and Control in Health Services of the Health Surveillance Foundation – Dr. Rosemary Costa Pinto (CECISS/FVS-RCP). These data include records from ICUs in the state of Amazonas related to blood cultures and urine cultures and were used as the main analysis tool in this study.

Although data collection began in 2022, the 2023 ANVISA guidelines were adopted as a normative reference because they were the most current and consolidated version at the time of analysis and interpretation. The use of these standards was essential to ensure greater methodological rigor, standardization of diagnostic criteria, and alignment with the latest epidemiological surveillance practices in the country.

Data organization and analysis

The collected data were digitized and organized in spreadsheets using Microsoft Excel® software. They were then subjected to descriptive statistical analysis to identify patterns of occurrence of microorganisms and their MR profile in ICUs in the state of Amazonas from 2019 to 2021.

The data were separated to allow comparisons between the isolated microorganisms, the years of occurrence, and the types of infection observed in different age groups (adults, pediatric, and neonatal).

The study allowed the identification of the main microorganisms isolated according to their epidemiological relevance, as well as a comparative analysis of the antimicrobial resistance profile over the three years of investigation. In addition, the data were stratified by type of infection, enabling a detailed assessment of microbiological behavior in the different population groups admitted to ICUs.

Ethical considerations

The research followed the ethical precepts of Resolution No. 466 of the National Health Council (CNS) of December 12, 2012. As this was a study using secondary data and did not involve participants, the project was not submitted to the Research Ethics Committee, requiring only submission for review and obtaining consent.

RESULTS

Analysis of data from 2019 to 2021 reveals important changes in the MR profile in ICUs in the state of Amazonas, particularly when comparing the pre-pandemic period with the Covid-19 pandemic context. Initially, there was a significant increase in the frequency of microorganism isolation in blood and urine cultures throughout the period evaluated.

During the research period, 26 microorganisms were identified in blood and urine cultures from ICU patients in Amazonas, classified as Gram-negative bacteria (57.7%), Gram-positive bacteria (23.1%), fungi (11.5%), atypical microorganisms (3.8%), and unlisted microorganisms (3.8%).

A total of 1,508 microorganisms were isolated in ICU blood cultures, with gram-negative bacteria such as K. pneumoniae (16.84%) and Acinetobacter spp. (6.23%) being the most prevalent. On the other hand, Gram-positive bacteria had a higher incidence when comparing the three years, with emphasis on coagulase-negative Staphylococcus (CNS) (37.53%) and S. aureus (14.46%), which were the main microorganisms of LPBI-CVC (Table 1).

Table 1. Microorganisms isolated in adult, pediatric, and neonatal blood cultures in Amazonas during the period from 2019 to 2021.

Isolated Microorganisms	2019			2020			2021		
	Adult	Pediatric	Neonatal	Adult	Pediatric	Neonatal	Adult	Pediatric	Neonatal
Acinetobacter spp.	10	4	13	8	12	2	36	6	3
Alcaligenes faecalis	0	1	0	0	0	0	0	0	0
Burkholderia cepacia	2	1	0	5	3	0	13	13	7
Escherichia coli	3	2	6	11	2	7	13	2	3
Enterococcus faecalis	6	2	3	7	2	7	0	3	9
Enterococcus faecium	0	3	0	1	0	0	4	0	0
Enterobacter cloacal	0	0	0	0	0	0	0	0	0
Enterobacter spp.	6	7	4	10	5	4	16	3	10
Enterococcus spp.	0	0	1	3	1	3	6	3	1

Isolated Microorganisms	2019			2020			2021		
	Adult	Pediatric	Neonatal	Adult	Pediatric	Neonatal	Adult	Pediatric	Neonatal
Klebsiella sp.	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	17	19	63	18	13	45	32	13	34
Other enterobacteria	3	2	0	4	1	0	5	0	0
Pseudomonas aeruginosa	12	1	2	12	10	2	34	3	4
Proteus spp.	0	0	0	0	0	0	0	0	0
Ralstonia spp.	0	0	0	0	0	0	0	0	1
Ralstonia picketti	0	1	0	0	0	0	0	0	0
Streptococcus pneumoniae	0	1	0	0	0	0	0	0	0
Staphylococcus aureus	24	10	29	30	11	18	57	18	21
Stenotrophomonas maltophilia	0	2	0	2	4	0	6	0	2
Staphylococcus Coagulase Negative	31	40	113	53	41	69	151	26	42
Serratia spp.	2	11	0	2	5	0	11	2	5

Microorganisms such as SCN and S. aureus stand out for being consistently among the most frequently isolated, with SCN increasing from 113 isolates in 2019 to 219 in 2021, predominantly in adult patients. Similarly, K. pneumoniae, a pathogen widely associated with severe hospital infections, had a high number of isolates, particularly in adult and neonatal patients. Also noteworthy is the significant growth in isolates of Acinetobacter spp., which increased from 27 in 2019 to 45 in 2021, predominantly in adults.

For CAUTI data in urine cultures during the study period, a total of 768 isolated microorganisms were identified, the most frequent being Enterobacter spp. (41.80%) and E. coli (20.31%). There was a 3% decrease in the rate of indwelling urinary catheter use and consequent CAUTI in urine cultures of patients admitted to pediatric ICUs compared to 2019 (Table 2). In addition, although the focus of this study was microorganisms belonging to Prokaryota, it is important to mention that there was also a high incidence of fungi such as Candida albicans and non-albicans Candida. Data on these microorganisms were not presented because they belong to the Eukaryota group, and the emphasis of this study was on the resistance profile without addressing antifungals.

Table 2. Microorganisms isolated in adult and pediatric urine cultures in Amazonas during the period from 2019 to 2021.

Isolated Microorganisms	**2019**		**2020**		**2021**	
	Adult	**Pediatric**	**Adult**	**Pediatric**	**Adult**	**Pediatric**
Acinetobacter spp.	1	0	5	0	20	2
Alcaligenes faecalis	0	0	0	0	0	0
Burkholderia cepacia	0	0	2	0	7	0
Escherichia coli	25	22	31	9	64	5
Enterococcus faecalis	2	1	3	0	15	1
Enterococcus faecium	0	0	0	0	2	1
Enterobacter cloacal	0	0	0	0	1	0
Enterobacter spp.	65	3	77	7	168	1
Enterococcus spp.	0	0	1	0	4	1
Klebsiella sp.	0	0	0	0	1	0
Klebsiella pneumoniae	11	12	19	10	40	2
Other enterobacteria	0	0	0	0	4	0
Pseudomonas aeruginosa	20	8	16	7	22	2
Proteus spp.	6	0	3	0	5	0
Ralstonia spp.	0	0	0	0	0	0
Ralstonia picketti	0	0	0	0	0	0
Streptococcus pneumoniae	0	0	0	0	0	0
Staphylococcus aureus	0	0	0	1	1	1
Stenotrophomonas maltophilia	0	0	0	1	4	0
Staphylococcus Coagulase Negative	4	1	7	0	3	0
Serratia spp.	0	1	2	2	5	1

Regarding the resistance profile of microorganisms in blood cultures from adult, pediatric, and neonatal patients, as well as in urine cultures, these data can be seen in Tables 3, 4, and 5, divided by year.

Table 3. Resistance profile of microorganisms in blood cultures and urine cultures in Amazonas during 2019.

Microrganisms	AM	Car	CP	CAZ	MP	OX	PO	TS	VA
Acinetobacter spp.	0	10	0	0	0	0	0	0	0
Alcaligenes faecalis	0	0	0	0	0	0	0	0	0
Burkholderia cepacia	0	0	0	1	0	0	0	0	0
Escherichia coli	0	10	35	0	0	0	0	0	0
Enterococcus faecalis	0	0	0	0	0	0	0	0	0
Enterococcus faecium	0	0	0	0	0	0	0	0	0
Enterobacter cloacal	0	0	0	0	0	0	0	0	0
Enterobacter spp.	0	5	16	0	0	0	0	0	0
Enterococcus spp.	0	0	0	0	0	0	0	0	0
Klebsiella sp.	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	0	13	52	0	0	0	0	0	0
Other enterobacteria	0	1	6	0	0	0	0	0	0
Pseudomonas aeruginosa	0	5	0	0	0	0	0	0	0
Proteus spp.	0	0	0	0	0	0	0	0	0
Ralstonia spp.	0	0	0	0	0	0	0	0	0
Ralstonia picketti	0	0	0	0	0	0	0	0	0
Streptococcus pneumoniae	0	0	0	0	0	0	0	0	0
Staphylococcus aureus	0	0	0	0	0	31	0	0	0
Stenotrophomonas maltophilia	0	0	0	0	0	0	0	0	0
Staphylococcus Coagulase Negative	0	0	0	0	0	132	0	0	0
Serratia spp.	0	1	1	0	0	0	0	0	0

Abbreviation: AM = ampicillin; Car = carbapenems; CP = third- and/or fourth-generation cephalosporins; CAZ = ceftazidime; MP = meropenem; OX = oxacillin; PO = polymyxin; TS = sulfamethoxazole/trimethoprim; VA = vancomycin.

Table 4. Resistance profile of microorganisms in blood cultures and urine cultures in Amazonas during 2020.

Microrganisms	AM	Car	CP	CAZ	MP	OX	PO	TS	VA
Acinetobacter spp.	0	12	0	0	0	0	3	0	0
Alcaligenes faecalis	0	0	0	0	0	0	0	0	0
Burkholderia cepacia	0	0	0	1	3	0	0	1	0
Escherichia coli	0	2	29	0	0	0	2	0	0
Enterococcus faecalis	0	0	0	0	0	0	0	0	0
Enterococcus faecium	0	0	0	0	0	0	0	0	0
Enterobacter cloacal	0	0	0	0	0	0	0	0	0
Enterobacter spp.	0	4	8	0	0	0	1	0	0
Enterococcus spp.	0	0	0	0	0	0	0	0	2
Klebsiella sp.	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	0	19	58	0	0	0	1	0	0
Other enterobacteria	0	1	6	0	0	0	0	0	0
Pseudomonas aeruginosa	0	8	0	0	0	0	0	0	0
Proteus spp.	0	0	0	0	0	0	0	0	0
Ralstonia spp.	0	0	0	0	0	0	0	0	0
Ralstonia picketti	0	0	0	0	0	0	0	0	0
Streptococcus pneumoniae	0	0	0	0	0	0	0	0	0
Staphylococcus aureus	0	0	0	0	0	29	0	0	0
Stenotrophomonas maltophilia	0	0	0	0	0	0	0	2	0
Staphylococcus Coagulase Negative	0	0	0	0	0	146	0	0	0
Serratia spp.	0	4	4	0	0	0	0	0	0

Abbreviation: AM = ampicillin; Car = carbapenems; CP = third- and/or fourth-generation cephalosporins; CAZ = ceftazidime; MP = meropenem; OX = oxacillin; PO = polymyxin; TS = sulfamethoxazole/trimethoprim; VA = vancomycin.

There was an 8.46% increase in the number of resistant microorganisms in 2020 (n=346) compared to 2019 (n=319) and a 56% increase in 2021 (n=540) compared to 2020 (Table 5).

Table 5. Resistance profile of microorganisms in blood cultures and urine cultures in Amazonas during the period of 2021.

Microrganisms	AM	Car	CP	CAZ	MP	OX	PO	TS	VA
Acinetobacter spp.	0	36	0	0	0	0	2	0	0
Alcaligenes faecalis	0	0	0	0	0	0	0	0	0
Burkholderia cepacia	0	0	0	7	7	0	0	1	0
Escherichia coli	0	14	62	0	0	0	0	0	0
Enterococcus faecalis	0	0	0	0	0	0	0	0	0
Enterococcus faecium	0	0	0	0	0	0	0	0	0
Enterobacter cloacal	1	0	0	0	0	0	0	0	0
Enterobacter spp.	0	7	20	0	0	0	1	0	0

Microrganisms	AM	Car	CP	CAZ	MP	OX	PO	TS	VA
Enterococcus spp.	0	0	0	0	0	0	0	0	1
Klebsiella sp.	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	0	26	80	0	0	0	0	0	0
Other enterobacteria	0	1	11	0	0	0	0	0	0
Pseudomonas aeruginosa	0	6	0	0	0	0	0	0	0
Proteus spp.	0	0	0	0	0	0	0	0	0
Ralstonia spp.	0	0	0	1	0	0	0	0	0
Ralstonia picketti	0	0	0	0	0	0	0	0	0
Streptococcus pneumoniae	0	0	0	0	0	0	0	0	0
Staphylococcus aureus	0	0	0	0	0	65	0	0	0
Stenotrophomonas maltophilia	0	0	0	0	0	0	0	4	0
Staphylococcus Coagulase Negative	0	0	0	0	0	164	0	0	0
Serratia spp.	0	11	12	0	0	0	0	0	0

Abbreviation: AM = ampicillin; Car = carbapenems; CP = third- and/or fourth-generation cephalosporins; CAZ = ceftazidime; MP = meropenem; OX = oxacillin; PO = polymyxin; TS = sulfamethoxazole/trimethoprim; VA = vancomycin.

In summary, the results indicate that the Covid-19 pandemic had a direct impact on the increase in MR in ICUs in Amazonas. This scenario reinforces the importance of strengthening microbiological surveillance programs, implementing effective policies for the rational use of antimicrobials, and continuously investing in the training of healthcare teams and rigorous hospital infection control practices. The adoption of these measures is essential to contain the spread of MR and preserve the effectiveness of available antimicrobials.

DISCUSSION

Empirical antibiotic therapy was used during the Covid-19 pandemic. Severely ill patients hospitalized for coronavirus developed Acute Respiratory Distress Syndrome and underwent mechanical ventilation, which caused various cases of lung injury and, more rarely, VAP coinfection due to secondary bacterial colonization. Such indiscriminate use of antibiotics certainly increased the generalized selective pressure on these drugs, which probably explains the increase in resistance profile found in our results during the Covid-19 pandemic.[10,11]

Additionally, it is reported that during the coronavirus pandemic, 88.3% of patients hospitalized for Covid-19 in health services were treated with broad-spectrum antibiotics, including third-generation cephalosporins, generating a weekly growth of 0.6% in antibiotic consumption. This scenario contributed to the intensification of selective pressure and favored the growth of multidrug-resistant strains, which was also reflected in the data presented here.[12,13]

Similarly, the high occurrence of SCN identified in our results in pediatric and neonatal units stands out, since this microorganism is an important nosocomial agent, often related to SSI in premature or low birth weight newborns undergoing invasive procedures, such as central venous catheters and prosthetic devices. In these vulnerable populations, immunological immaturity potentiates the severity of infections, especially when associated with inappropriate antibiotic use.[5,14]

In the findings of this study, K. pneumoniae stood out as one of the main agents isolated in ICUs, especially in cases of primary bloodstream infection (PBSI). This Gram-negative bacterium, recognized as the second leading cause of this type of infection, has a high resistance capacity due to the production of carbapenemases, enzymes capable of degrading carbapenems, limiting the available therapeutic options. Its higher occurrence among patients undergoing long periods of catheterization observed in the results is consistent with evidence linking prolonged use of invasive devices with the selection and spread of multidrug-resistant strains.[3,15]

There was also an increase in the gram-positive bacterium S. aureus, classified by the World Health Organization as a high priority for epidemiological surveillance, research, and development of new antimicrobials. In addition, there was a high incidence of fungi such as Candida albicans and non-albicans Candida, found in neonatal blood cultures and adult urine cultures. Although these fungi are commonly found in adult patients in ICUs, these infections increase the length of stay with a mortality rate ranging from 35% to 50%.[2,16]

According to Technical Standard No. 3 GVIMS/GGTES/DIRE/ANVISA, it is mandatory to separate data from hospitalized pediatric and neonatal patients, considering the diagnosis of neonatal patients when they are younger than 28 days or when they are older than 28 days but born prematurely and/or with low birth weight. In the context of the research, it was observed that the number of isolated microorganisms found in both blood cultures and urine cultures of adult patients was higher than in pediatric and neonatal patients admitted to ICUs. One possible cause could be that one of the risk factors for complications and consequent hospitalizations due to Covid-19 is age equal to or greater than 60 years.[17]

Another study conducted in Minas Gerais performed a microbiological analysis of indwelling urinary catheters and concluded that the prophylactic use of antibiotics had no influence on the growth or decrease of bacterial colonies. In addition, their inappropriate use favored bacterial resistance, and their use prior to urine cultures led to false-negative results.[18]

Extended-spectrum β-lactamase (ESBL)-producing enterobacteria are resistant to a wide range of antibiotics effective against gram-positive and gram-negative bacteria. These antimicrobials have proven increasingly ineffective in treating infections caused by *A. baumannii*, *P. aeruginosa*, and *S. maltophilia* due to the progressive increase in resistance of these pathogens related to ESBL.[19]

P. aeruginosa is a gram-negative bacterium considered epidemiologically important only when it is resistant to at least 3 of 5 antibiotics in cultures, which was not observed in the present study.

Overall, it can be observed that the increase in the quantity and profile of MR in the state of Amazonas coincided directly during the Covid-19 pandemic with the indiscriminate use of antibiotics.

This study had limitations because it was retrospective in nature and only used secondary data collected by the Amazonas Health Surveillance Foundation, which may be subject to underreporting.

It is concluded that empirical treatment with antimicrobials was used to minimize high mortality in health services during the coronavirus pandemic, but its approach lacked adequate clinical reasoning by multidisciplinary team professionals to conduct therapy only in more severe patients. Avoiding the indiscriminate use of antibiotics reduces unnecessary public and private costs and expenses, in addition to slowing down the speed of RM propagation.

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AUTHORS' CONTRIBUTIONS

Esther Pereira Abensur contributed to the literature review, writing of the abstract, introduction, methodology, discussion, interpretation and description of results, preparation of tables, conclusions, review, and statistics. **Adriany da Rocha Pimentão** contributed to project management, literature review, writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics. **Vinícius Moura de Araújo** contributed to writing the abstract, revision, and statistics. **Albe Dias Batista** contributed to the revision and organization of the sections of the article. **Eidie Souza de Queiroz** contributed to project management, fund acquisition, bibliographic research, revision, and statistics. **Maria Luiza Silva dos Santos** contributed to writing the abstract, revision, and statistics. **Pedro Eduardo Garcia de Andrade** contributed to the writing of the abstract, revision, and statistics. **Elielza Guerreiro Menezes** contributed to the writing of the abstract, methodology, conclusions, and revision. **Evelyn Cesar Campelo** contributed to project management, bibliographic research, writing of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, revision, and statistics. **Timóteo Tadashi Watanabe** contributed to project management, bibliographic research, writing the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, review, and statistics.

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