DOI: 10.17058/reci.v14i3.19041

ORIGINAL ARTICLE

Epidemiological profile of patients hospitalized for COVID-19 and diagnosed with ventilator-associated pneumonia

Perfil epidemiológico de pacientes internados por COVID-19 e diagnosticados com pneumonia associada à ventilação mecânica

Perfil epidemiológico de pacientes hospitalizados por COVID-19 y diagnosticados con neumonía asociada al ventilador

Raphaela de Matos Borges[1] ORCID 0000-0002-5679-524X
Rute Merlo Somensi[2] ORCID 0000-0002-0231-4236
Ariane Baptista Monteiro[3] ORCID 0000-0002-4667-0224
Rita Catalina Aquino Caregnato[4] ORCID 0000-0001-7929-7676

[1]*Universidade Federal de Ciências da Saúde de Porto Alegre*, Porto Alegre, Rio Grande do Sul, Brazil.
[2]*Irmandade Santa Casa de Misericórdia de Porto Alegre*, Porto Alegre, Rio Grande do Sul, Brazil.
[3]*Hospital São Lucas da Pontifícia Universidade Católica do Rio Grande do Sul*, Porto Alegre, Rio Grande do Sul, Brazil.
[4]*Universidade Federal de Ciências da Saúde de Porto Alegre*, Porto Alegre, Rio Grande do Sul, Brazil.

Address: Rua Sarmento Leite, 245 - Centro Histórico, Porto Alegre, Rio Grande do Sul, Brazil.
E-mail: raphaelamatosb@gmail.com

Submitted: 01/03/2024
Accepted: 06/13/2024

ABSTRACT

Background and Objectives: due to complications associated with Coronavirus Disease-2019 (COVID-19) infection, there was an increase in hospitalizations in intensive care and the use of mechanical ventilation and healthcare-associated infections during the pandemic period. Therefore, the objective was to understand the epidemiological profile of patients hospitalized for COVID-19 in an Intensive Care Unit (ICU) who developed ventilation-associated pneumonia (VAP). **Methods:** a retrospective cross-sectional study, with data collection from electronic medical records. It was conducted in a specific ICU for COVID-19, located in southern Brazil, between July 2020 and June 2021. Patients with COVID-19 who developed VAP were included. Patients who developed clinical VAP or who did not have all information available for access were excluded. **Results:** fifty-four patients participated in the study, predominantly male (55.6%), aged 60 years or over (38.9%) and overweight (53.7%). The most prevalent comorbidities were hypertension (63.8%) and diabetes mellitus (20.4%). Only cases of bacterial etiology were identified, with a predominance of the gram-negative *Acinetobacter baumannii* (57.4%), *Pseudomonas aeruginosa* (24.1%), *Klebsiella pneumoniae* (20.4%) and microbial resistance. The predominant clinical outcome was death. **Conclusion:** a similar pattern to that found in the literature regarding the profile of patients admitted to intensive care for COVID-19 who developed VAP was evident. Factors such as immunosuppression,

advanced age, and chronic diseases were predominant in the cases. Consistent with the literature, bacterial etiology appears to be more prevalent in VAP as well as the prevalence of gram-negative bacteria and antimicrobial resistance.

Keywords: *COVID-19*. *Intensive Care Units*. *Ventilator-Associated Pneumonia*. *Epidemiological Monitoring*.

RESUMO

Justificativa e Objetivos: devido às complicações associadas à infecção pela doença do Coronavírus-2019 (COVID-19), houve um aumento de hospitalizações em terapia intensiva e do uso de ventilação mecânica e das infecções relacionadas à assistência à saúde no período pandêmico. Diante disso, objetivou-se conhecer o perfil epidemiológico de pacientes internados por COVID-19 em uma Unidade de Terapia Intensiva (UTI) que desenvolveram pneumonia associada à ventilação mecânica (PAV). **Métodos:** estudo transversal retrospectivo, com coleta de dados do prontuário eletrônico. Realizado em uma UTI específica para COVID-19, localizada no sul do Brasil, entre julho de 2020 e junho de 2021. Incluíram-se pacientes com COVID-19 que desenvolveram PAV. Excluíram-se aqueles que desenvolveram PAV clínica ou que não apresentavam informações disponíveis para acesso. **Resultados:** participaram do estudo 54 pacientes, com predominância do sexo masculino (55,6%), faixa etária de 60 anos ou mais (38,9%) e sobrepeso (53,7%). As comorbidades mais prevalentes foram hipertensão arterial sistêmica (63,8%) e diabetes mellitus (20,4%). Identificaram-se somente casos de etiologia bacteriana, com predominância das gram-negativas *Acinetobacter baumannii* (57,4%), *Pseudomonas aeruginosa* (24,1%), *Klebsiella pneumoniae* (20,4%) e de resistência microbiana. O desfecho clínico predominante foi óbito. **Conclusão:** evidenciou-se um padrão semelhante ao encontrado na literatura relacionado ao perfil de pacientes que internaram em terapia intensiva por COVID-19 e que desenvolveram PAV. Fatores como imunossupressão, idade avançada e doenças crônicas apresentaram predominância nos casos. Condizentemente à literatura, a etiologia bacteriana mostrou-se mais prevalente em PAV, assim como a prevalência de bactérias gram-negativas e com resistência a antimicrobianos.

Descritores: *COVID-19*. *Unidade de Terapia Intensiva*. *Pneumonia Associada à Ventilação Mecânica*. *Monitoramento Epidemiológico*.

RESUMEN

Justificación y Objetivos: debido a las complicaciones asociadas a la infección por la enfermedad del Coronavirus-2019 (COVID-19), hubo un aumento en las hospitalizaciones en cuidados intensivos y el uso de ventilación mecánica y las infecciones relacionadas con la atención médica durante el período de pandemia. Por tanto, el objetivo fue comprender el perfil epidemiológico de los pacientes hospitalizados por COVID-19 en una Unidad de Cuidados Intensivos (UCI) que desarrollaron neumonía asociada al ventilador (NAV). **Métodos:** estudio transversal retrospectivo, recogiendo datos de historias clínicas electrónicas. Fue realizado en una UCI específica para COVID-19, ubicada en el sur de Brasil, entre julio de 2020 y junio de 2021. Se incluyeron pacientes con COVID-19 que desarrollaron NAV. Se excluyeron aquellos que desarrollaron NAV clínica o que no tenían información disponible para el acceso. **Resultados:** participaron del estudio 54 pacientes, predominantemente del sexo masculino (55,6%), con edad igual o superior a 60 años (38,9%) y con sobrepeso (53,7%). Las comorbilidades más prevalentes fueron la hipertensión arterial sistémica (63,8%) y la diabetes mellitus (20,4%). Sólo se identificaron casos de etiología bacteriana, con predominio de los gramnegativos *Acinetobacter baumannii* (57,4%), *Pseudomonas aeruginosa* (24,1%),

Klebsiella pneumoniae (20,4%) y resistencia microbiana. El resultado clínico predominante fue la muerte. **Conclusión:** se evidenció un patrón similar al encontrado en la literatura relacionado con el perfil de los pacientes participantes de la muestra. En los casos predominaron factores como la inmunosupresión, la edad avanzada y las enfermedades crónicas. De acuerdo con la literatura, la etiología bacteriana demostró ser más prevalente en la NAV, así como la prevalencia de bacterias gramnegativas y con resistencia a los antimicrobianos.

Palabras Clave: *COVID-19*. *Unidades de Cuidados Intensivos*. *Neumonía Asociada al Ventilador*. *Monitoreo Epidemiológico*.

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is transmitted through aerosols and droplets and can cause respiratory symptoms of varying severity. Since the beginning of 2020, when the COVID-19 pandemic was declared by the World Health Organization (WHO), several variants of the new coronavirus have been identified, with different transmission and mortality potentials. Moreover, there have been considerable numbers of cases and deaths worldwide.[1-2] After three years of pandemic, on May 5, 2023, the WHO declared the end of the Public Health Emergency of International Concern associated with COVID-19, due to the downward trend in deaths associated with the disease.[3]

Symptoms caused by coronavirus infection may require hospitalization and, in some cases, intensive care.[4] During the peaks caused by COVID-19, there was evidence of saturation of the Brazilian healthcare system associated with an increase in hospital admissions as well as Intensive Care Unit (ICU) beds.[5]

Healthcare-associated infections (HAIs) are directly associated with intensive care, due to the greater propensity of critically ill patients to develop them. During the COVID-19 pandemic, an increase in HAI rates was observed.[6] The occurrence of these infections causes numerous complications for patients, such as prolonged recovery time and, consequently, hospital stay, in addition to worsening clinical condition and death.[6-7] In intensive care, ventilator-associated pneumonia (VAP) is the most common nosocomial infection. It is associated with the use of invasive ventilatory support and is characterized when patients present pneumonia after the use of this device from the second day of intubation.[6-7] VAP has a considerable mortality rate, with more than 30% of patients dying.[7]

VAP and COVID-19 became mandatory notification conditions for the Brazilian healthcare system in 2017 and 2022, respectively.[7-8] Epidemiological notification to regional and federal agencies of diseases, such as highly transmissible respiratory infections and nosocomial infections, is of utmost importance to identify rates, patterns and outbreaks,

enabling the creation of prevention and control measures.

Given the pandemic scenario that occurred between 2020 and 2023, associated with the increase in ICU admissions and HAIs, the research question was developed: what is the epidemiological profile of patients hospitalized for COVID-19 in an ICU located in Porto Alegre, RS, who developed VAP? Based on this question, the objective was to understand the epidemiological profile of patients hospitalized for COVID-19 in an ICU who developed VAP.

METHOD

This is a retrospective cross-sectional study. This study design is indicated to assess the frequency of variables that are the objects of research investigation.[9]

The sample participants were selected intentionally and non-probably. Those admitted to an ICU in a hospital complex located in Porto Alegre, RS, which exclusively treated adult patients with COVID-19 between July 2020 and June 2021, were included.

Patients admitted to the ICU due to complications from COVID-19 and who received a microbiological diagnosis of VAP were included. Patients with a clinical diagnosis of VAP, i.e., without microbial proof, and those who did not present all the information regarding the variables collected in their medical records were excluded.

Data were collected through research in electronic medical records in the institution's management system, with the researcher's own access, and tabulated in a spreadsheet using Microsoft Excel®. The variables collected were: sex; date of birth and age at the time of admission to the ICU (in years); weight (in kilograms), height (in meters) and Body Mass Index (BMI); presence of comorbidities, such as smoking, diabetes mellitus (DM), hypertension (HT) and history or current condition of malignant neoplasia, heart, kidney, liver, lung and/or immunosuppressive disease; outcome (hospital discharge or death); length of hospital stay (days); length of ICU stay (days); readmission to the ICU after 30 days of transfer to the inpatient unit or discharge; time of invasive mechanical ventilation (IMV) (days); microorganisms identified in the sample; and whether they have microbial resistance to the main antimicrobials used in each case.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS®). Data were presented as frequencies and percentages. Quantitative variables were expressed as mean and standard deviation when symmetrical, and median and interquartile range when asymmetrical. Variables were compared using the Mann-Whitney test, with statistical significance if p-value was less than 0.05.

This study is part of a larger project entitled "*Inteligência Artificial na Sistematização*

da Assistência de Enfermagem em pacientes com Síndrome Respiratória Aguda Grave", which was approved by the Research Ethics Committee (REC) of the institution in question, via Opinion 4.694.150 and Certificate of Presentation of Ethical Consideration (*Certificado de Apresentação para Apreciação Ética*) 45203121.6.0000.5335. The researchers were included in the REC's consolidated opinion through Opinion Amendment 5.329.313. Due to the retrospective nature of the methodology, the application of an Informed Consent Form was not necessary. Therefore, a Commitment Form for Data Use was applied, signed by the researcher. The research was conducted in compliance with the ethical standards required by Resolutions 466/2012, 510/20216 and 580/2018 of the Brazilian National Health Council.

RESULTS

Regarding the sample profile, the majority were male, with a minimum age of 30 and a maximum of 89 years, with a mean of 58.8±14.5 years. The table below presents the relationship of sociodemographic characteristics, age groups and classification according to BMI of the sample.

Table 1. Relationship between sex, age groups and Body Mass Index classifications of patients hospitalized due to complications of COVID-19 and who acquired ventilator-associated pneumonia. Porto Alegre, Rio Grande do Sul, Brazil, 2020-2021

Variables	N (%)
Male	30 (55.6)
Age group	
30 to 39 years	7 (13.0)
40 to 49 years	9 (16.7)
50 to 59 years	6 (11.1)
60 to 69 years	21 (38.9)
70 to 79 years	7 (13.0)
80 years and older	4 (7.4)
Body Mass Index	
Malnutrition	2 (3.7)
Eutrophy	12 (22.2)
Overweight	29 (53.7)
Obesity	11 (20.4)

BMI values ranged from 21.1 to 44.5 points, with a mean of 30.2±5.7. Among the patients with obesity, five (9.3%) had grade I obesity, four had grade II obesity (7.4%) and two (3.7%) had grade III obesity.

Most patients had some comorbidity or risk factor (n=47, 87.0%). History of smoking or active smoking, obesity, hypertension, DM, previous or active diagnosis of malignant neoplasia and/or presence or history of cardiac, hepatic, immunological, pulmonary and renal diseases were considered as comorbidity or risk factor. Table 2 presents the relationship between comorbidities or risk factors identified in the portion of the sample that presented one

or more cases (n=47). It was decided not to present the cases of obesity in this study, as they were already presented in Table 1.

Table 2. Comorbidities or risk factors of patients hospitalized due to complications of COVID-19 and who acquired ventilator-associated pneumonia. Porto Alegre, Rio Grande do Sul, Brazil, 2020-2021

Variables	N (%)
Hypertension	30 (63.8)
Diabetes mellitus	20 (42.6)
Smoking	
Active	2 (4.3)
Former smoker	3 (6.4)
Heart disease	
Coronary artery disease	4 (8.5)
History of aneurysm	1 (2.1)
History of unspecified cardiac surgery	1 (2.1)
Congestive heart failure	2 (4.3)
Liver disease	
Hepatitis	2 (4.3)
Liver transplant recipient	1 (2.1)
Immune disease	
HIV and/or AIDS	2 (4.3)
Myasthenia gravis	1 (2.1)
Antiphospholipid syndrome	1 (2.1)
Use of immunosuppressive medication	6 (12.8)
Lung disease	
Asthma	5 (10.6)
Chronic obstructive pulmonary disease	1 (2.1)
Cystic fibrosis	1 (2.1)
History of pulmonary tuberculosis	2 (4.3)
Obstructive sleep apnea syndrome	1 (2.1)
Lung transplant recipient	1 (2.1)
Kidney disease	
Chronic kidney disease	2 (4.3)
Prior nephrectomy	1 (2.1)
Kidney transplant recipient	4 (8.5)
Malignant neoplasm	
History of malignant neoplasm	1 (2.1)
Malignant neoplasm at time of admission	4 (8.5)

Note: HIV - Human Immunodeficiency Virus; AIDS - Acquired Immunodeficiency Syndrome.

Seven patients (14.9%) had heart disease, and one (2.1%) had two concomitant diseases (coronary artery disease and history of aneurysm). Liver disease was present in three (6.4%) patients. Conditions associated with the immune system (autoimmune diseases, infectious diseases that affect immunity and/or use of immunosuppressive medication) were present in ten (21.3%) patients, and six of these were using maintenance immunosuppressive therapy to prevent rejection of the transplanted organ, as four were kidney transplant recipients, one was liver transplant recipient and one was lung transplant recipient. Concerning lung disease, ten (21.3%) had a history or current situation of this health condition, and one (2.1%) had two concomitant lung conditions (cystic fibrosis and lung transplant). Kidney conditions were present in seven (14.9%) patients. As for malignant neoplasia, five (10.6%) had a condition

already treated or under treatment at the time of hospital admission for COVID-19.

In relation to infections by microorganisms associated with VAP, 36 (66.7%) patients presented infection by a single microorganism; 16 (26.6%) presented infection by two concomitant microorganisms; and two (3.7%) presented infection by three concomitant microorganisms. Table 3 shows the relationship between the microorganisms found in the sample and the microbial resistance of each specimen.

Table 3. Relationship between microorganisms and microbial resistance rate of causative agents of ventilator-associated pneumonia in patients hospitalized due to complications of COVID-19. Porto Alegre, Rio Grande do Sul, Brazil, 2020-2021

Microorganism	n (%)
Acinetobacter baumannii	31 (57.4)
Carbapenem-resistant	31 (100*)
Citrobacter koseri	1 (1.9)
Carbapenem-resistant	-
Enterobacter cloacae	1 (1.9)
Carbapenem-resistant	1 (100*)
Enterobacter sp	2 (3.7)
Carbapenem-resistant	-
Klebsiella aerogenes	1 (1.9)
Carbapenem-resistant	1 (100*)
Klebsiella pneumoniae	11 (20.4)
Carbapenemase producers (KPC)	8 (72.7*)
Klebsiella variicola	1 (1.9)
Carbapenem-resistant	1 (100*)
Pseudomonas aeruginosa	13 (24.1)
Carbapenem-resistant	5 (38.5*)
Pseudomonas sp	1 (1.9)
Carbapenem-resistant	-
Serratia marcescens	3 (5.6)
Carbapenem-resistant	2 (66.7*)
Staphylococcus aureus	6 (11.1)
Methicillin/oxacillin-resistant	-
Stenotrophomonas maltophilia	3 (5.6)
Carbapenem-resistant	-

Notes: - Numerical data equal to zero not resulting from rounding; *Percentage of microbial resistance of the microorganism in question.

All infections were caused by bacterial pathogens, with *Staphylococcus aureu*s being the only gram-positive pathogen. All cases of carbapenem-resistant *Klebsiella pneumoniae* were *K. pneumoniae carbapenemase* (KPC), i.e., carbapenemase enzyme producers. Regarding *S. aureus*, all bacterial isolates showed sensitivity to methicillin/oxacillin.

Concerning clinical outcomes, most patients died (n=43, 79.6%). Only one (1.85%) patient was readmitted to the ICU within 30 days after discharge from the first intensive care admission. There was only one (1.9%) case of reintubation within 30 days associated with accidental extubation.

The length of hospital stay had a minimum value of 11 days and a maximum of 104 days, with a median of 33 (22;44). The length of ICU stay ranged from six to 90 days, with a

median of 29 (20;41). As for the length of IMV, the data showed a minimum time of six and a maximum of 75 days, with a median of 26 (19;40). From the comparison of these data with the clinical outcomes of discharge or death, the result shown in Table 4 was obtained.

Table 4. Relationship between clinical outcomes and variables of length of hospital stay, length of Intensive Care Unit stay, and duration of invasive mechanical ventilation of patients hospitalized due to complications of COVID-19 who acquired ventilator-associated pneumonia. Porto Alegre, Rio Grande do Sul, Brazil, 2020-2021

Variable	Death (n=43) Med (Interq)	Discharge (n=11) Med (Interq)	p-value
Length of hospital stay	25 (20;40)	45 (44;74)	<0.001†
Length of ICU stay	22 (17;40)	35 (33;59)	0.002†
Length of IMV	22 (17;38)	32 (27;52)	0.014†

Note: Med - median; Interq - interquartile range; †Mann-Whitney test.

DISCUSSION

The profile of patients admitted to the ICU due to COVID-19 and developed VAP included males, aged between 60 and 69 years, overweight, and preexisting comorbidities, with the majority dying during hospitalization. Accordingly, a review conducted in 2023 showed that advanced age, males, and the presence of preexisting comorbidities were risk factors for worsening COVID-19 infection, consistent with the findings of this study.[10]

The mean age found in the sample was 58.8 years, with more than 50% of patients being 60 years or older. Similarly, an observational study carried out in 2021 showed a mean age of 64 years in patients with COVID-19 who developed VAP.[11] The predominance of patients over 60 years of age may be associated with the immunological vulnerability found in this population, increasing susceptibility to infections and more serious complications.[10-11]

A considerable portion of the sample had a BMI equal to or greater than 30 kg/m², which, in the Ministry of Health (MoH) classification for adults (age group composed of people between 18 and 59 years old), is defined as obesity.[12] However, the MoH classification differs for people aged 60 or over, where rates in this range are not classified as obesity, but as overweight.[12] When applying this distinction to the sample, composed mainly of older adults, a predominance of overweight was observed, despite the majority having a BMI equal to or greater than 30 kg/m². The literature has identified a relationship between overweight and, especially, obesity, and an increase in severity and mortality in cases of infection by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). A meta-analysis carried out in 2020, based on 16 studies that presented a population with more than 100,000 patients with COVID-19, identified a direct relationship between BMI and the severity and mortality of the infection by the disease.[13] No studies were found that relate excess weight in patients who developed VAP after hospitalization for complications associated with COVID-19. However, from the

analysis, it can be inferred that the results found regarding BMI are consistent with those found in the literature, since patients in the sample were admitted to intensive care due to complications associated with the virus infection.

Among the comorbidities observed in the sample, there was a predominance of hypertension and DM, respectively. Hypertension is the most prevalent comorbidity in cases of severe COVID-19, linking the complications associated with SARS-CoV-2 infection to the binding of the virus to angiotensin-converting enzyme (ACE) receptors.[14] A study carried out in 2021 shows that, when using angiotensin-converting enzyme inhibitors (ACEIs), which inhibit the expression of ACE1 and promote the expression of ACE2, there is an excess of this protein in the body, allowing for an increase in susceptibility to coronavirus infection, severity and mortality from the disease.[14] In line with this study, a review carried out in 2022 addresses that hypertension, in isolation, does not present an aggravating factor in cases of COVID-19, and ceasing the use of antihypertensives from the ACE inhibitor class is not a protective factor for complications associated with SARS-CoV-2 infection, recommending maintaining the use of drug therapy in order to also avoid target organ damage associated with uncontrolled hypertension.[15]

Studies have shown an influence on the occurrence of severe cases of COVID-19 in patients with DM. Based on the literature, it can be inferred that hyperglycemia negatively influences the action of the immune system, as well as promoting a state of chronic systemic inflammation, providing greater susceptibility to the severe form of COVID-19. The influence of the binding of SARS-CoV-2 to ACE2 produced by the pancreas in severe cases of the disease in diabetic patients is also highlighted.[16]

During the course of this research, a considerable number of patients who received solid organ transplants prior to hospitalization due to COVID-19 stood out. It is inferred that this result is associated with the use of immunosuppressive medications to maintain the transplant, which causes a reduction in the immune response to antigens, such as the coronavirus. Another study presented data that are in line with the findings of research.[17] A retrospective cohort study evaluating 600 patients who underwent solid organ transplants and were diagnosed with COVID-19 revealed higher rates of hospitalization, ICU admission, and mortality in transplant patients with the disease. Patients infected with SARS-CoV-2 were compared with those who had never received organ transplants, with a predominantly older adults with other comorbidities standing out in the transplant group.[17] A systematic review that assessed the impact of COVID-19 on patients who received solid organ transplants concluded that mortality was not associated with immunosuppression, but rather with the advanced age of these

patients.[18] Therefore, there is a need for new studies to analyze the relationship between mortality from COVID-19 and immunosuppression caused by maintenance medications for late transplants. No evidence was found indicating a relationship between VAP, COVID-19, and solid organ transplant recipients.

Furthermore, the study included four patients who were undergoing oncological treatment during their hospitalization due to complications associated with the coronavirus and who developed pneumonia due to the use of IMV. This data is consistent with that found in a study that assessed the impacts of the pandemic on oncological patients, identifying a higher prevalence of nosocomial infections in these patients, with VAP being the most common in patients with COVID-19.[19] It can be inferred that, similarly to what was previously mentioned in the cases of transplant recipients, patients undergoing cancer treatment are more susceptible to infections and complications associated with them, due to the immunosuppression associated with drug therapy.[19]

Among the comorbidities, the prevalence of patients with lung diseases also stood out, totaling ten cases of history or active disease of these. Accordingly, the study identified that patients diagnosed with diseases such as asthma, chronic obstructive pulmonary disease, obstructive sleep apnea and hypopnea syndrome, emphysema and lung carcinoma presented greater complications associated with COVID-19 when compared to patients infected by the virus, but who did not present any respiratory tract comorbidity.[20] This result is associated with the nature of the disease, since COVID-19 is considered an acute respiratory infection, which can cause, in patients with previous pulmonary comorbidities, an exacerbation of the chronic condition, with worsening of respiratory function and development of serious complications, such as acute respiratory failure and acute respiratory distress syndrome.[10]

In the present study, only pathogens causing VAP of bacterial etiology were identified. Among these, a greater number of infections caused by gram-negative bacteria were observed, with the three main causes of infection being, respectively, *A. baumannii*, *P. aeruginosa* and *K. pneumoniae*. The first presented 100% microbial resistance, which is consistent with what was found in the literature. As presented by the Brazilian National Health Regulatory Agency, an increase in the rates of microbial resistance associated with *A. baumannii* strains was observed.[21] Furthermore, a literature review indicates that more than 20% of nosocomial infections in ICUs are caused by this gram-negative bacterium, which is the main causative agent of VAP, with a considerable increase in cases of infection associated with *A. baumannii* in recent years.[22] According to the findings in the study, *P. aeruginosa* and *K. pneumoniae* were also predominant in the narrative review.[23] As for gram-positive microorganisms, the only

one present in the sample was *S. aureus*. A cohort study carried out in 2023 showed that this is the most predominant gram-positive bacteria in pneumonias associated with the use of IMV, as evidenced.[24] No studies were found that presented the survey of VAP associated with one or more causative microorganisms.

The study showed that, regardless of the outcome, the median length of hospital stay was over 30 days. Concerning the length of ICU stay, the median was 29 days. In line with this, another study presented values higher than those found in this study, with a median of 39.5 days of hospital stay and 43 days of ICU stay in cases of patients admitted to the ICU due to complications from COVID-19 and diagnosed with VAP.[24] Due to the unavailability of these data, this study did not analyze the number of days on IMV until the diagnosis of VAP, but rather the total number of days on IMV until patients' outcome. Therefore, no studies were found that analyzed the total number of days on mechanical ventilation of patients with COVID-19 and VAP until the time of hospital discharge or death.

From the analysis of the associations between the variables of length of hospital stay, ICU stay and IMV and clinical outcomes, fewer days were observed in the cases of patients who died during hospitalization compared to those who were discharged from hospital. It is inferred that this result is related to the severity of sample participants, since, due to instability, patients presented worsening of their general condition and death shortly after transfer to the ICU.

Most patients died during hospitalization, due to the predominance of comorbidities, advanced age, and the absence or small number of people vaccinated against COVID-19 during the study period, as well as infection by microorganisms that cause VAP, allowing the occurrence of cases of acute respiratory failure, acute respiratory distress syndrome, sepsis, septic shock, and death. Although vaccination against COVID-19 began in the country during the study period, only a small percentage of Brazilians had received one or more doses of the vaccine, which explains the high mortality rate in the sample as well as due to the multiple comorbidities observed during the research.

Due to the researchers' choice to conduct the study in the ICU of the hospital complex that remained for the longest time with exclusive care for COVID-19 cases, the sample was smaller than expected, which proved to be a limitation of this study. It is suggested that new studies with a larger sample size be carried out. Furthermore, the present study cannot present a comparison of the morbidity and mortality of the disease caused by SARS-CoV-2 before and after the advent of vaccination in the country, due to lack of information in the electronic system, indicating the conduct of studies that present the relationship between the morbidity

and mortality linked to COVID-19, before and after the advent of vaccination in Brazil, associated with comorbidities and the multiple pathogens that cause VAP.

It is believed that the results of this research may record part of what occurred during the pandemic and support future research that assesses the relationship between complications associated with SARS-CoV-2 infection, the presence of comorbidities and VAP.

REFERENCES

1. Fundação Oswaldo Cruz (BR). Boletim Observatório Covid-19: Boletim Especial - Balanço de dois anos da pandemia Covid-19. Rio de Janeiro: FIOCRUZ; 2022. https://www.arca.fiocruz.br/handle/icict/55828.

2. Organização Pan-Americana da Saúde. OMS afirma que Covid-19 é agora caracterizada como pandemia. Brasília, DF: OPAS; 2020. https://www.paho.org/pt/news/11-3-2020-who-characterizes-covid-19-pandemic.

3. Organização Pan-Americana da Saúde. OMS declara fim da Emergência de Saúde Pública de Importância Internacional referente à Covid-19. Brasília, DF: OPAS; 2023. https://www.paho.org/pt/noticias/5-5-2023-oms-declara-fim-da-emergencia-saude-publica-importancia-internacional-referente.

4. Corrêa TD, Midega TD, Timenetsky KT, et al. Características clínicas e desfechos de pacientes com Covid-19 admitidos em unidade de terapia intensiva durante o primeiro ano de pandemia no Brasil: um estudo de coorte retrospectivo em centro único. Einstein. 2021; 19: eAO6739. https://doi.org/10.31744/einstein_journal/2021AO6739.

5. Fundação Oswaldo Cruz (BR). MonitoraCovid-19. Rio de Janeiro: FIOCRUZ; 2022. https://bigdata-covid19.icict.fiocruz.br/.

6. Blot S, Ruppé E, Harbarth S, et al. Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, prevention and contributions of new technologies. Intensive Crit Care Nurs. 2022; 70: 1-15. https://doi.org/10.1016/j.iccn.2022.103227.

7. Agência Nacional de Vigilância Sanitária (BR). Medidas de Prevenção de Infecção Relacionada à Assistência à Saúde. Brasília, DF: ANVISA; 2017. 122p. https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/caderno-4-medidas-de-prevencao-de-infeccao-relacionada-a-assistencia-a-saude.pdf.

8. Ministério da Saúde (BR). Portaria GM/MS nº 1.102, de 13 de maio de 2022. Altera o Anexo 1 do Anexo V à Portaria de Consolidação GM/MS nº 4, de 28 de setembro de 2017, para incluir o Sars-CoV-2 [...]. Diário Oficial da República Federativa do Brasil, Brasília (DF), 2022 Mai 13; Seção 1. https://bvsms.saude.gov.br/bvs/saudelegis/gm/2022/prt1102_16_05_2022.html.

9. Martins AAB, Teixeira D, Batista BG, et al. Epidemiologia. Porto Alegre: SAGAH; 2018. 284 p. ISBN: 9786556903651.

10. Zhang J, Dong X, Liu G, et al. Risk and Protective Factors for Covid-19 Morbidity,

Severity, and Mortality. Clin Rev Allergy Immunol. 2023; 64 (1): 90-107. https://doi.org/10.1007/s12016-022-08921-5.

11. Giacobbe DR, Battaglini D, Enrile EM, et al. Incidence and Prognosis of Ventilator-Associated Pneumonia in Critically Ill Patients with Covid-19: A Multicenter Study. J Clin Med. 2021; 10 (4): 555. https://doi.org/10.3390/jcm10040555.

12. Ministério da Saúde (BR). Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Cadernos de Atenção Básica, nº 38: Estratégias para o cuidado da pessoa com doença crônica - Obesidade. Brasília, DF: Ministério da Saúde; 2014. 212 p. http://189.28.128.100/dab/docs/portaldab/publicacoes/caderno_38.pdf.

13. Du Y, Lv Y, Zha W, et al. Association of body mass index (BMI) with critical Covid-19 and in-hospital mortality: A dose-response meta-analysis. Metabolism. 2020; 117: 154373. https://doi.org/10.1016/j.metabol.2020.154373.

14. Gasmi A, Peana M, Pivina L, et al. Interrelations between Covid-19 and other disorders. Clin Immunol. 2021; 224: 108651. https://doi.org/10.1016/j.clim.2020.108651.

15. Gallo G, Calvez V, Savoia C. Hypertension and Covid-19: Current Evidence and Perspectives. High Blood Press Cardiovasc Prev. 2022; 29 (2): 115-123. https://doi.org/10.1007/s40292-022-00506-9 .

16. Govender N, Khaliq OP, Moodley J, et al. Insulin resistance in Covid-19 and diabetes. Prim Care Diabetes. 2021; 15 (4): 629-634. https://doi.org/10.1016/j.pcd.2021.04.004.

17. Sahota A, Tien A, Yao J, et al. Incidence, Risk Factors, and Outcomes of Covid-19 Infection in a Large Cohort of Solid Organ Transplant Recipients. Transplantation. 2022; 106 (12): 2426-2434. https://doi.org/10.1097/TP.0000000000004371.

18. Opsomer R, Kuypers D. Covid-19 and solid organ transplantation: Finding the right balance. Transplant Rev. 2022; 36 (3): 100710. https://doi.org/10.1016/j.trre.2022.100710.

19. Cornejo-Juárez P, Volkow-Fernández P, Vázquez-Marín CL, et al. Impact of coronavirus disease 2019 (Covid-19) pandemic in hospital-acquired infections and bacterial resistance at an oncology hospital. Antimicrob Steward Healthc Epidemiol. 2023; 3 (1): e70. https://doi.org/10.1017/ash.2023.148.

20. Beltramo G, Cottenet J, Mariet A, et al. Chronic respiratory diseases are predictors of severe outcome in Covid-19 hospitalised patients: a nationwide study. Eur Respir J. 2021; 58: 2004474. https://doi.org/10.1183/13993003.04474-2020.

21. Agência Nacional de Vigilância Sanitária (BR). Microbiologia Clínica para o Controle de Infecção Relacionada à Assistência à Saúde. Brasília, DF: ANVISA; 2020 [cited 2023 Dec 28]. 162p. https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/modulo-10_manual-de-microbiologia.pdf.

22. Shadan A, Pathak A, Ma Y, et al. Deciphering the virulence factors, regulation, and immune response to Acinetobacter baumannii infection. Front Cell Infect Microbiol. 2023; 13: 1053968. https://doi.org/10.3389/fcimb.2023.1053968.

23. Boyd S, Nseir S, Rodriguez A, et al. Ventilator-associated pneumonia in critically ill patients with Covid-19 infection: a narrative review. ERJ Open Res. 2022; 8 (3): 00046. https://doi.org/10.1183/23120541.00046-2022.

24. Moreno J, Carvelli J, Lesaux A, et al. Ventilator Acquired Pneumonia in Covid-19 ICU Patients: A Retrospective Cohort Study during Pandemia in France. J Clin Med. 2023; 12 (2): 421. https://doi.org/10.3390/jcm12020421.

Authors' contributions:

Raphaela de Matos Borges contributed to project management, literature search, abstract writing, introduction, methodology, discussion, interpretation and description of results, preparation of tables, conclusions, review and statistics. **Rute Merlo Somensi** contributed to project management, abstract writing, introduction, methodology, discussion, interpretation and description of results, conclusions and review. **Ariane Baptista Monteiro** contributed to abstract writing, introduction, methodology, interpretation and description of results and review. **Rita Catalina Aquino Caregnato** contributed to project management, literature search, abstract writing, introduction, methodology, discussion, interpretation and description of results, conclusions, review and statistics.

All authors have approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.