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Severe Acute Respiratory Syndrome by COVID-19: Clinical-Epidemiological Profile and Spatial Distribution of Deaths in the States of Brazil

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Abstract

Severe Acute Respiratory Syndrome (SARS) is a severe manifestation of COVID-19 infection that, in some cases, can result in death. In the current global epidemiological scenario, Brazil is the second country with highest number of deaths from the disease; thus, it is necessary to know the clinical and epidemiological characteristics of deaths and how they are spatially distributed across territories. Therefore, the objective was to describe the clinical and epidemiological characteristics and the spatial distribution of SARS deaths due to COVID-19 in the Brazilian federative units (states). This is a descriptive and ecological study of SARS deaths due to COVID-19 in Brazilian states, from March 2020 to June 2021, based on secondary data available on the openDataSUS database. Descriptive statistics were performed for the clinical-epidemiological variables and the monthly mortality rates were determined by state and thematic maps were made in QGIS software version 2.4.17. A total of 196,109 deaths were recorded in the investigated period, predominantly male, older, white, and low-educated. Among the clinical variables, cough, respiratory distress, dyspnea, and the presence of comorbidities stood out. A heterogeneous spatial distribution of deaths was observed, with rates ranging from 0.00 to 24.59 deaths/100,000 inhabitants, the highest rates were in the states of Rio de Janeiro, Amazonas, Ceara, Sergipe, Sao Paulo, and Pernambuco. These findings raise the need for investments on the part of public management and health systems and services in the most affected states, improvements in epidemiological surveillance, permanent health education, increased access to immunization and health prevention measures to control and monitor SARS caused by COVID-19.

Keywords: SARS-CoV-2. Mortality. Spatial Analysis.

INTRODUCTION

Severe Acute Respiratory Syndrome (SARS) is one of the manifestations that may arise related to infection by the new coronavirus (Sars-CoV-2). It requires hospitalization and the affected individual has flu-like symptoms, fever, dyspnea, and decreased oxygen saturation to values less than 95%[1], which is one of the most severe clinical presentations of the COVID-19 infection as it causes deaths among patients[2,3].

In the global epidemiological context, until February 27, 2022, 6,514,397 deaths from COVID-19[4] were recorded, specifically on the American continent, around 2.8 million dea-

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ths were recorded, of which approximately 53,400 were in Central America, 1.4 million in North America and 1.3 million in South America. The South American region contains Brazil which is the country that currently has the highest accumulated number of deaths with approximately 685,000[5], and among all countries in the world it ranks second in numbers of deaths from the disease[4].

The great ability of the virus to spread and its epidemiological magnitude has attracted the attention of authorities and health professionals around the world. Furthermore, it is evident from the morbidity and mortality data that Brazil has been one of the countries most affected by the COVID-19[4]. It should also be added that the traditionally known context of great social inequality, in which many people live in precarious conditions of income, housing, sanitation, overcrowding, and great vulnerability, makes it even more complex and challenging to minimize and manage the consequences of the pandemic in Brazilian territory[6].

Moreover, the vulnerability of the population is related to three factors, which start with the individual factors, that consider the biological, emotional, cognitive, attitudinal aspects of the subject. Then there are the social factors, which deal with the cultural, social, and economic aspects that determine access to goods and services. Finally, there are the programmatic factors, which concern access to programs, services, and records[7]. The recognition of these aspects helps to identify the most vulnerable population, which characterizes an important strategy for reducing territorial inequalities and facing the COVID-19 crisis.

On the other hand, what was observed in the country was a lack of commitment and articulation on the part of the government so that health actions were carried out systematically. Therefore, isolated measures were adopted by each state and by different levels of government resulting in high rates of morbidity and mortality[8].

Furthermore, it is highlighted that several factors can influence the response of the affected individual, among them being 65 years old or more and male, where age is seen as a predisposing factor to severity and death[9]. Comorbidities seem to be more associated with cases of SARS-related deaths due to COVID-19, among them cardiovascular diseases (CVD), type II diabetes mellitus, and pneumopathies stand out[10,11]. Therefore, it is assumed that early diagnosis and offering healthcare that considers the events of comorbidities associated with SARS caused by COVID-19, can collaborate in obtaining better prognoses.

Understanding the dynamics of clinical-epidemiological aspects and the spatial distribution of an injury or disease allows us to better understand the socio-environmental conditions associated with the worst outcomes of an illness[12]. Thus, it is believed that studies that investigate these aspects collaborate to elucidate how, when, and why the event occurs, thus, making it possible to think, elaborate, and implement effective strategies that can contribute to the direction of a more adequate assistance to the patient with COVID-19-induced SARS in different territories.

A study carried out on morbidity and mortality by COVID-19 including 185 countries around the world identified that the disease was related to chronic conditions, population aging, the low capacity of health institutions for testing, and the lower availability of hospital beds, situations that worsen in countries and regions with great social disparities[13].

An ecological investigation on the incidence and mortality of COVID-19, including all the states in Brazil where 50 or more deaths were recorded up to May 25, 2020, identified

that mortality was more associated with sociodemographic aspects such as black individuals, low income, and states with worse HDI's[14]. Another space-time investigation carried out in the Northeast of the country showed that in the first year of the pandemic there were 66,358 deaths related to COVID-19 in that region, the mortality rate was 116.2/100,000 inhabitants, and the states of Bahia and Pernambuco had the highest number of deaths in the period[15]. These states, as well as the Brazilian Northeast, in general, have precarious socioeconomic indicators, a high rate of social vulnerability, and marked social disparity[15].

It should also be added that the use of geographic information systems (GIS) and spatial analysis techniques provide mapping and can point out areas of high or low risk for mortality from COVID-19, as well as demonstrate the presentation of the disease in the territory; thus, providing data to healthcare services that will collaborate in the planning and implementation of healthcare measures. Furthermore, according to Ordinance 1631/201 of the Ministry of Health[16], epidemiological studies can collaborate in the distribution of the minimum number of beds to be offered according to local realities, favoring an improved offering of services and, consequently, more effective control of the disease.

Thus, ecological studies, using these tools, should be carried out because they allow for understanding the epidemiological impact of mortality from COVID-19 in terms of clinical-epidemiological characterization and its geographic distribution in the territory[15]. In view of the above, the objective was to describe the clinical and epidemiological characteristics and the spatial distribution of SARS deaths due to COVID-19 in Brazil.

METHODS

This is a descriptive and ecological study carried out in Brazil, located in the South American continent, with an estimated population of 213,759,869 inhabitants, has 27 federative units (states) that are distributed in 5 macro-regions (North, Northeast, Midwest, South, and Southeast)[17].

The study population consisted of all SARS deaths due to COVID-19 in the period from March 22, 2020 (date of the first SARS/COVID-19 death record in the country) to June 30, 2021. The data were collected in July 2021, through extraction from the openDataSUS[18] database, linked to the Ministry of Health. Estimated population data for the states were collected from the Brazilian Institute of Geography and Statistics[19].

Clinical and epidemiological variables were selected for the study, namely: gender [male/female], age [less than 1 year, 1 to 11 years, 12 to 19 years, 20 to 39 years, 40 to 59 years, 60 to 69 years old, over 70 years old], race/Color [white, black (black and brown), yellow, indigenous], schooling [illiterate, up to 5 years of study (elementary school), up to 9 years of study (middle school), over 9 years of study (high school) and higher education], all SARS deaths due to COVID-19 in the period, presence and type of comorbidity(ies), cough, fever, dyspnea, respiratory distress, oxygen saturation less than 95%, diarrhea, vomiting, sore throat, and admission to the Intensive Care Unit (ICU). This information is contained in the individual registration form of SARS cases in the influenza epidemiological surveillance information system (SIVEP Gripe).

Initially, a descriptive analysis of the clinical-epidemiological variables was performed, expressing their absolute and relative values. Monthly COVID-19 SARS death rates were

calculated for each state. For the calculation, the total number of deaths for each month was selected and divided by the total population of each state, multiplying by the constant of 100,000. The number of inhabitants of each state was considered based on the estimated population of the IBGE[19].

In the spatial area analysis, the ecological units were the 27 states of the federation, in which the mortality rates of SARS cases due to COVID-19 were distributed monthly. The analysis period was divided into two, considering the first wave (March to October 2020) and the second wave (November 2020 to June 2021) of COVID-19 in the country. This wave classification was adopted based on data available from the Ministry of Health[20]. Maps were prepared with the distribution of mortality indicators, considering the beginning, middle, and end of the waves as well as a map with the average, which corresponds to all months within the period, at this stage the QGIS software version 2.4.17 was used.

As for ethical aspects, this research does not require approval by the Research Ethics Committee because it is a study with secondary data from the Ministry of Health, publicly available on an open access website.

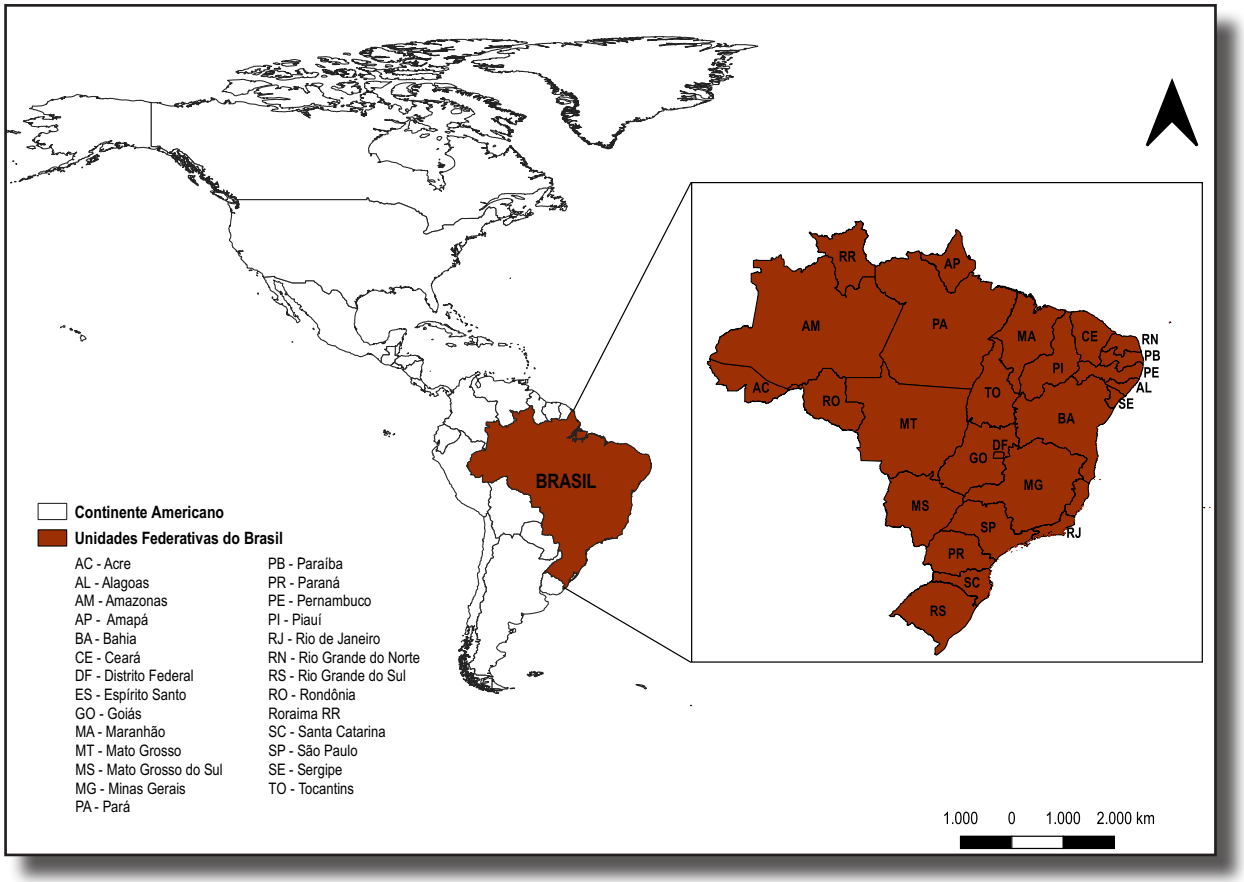

Figure 1 – American continents with emphasis on Brazil and its States.

RESULTS

In Brazil, in the period included in the study, 196,109 deaths due to SARS due to COVID-19 were recorded in all states of the federation. When evaluating the clinical-epidemiological variables, it was found that most deaths occurred in male patients (57.29%) aged above 70 years old (54.96%) and were black (42.10%). As for education, the highest percentage of deaths was among people with up to five years of study (12.94%) and the lowest among people who had studied for more than 13 years (higher education). It is noteworthy that the data regarding education and skin color had a significant lack of information, corresponding respectively to (62.37%) and (18.59%) of the sample.

The most frequent clinical characteristics were dyspnea (75.43%), cough (63.67%), and respiratory distress (62.96%), presence of one or more comorbidities (75.53%), with an emphasis on (CVD) and diabetes mellitus, and 52.81% of these patients were admitted to the Intensive Care Unit (ICU) (Table 1).

As for the spatial distribution of SARS mortality from COVID-19 during the first wave, heterogeneity was observed in the rates obtained, ranging from 0.00 to 24.59 deaths/100,000 inhabitants, the states with the lowest rates were Paraná, Bahia, Santa Catarina, and Rio Grande do Sul and those with the highest mortality rates in the period were Amazonas, Pernambuco, Sao Paulo, Ceara, Rio de Janeiro, and Sergipe. The North, Northeast, and Midwest regions had the highest mortality rates in this period, and in general, among the states, mortality rates were higher in the period comprised in the first wave. Figure 2 shows this mortality per 100,000 inhabitants in the period.

Specifically in the second wave, mortality rates showed a decrease in most states when compared to the period of the first wave. Thus, these rates also showed heterogeneous spatial distribution, with the lowest mortality rate being 0.00 and the highest 14.71 deaths/100,000 inhabitants. The states that stood out with the highest mortality rates from SARS due to COVID-19 were Manaus, Rio de Janeiro, Roraima, Santa Catarina, and Rio Grande do Sul; and those with the lowest mortality rates were Maranhão, Para, Tocantins, Ceara, and Mato Grosso. The Southeast and North regions of the country also had high mortality rates in the period (Figure 3).

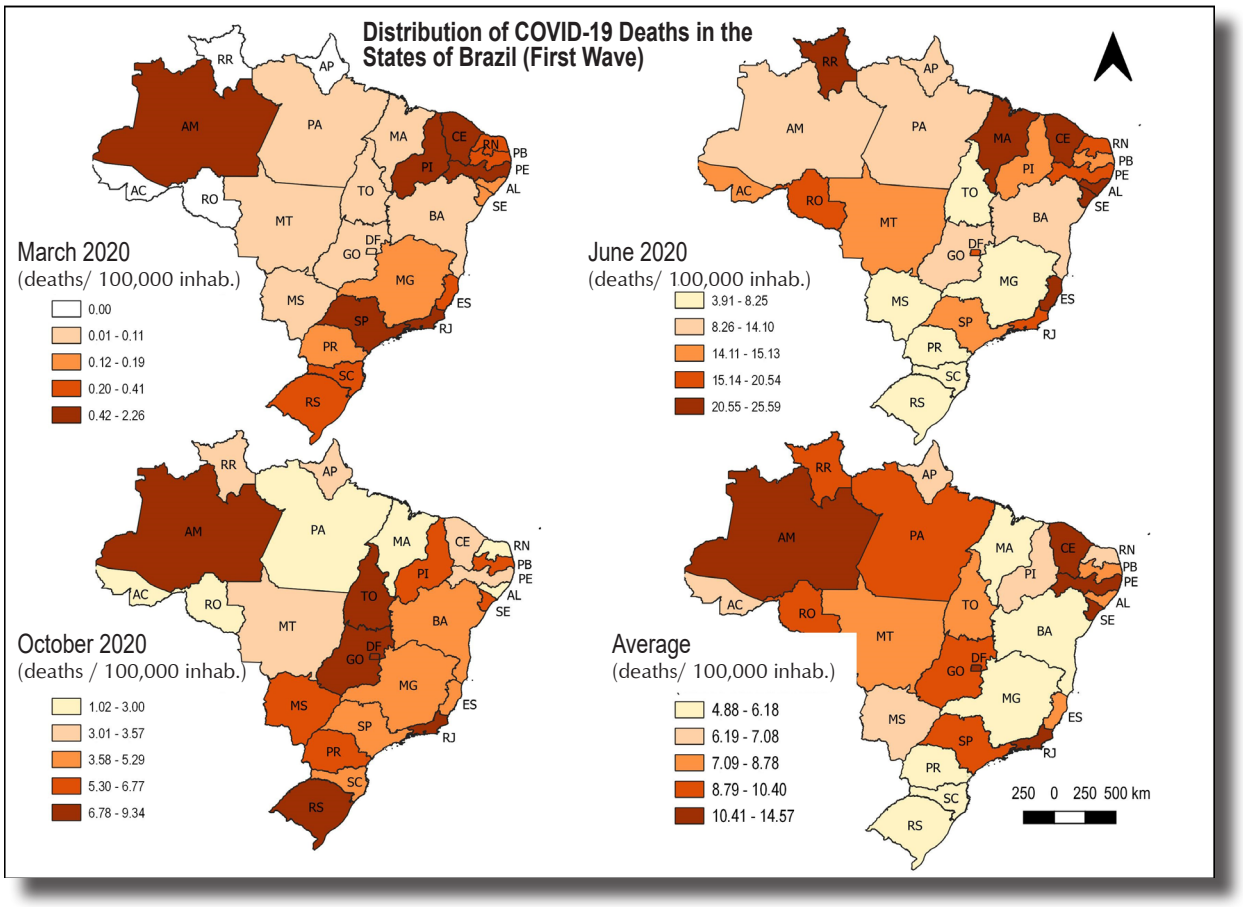

Figure 2 – Distribution of mortality from COVID-19 in the states of Brazil in the first wave.

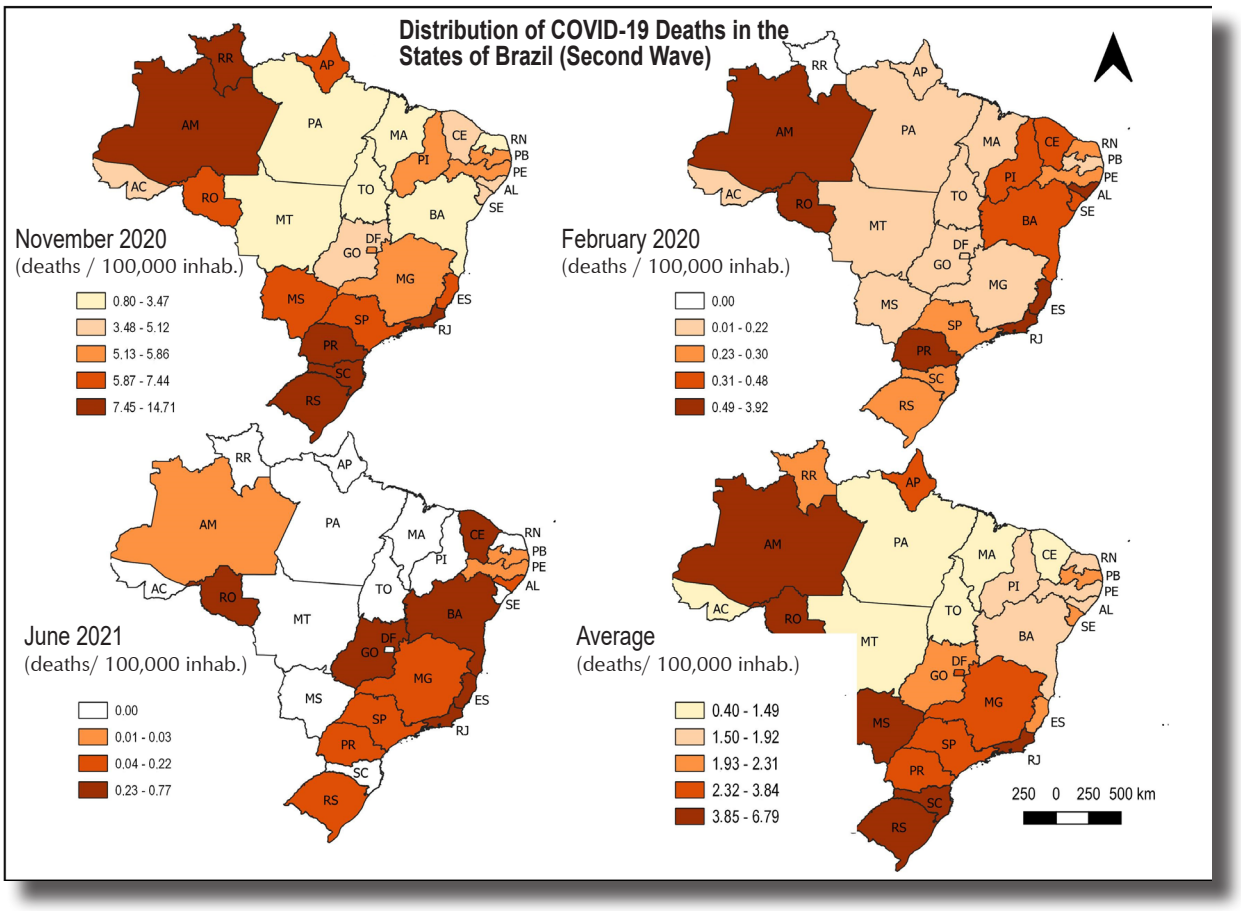

Figure 3 – Distribution of mortality from COVID-19 in the states of Brazil in the second wave.

Table 1 – Clinical-epidemiological profile of SARS deaths due to COVID-19, March 2020 to June 2021. Brazil, 2022.

Variable	N	%
Sex		
Male	112.347	57.29
Female	83.762	42.7
Age		
Less than 1 year old	70	0.03
1 to 11 years old	270	0.14
12 to 19 years old	385	0.20
20 to 39 years old	7.406	3.78
40 to 59 years old	36.330	18.53
60 to 69 years old	43.581	22.22
Over 70 years old	107.783	54.96
Not informed	284	0.14
Race / Color		
White	74.091	37.78
Black (black and brown)	82561	42.10
Yellow	2.139	1.09
Indigenous	673	0.34
Not informed	36.645	18.69
Education		
Illiterate	8.222	4.19
Up to 5 years of study (Elementary school)	25.367	12.93
Up to 9 years of study (Middle school)	14.681	7.49
Over 9 years of study (High school)	18.029	9.19
Higher education	7.505	3.83
Uninformed	122.305	62.37
Cough		
Yes	124.863	63.67
No	39.995	20.39
Not informed	31.251	15.94
Fever		
Yes	110.182	56.00
No	51.379	26.20
Not informed	34.548	17.80
Sore Throat		
Yes	27.736	13.69
No	105.445	53.77
Not informed	62.928	32.54
Dyspnea		
Yes	147.927	75.43
No	24.220	12.35
Not informed	23.962	12.22
Respiratory discomfort		
Yes	123.476	62.96
No	36.452	18.59
Not informed	36.181	18.45
Diarrhea		
Yes	20.896	10.66
No	110.757	56.48
Not informed	64.456	32.86
Vomit		
Yes	13.186	6.72
No	116.335	59.32
Not informed	66.588	33.96
O_2 Saturation < 95%		
Yes	131.024	66.81
No	31.928	16.28
Not informed	33.157	16.91
ICU admission		
Yes	103.574	52.81
No	58.860	30.01
Not informed	33.675	17.18
Presented Comorbidities		
Yes	148.129	75.53
No	47.980	24.47
Type of Comorbidity		
Cardiovascular Disease	84.001	42.83
Diabetes Mellitus	62.968	32.11
Systemic Arterial Hypertension	31.257	15.94
Obesity	15.978	8.15
Pneumopathies	13.440	6.85

DISCUSSION

Analyzing the clinical-epidemiological characteristics related to reported SARS deaths associated with COVID-19 among the Brazilian states, it was observed that males, black individuals, those aged above 70 years old, and those with the presence of comorbidities such as cardiovascular diseases and diabetes mellitus were the ones that stood out the most. Individuals with these traits deserve special attention for the adoption of control measures and clinical management of cases of the disease.

Males were the most prevalent, corresponding to 57.29% of deaths, which corroborates with studies carried out in other countries such as the USA, Spain, and Indonesia[21-23]. This same ratio of greater involvement in males was verified in other studies on mortality from COVID-19 carried out in Brazilian states[24-26]. A study carried out in the country covering the first weeks of the pandemic revealed that 60% of deaths occurred in men, despite the proportion of those infected being only 51% of cases[27].

This difference in proportion between genders can be interpreted from different perspectives, thus, possible justifications for this result are related to the production of a more effective and adaptive immune response to the virus by women, making them less prone to more severe outcomes of the disease[28]. Differences related to sex hormones are pointed out as a justification for this higher occurrence of deaths in males, considering that testosterone acts to inhibit innate immune responses, while estrogen has an immunostimulating action if it is in a low concentration[29]. In addition, the greater smoking habit among men and the higher frequency of cardiovascular and cerebrovascular diseases in this group are also factors that possibly increase mortality in this gender[27,30].

Age has been identified as one of the main primary risk factors for higher mortality, and age equal to and greater than 60 years significantly increases the chances of evolution to death[31,32]. This is justified by a decline in protective health factors, considering that the immune system is no longer as vigorous and inflammatory processes tend to be more severe[33,34]. Furthermore, in this age group, in general, there is at least one underlying chronic disease[35], which can potentiate an unfavorable prognosis of the disease.

It should be added that 44.53% of deaths occur in individuals of working age (20 to 69 years old) and that the number of deaths in this age group can be almost double in men than in women (Benavides, 2020). This difference is related to cultural and social factors, especially when considering gender issues, since in Latin American countries the role of seeking to support the family is generally attributed to men, thus, employment rates are higher among men, so there is a greater likelihood of occupational exposure to the COVID-19 contagion[36].

In this investigation, individuals with higher education were also those who had lower mortality from the disease. Several studies in different scenarios around the world also corroborate this finding, thus suggesting that people with less schooling have a higher risk of death from COVID-19[2,25,37]. This implies that the level of education contributes to the prevention and/or search for early treatment, contributing to the prevention of more serious conditions.

Corroborating with studies published both in Brazil and internationally, in relation to race/color, black individuals had higher mortality rates during the study period[38-40]. It is be-

lieved that the higher mortality among blacks is associated with socioeconomic issues such as lower income conditions and access to health[37].

It is estimated that the black population is 62% more likely to die when compared to whites, as blacks are more exposed to conditions of poverty, less availability and access to health services, and higher burden of infection and exposure to the virus. In addition, they are at greater risk of developing diabetes, hypertension, and asthma, comorbidities that worsen the condition of covid-19[41].

In this investigation, the incomplete data of the race/color variable represented 18.69% of the sample, this is often one of the fields not completed in the notification forms, making an accurate analysis of this information unfeasible. It is pointed out that when filling out this variable is completed, an increase in the proportion of black and brown deaths can be observed. There are indications that inequality also affects the quality of this information, since not filling out this socioeconomic variable occurs less frequently among the white population[42].

Therefore, the country needs to invest more in continuous health education so that health services, when making notifications, fill in this information properly. Moreover, it is important to train healthcare teams to use and respect the legislation regarding self-declaration of color, and, to collaborate in overcoming inequalities, healthcare actions aimed at the black population must also be implemented.

As for the predominant symptoms, respiratory ones such as coughing, respiratory distress, and dyspnea stood out, corroborating the findings from other countries like Italy, Indonesia, and Spain[30,43,44]. This is due to the tropism of the virus through the airways[45], the most frequent manifestation symptoms are respiratory ones, but especially among individuals who develop SARS, other more serious and severe signs and symptoms may occur.

Among the other clinical signs and laboratory alterations that may also manifest in cases of patients with SARS are coagulopathies, increased blood pressure, increased prothrombin time, increased D-dimer, C-reactive protein, and ferritin. A cohort study carried out in the United States with 1,325 patients hospitalized for COVID-19 showed that among the patients, 23% had myocardial injury and 30% had alterations with low glomerular filtration rates and target organ damage. These factors and associated preexisting diseases were predictors of lower survival[46].

Regarding comorbidities, cardiovascular diseases (CVD) and diabetes mellitus were the ones with the highest percentage of SARS mortality in this study. In individuals with CVD, the SARS-CoV-2 virus binds to the angiotensin-converting enzyme receptor 2 (ACE2) to infect the cell. Since part of the myocardial cells contains ACE2, when gaining access to cardiomyocytes the virus can cause direct cardiotoxicity[47]. Moreover, in patients with diabetes mellitus, there is a greater impairment of immunity and a higher concentration of glucose in the body, conditions that may favor greater replication of the virus[48].

The pattern observed regarding the spatial distribution of SARS deaths due to COVID-19 in the states of Brazil was heterogeneous. The three states with the average mortality rates were Rio de Janeiro, Amazonas, and Pernambuco, respectively 11.23, 10.44, and 7.23 per 100,000 inhabitants, which may indicate a greater impact of the pandemic in these states. Thus, it is considered that the territories are affected in different proportions by the disease, and the most affected areas within the states are often related to socioeconomic inequalities and the supply of healthcare services[15].

In terms of the mortality rates detected,

in 2020, the period in which the first wave is included, there was a significant increase in general mortality in different locations in Brazil[49,50]. Such findings may be attributed to the installation of the pandemic scenario and the overload that it generated for the Brazilian healthcare system[51], which required readjustments in the various healthcare sectors and in the estimations of human and financial resources needed to meet the healthcare needs imposed by such a scenario.

In the first wave, it is pointed out that the state of Ceara had a rate of 35.01 deaths/100,000 inhabitants in the month of May 2020, a result close to that indicated by the epidemiological bulletin of the state of Ceara (37.3 deaths/100,000 inhab)[52]; second only to Rio de Janeiro with a rate of 35.47 deaths/100,000 inhabitants. A study carried out in the state of Rio de Janeiro found that unequal socioeconomic conditions influenced this higher mortality, and that males, less educated, and non-white people were the most affected[25]. With regards to Ceara, it is considered that these high rates may be associated with factors such as the majority of the population being brown (62.4%), as some scholars point out that race/color as more susceptible to serious outcomes of the disease, and the average delay in receiving COVID-19 exam/test results in the state[53].

Thus, it can be considered that the strategies and measures to face the pandemic in this region were not implemented in accordance with the recommendation of the health council, in which health actions must guarantee universal and equitable access, with the capacity to include all individuals, overcoming socioeconomic inequalities[54].

The state of Sao Paulo also presented significant rates in the first wave, ranging from 8.79 to 15.49 deaths/100,000 inhabitants in the period. Phylogenetic analyses of the viral strains isolated in the country showed that the entry of the pathogen at the beginning of the pandemic occurred in Sao Paulo and Rio de Janeiro[55], which may have contributed to this increase in deaths from the disease in that first moment. It is also believed that another influencing factor may be related to the state having intense commercial activity and having several routes and connections for national and international flights.

The state of Amazonas, in this first wave, also had high mortality. In January 2021 there was a collapse in the healthcare network in the city of Manaus (capital of the state), which was widely publicized by the media, and which caused excessive mortality from COVID-19. At that time, this mortality rate was considerably higher than in other capitals[56].

In the period of the second wave, there was a significant drop in mortality rates from March 2021, a factor that was evaluated as a possible response to the immunization of the population with vaccines against COVID-19. Immunization in the country began on January 17, 2021, and with its advancement it was possible to achieve notable benefits for public health, significantly reducing severe cases and deaths[57]. A study carried out in the USA demonstrated a proven reduction in morbidity and mortality among vaccinated people, where hospital admissions decreased by 39% in the individuals aged 29-48 years old, while cases of those from 60 to 69 years old reduced by 60%, and cases of deaths also showed a decrease of 40%[58].

Regarding vaccination, it should be noted that this action promotes changes in the patterns of hospitalizations and deaths from COVID-19. However, despite its advance throughout the Brazilian territory, the number of people with a complete vaccination schedule is still low and the application of vaccines in the Brazilian states is heterogeneous, that is, there is an unequal distribution of doses. Such factors may interfere with disease control and,

consequently, with an increase in mortality rates[59].

In these months referring to the second wave, the states that stood out with higher mortality rates were Roraima, Amazonas, and Rondonia in the north of the country, and in the south Parana, Santa Catarina, and Rio Grande do Sul are highlighted with an average between 2.32 to 6.79 deaths/100,000 inhabitants in that period. The states of Maranhão and Ceara had the lowest average rates, with values of 0.40 and 1.32 deaths/100,000 inhabitants, respectively.

A study that adjusted mortality by age indicated that the standardized rates in the Amazon region were also higher when compared to other regions of the country. Despite presenting a younger population, this region, when compared to Sao Paulo and Rio de Janeiro, had more than twice the mortality rate of inhabitants over 60 years of age[60].

The North region of the country has a lower proportion of ICU beds, doctors, and mechanical ventilators, which are necessary in the treatment and care of patients with serious conditions, which can result in mortality, this support is also necessary to assist with complications and sequelae caused by disease[61]. Patients who develop SARS often require intensive care support, as many of them require mechanical ventilation. Thus, this region is more vulnerable and has more difficulty in offering an adequate response to COVID-19, which may explain why the states in this region have shown higher mortality rates.

Data from the State Department of Health of Rio Grande do Sul (SDH-RS) show that among the states in the southern region, this had the lowest number of deaths in the period between 03/16/2020 and 05/15/2021, which were 28.1% in Rio Grande do Sul, 33.8% in Santa Catarina, and 35.5% in Paraná. Rio Grande do Sul had among the lowest numbers until November 2020, after which there was accelerated growth and later a peak between February and April 2021. This excess is associated with the increase in deaths from COVID-19[62].

As for the state of Maranhão, it was found that the low mortality rates may be associated with the strategies implemented to face the pandemic. In addition to being the first state to enact a lockdown[63], healthcare centers were also expanded at primary and secondary levels and as soon as available, immunization against COVID-19 was widely encouraged to the population[64]. It should also be noted that these mortality rates due to COVID-19 may be underestimated due to underreporting. This state has death rate twice as high as the number of deaths recorded by COVID-19[65] due the ratio between the proportional number of deaths and the COVID-19 mortality rate/100,000 inhabitants.

In the case of the state of Ceara, in the northeast region of the country, there is an effective performance of epidemiological surveillance, distancing measures, and advances in immunization that collaborated to obtain lower mortality rates due to the disease[66].

With regards to the limitations of the study, we mention the source of data extraction, which was from a secondary database, and, therefore, there may be underreporting of the number of deaths from the disease, as well as the absence of some information in this database, from the non-mandatory fields to fill in on the notification forms. Also, the most ignored/unfilled fields were schooling and race/color.

It appears that this underreporting of cases/deaths and incomplete filling out of COVID-19 notifications in the country has also been reported in other studies[12,29,39,51]. This raises the need for continuing health education to alert professionals and reporting institutions to the importance and need to correctly report these data, thus, producing reliable information and notifying of cases, especially SARS.

CONCLUSION

It was observed that males, black, those aged from seventy years old, O2 saturation lower than <95%, ICU admission, and the presence of comorbidities with an emphasis on cardiovascular diseases and diabetes mellitus were the outstanding characteristics regarding the clinical-epidemiology profile of SARS deaths due to COVID-19 in Brazil. Furthermore, with the division of the period by waves, more expressive mortality rates were seen during the first wave, ranging from 0.00 to 25.59 deaths/100,000 inhabitants and in the second wave from 0.0 to 14.71/100,000 inhabitants.

As for the spatial distribution of mortality in the states of the federation, it was heterogeneous, among the states most affected in the first wave were the states of Sao Paulo, Rio de Janeiro, and Ceara, while in the second, Roraima, Amazonas, and Rondonia. It is noteworthy that the states of Maranhao and Ceara had the lowest mortality rates in the period of the second wave.

Such findings raise the need for investments on the part of public management and health systems and services in the most affected states, such as expanding access to immunization, improving vaccine logistics, access to vaccination for the most vulnerable, and carrying out an active search for defaulters, as well as the implementation of preventive measures. Furthermore, it is important to improve epidemiological surveillance, through permanent health education in reporting units and the creation of support teams to adequately feed the information systems, so that data is filled in correctly.

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