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ORIGINAL ARTICLE

Epidemiological perspective of the evolution of the COVID-19 pandemic in Amapá State, Northern Brazil

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Abstract

Introduction: COVID-19 impacted health systems worldwide; the virus quickly spread in Brazil, reaching its 27 Federative units peculiarly. The northern country region recorded the lowest number of cases and accumulated deaths from the disease. However, it is a region of sizeable territorial extension and low demographic density, marked by socioeconomic inequalities and vulnerable groups, such as indigenous tribes, riverine peoples, and quilombolas. Sociodemographic factors may contribute to the dissemination of the coronavirus in this territory; thus, studies are needed to analyze the epidemiological indicators related to the pandemic.

Objective: to evaluate incidence, mortality, and case fatality of COVID-19 trends in the state of Amapá, Brazil, from March 2020 to April 2021.

Methods: an ecological time-series study was conducted with publicly accessible data from the Health Department of the State of Amapá. Incidence and mortality rates per 100,000 inhabitants and percentage case fatality were calculated. Crude rates were calculated by municipalities, age, and sex, per month. The Prais-Winsten regression test was performed, and the trends of monthly rates were classified as increasing, decreasing, or flat.

Results: during the study period, there were 99.936 cases and 1,468 deaths accumulated by COVID-19 in the State of Amapá, Brazil. Macapá and Santana's cities, which have the highest demographic density and Human Development Index (HDI), had the highest number of cases and deaths. The most vulnerable population was elderly males aged 70 years or over; these individuals had the highest cumulative incidence, case fatality, and mortality rates. The second wave of the disease (October 2020 to April 2021) illustrated a more aggravating scenario, with increasing incidence and mortality rates.

Conclusion: the COVID-19 pandemic in the state of Amapá, Brazil, is in increasing evolution, which illustrates that non-pharmacological prevention measures and acceleration of vaccination must be strengthened to avoid the development of future waves of the disease.

Keywords: COVID-19. incidence. case fatality. mortality. Amapá.

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Authors summary

Why was this study done?
The primary motivation of this study was to monitor the temporal evolution of mortality and lethality of COVID-19 in Amapá State and describe the main risk groups

What did the researchers do and find?
The authors performed secondary temporal data analysis of incidence, mortality, and lethality on COVID-19 in the state of Amapá, from March 2020 to July 2021. The Prais-Winsten regression model was used to calculate the construction of time series. Results show that the most vulnerable population consists of elderly males aged 70 years and older.

What do these findings mean?
The pandemic of COVID-19 in the state of Amapá is increasingly evolving, the strengthening of non-pharmacological prevention measures and acceleration to vaccination must be reinforced.

INTRODUCTION

In February 2020, the Brazilian Ministry of Health, through Law 13.979, declared a state of public health emergency due to infection by the SARS-CoV-2[1]. Since then, COVID-19 cases have increased, and the country has suffered drastically from the pandemic attack[2]. By July 2021, Brazil exceeded 550.000 fatalities and has surpassed 19 million cases of COVID-19[3] .

Before the pandemic, it was speculated that Brazil was better prepared to face situations of public calamity. One of the reasons is the solid presence of the Unified Health System (SUS - Sistema Único de Saúde), which provides free access healthcare to the population, through its primary care network, through the Family Health Strategy.

Besides that, Brazil exhibited examples of well-implemented vaccination programs in the past[4] . However, the exposure sustained by Brazil since the beginning of the pandemic of COVID-19 revealed several structural and management problems in making pandemic control decisions. Several factors influenced this, including the lack of non-pharmacological measures at the beginning of the pandemic to prevent community contagion, coupled with the lack of massive tests to diagnose infected people[5] and isolate them.

There is also evidence of a lack of beds in the Intensive Care Unit to take care of patients with high severity of COVID-19, limitations to refer patients to health centers with better infrastructure[6]. Brazil is classified as an upper-middle-income country[7]. However, its vast territorial extension shows great diversity in terms of economic development; these regional differences became more evident during the COVID-19 pandemic.

The country's areas present different scenarios; the North region has been characterized as one of the territories showing significant social inequalities and poor health services[8]. Amapá is a northern Brazilian state located in the context described above. It is noteworthy that 6.1% of its population is over 15 years old, and about 50,000 people do not read or write[9] .

According to data from the National Information System on Basic Sanitation (Sistema Nacional de Informação sobre Saneamento Básico - 2019), only 38% of the population of the state capital, Macapá, has potable water supply, with the worst percentage of this indicator. There is a shortage of health workforce; for example, the number of doctors per thousand inhabitants in the state is 0.75; in comparison with the Federal District, it is 3.61, Rio de Janeiro, 3.52, and São Paulo, 2.5[10].

Under these circumstances, the pandemic of COVID-19 reached Amapá, and its first confirmed case was reported on March 20, 2020. By the end of May of the same year, the state recorded 163 cases, representing the highest infection rate in Brazil (751 per 100,000 inhabitants), followed by the already collapsed state of Amazonas, whose rate was 721 per 100.000. COVID-19 patients occupied Ninety-eight percent of the beds in the Intensive Care Unit.

The situation was so critical that patients hospitalized for suspected COVID-19 were mixed with patients with other diseases due to lack of space, increasing the risk of contagion[11]. In early August 2021, the Amapá government has registered more than 121,00 cases and 1,900 cumulative deaths from COVID-19[12]. All this complex scenario makes it necessary to monitor the indicators that determine the trends of the pandemic COVID-19 in the different regions of Brazil. Therefore, the objective of this study is to analyze the evolution of mortality, lethality, and incidence of COVID-19 in Amapá State from March 2020 to April 2021.

METHODS

Following the protocol of Abreu and Siqueira (2021)[13], a time series ecological study was conducted with information on cases and deaths of COVID-19 notified by the Department of Health of the State of Amapá, the northern region of Brazil. Inclusion criteria for the study were all cases and deaths that occurred in that state in the period from March 2020 to April 2021, which used the International Classification of Diseases, 10th edition (ICD-10), cause U07 (COVID-19, identified virus) or U07.2 (COVID 19, unidentified virus). Cases were confirmed using laboratory (molecular biology and immunology), clinical epidemiological, clinical by imaging (chest CT scan) and/ or laboratory (in asymptomatic individuals) criteria[14]. Cases were classified according to the notification date and deaths according to death; cases without this information were excluded. Data were obtained with the information available in a public access database by the Health Secretariat of the State of Amapá. The study population consisted of data on 99,936 cases and 1,468 deaths in Amapá from March 2020 to April 2021[12].

The collected data were transported to an Excel spreadsheet. Incidence rates were calculated (new cases/population) expressed as new cases per 100,000 inhabitants; mortality (deaths/population) expressed as the number of deaths per 100,000 inhabitants; and lethality (total deaths/total cases), expressed as a percentage. The estimate from the Population Projection of the Federation Units by sex and age groups: 2000-2030, was used for the calculation, considering the resident population of the state of Amapá for the year 2020, a total of 842,914 inhabitants. The resident population according to sex and age group is illustrated in the table 1[15].

The population used to calculate incidence and mortality per municipality was estimated for 2020 as described by the Brazilian Institute of Geography and Statistics[15], as illustrated in table 2.

The trends of incidence, mortality, and lethality indicators were conducted following the methods proposed by Antunes and Cardoso (2015)[17]. Prais-Winsten regression model was used to calculate the rates for building time series. This method allows the first-order autocorrelation corrections to be performed on the values, organized by time.

Table 1: Projection of resident population of Amapá State according to sex and age range.

Age Group	Total	Male	Female
0 to 19 years	330.184	165.523	164.661
20 to 29 years	160.666	81.055	79.611
30 to 39 years	131.633	65.809	65.824
40 to 49 years	99.763	50.330	49.433
50 to 59 years	64.706	34.031	30.675
60 to 69 years	35.441	18.067	17.374
70 to 79 years	14.576	7.008	7.568
80 years and over	5.945	2.494	3.451
Total	842.914	424.317	418.597

Source: Resident population of Amapá State in the year 2020, estimate 2020- 2030[15].

Table 2: Projection of the resident population in the municipalities that make up Amapá State.

Municipalities	Population
Amapá	9.187
Calçoene	11.306
Cutias	6.101
Ferreira Gomes	7.967
Itaubal	5.617
Laranjal do Jari	51.362
Macapá	512.902
Mazagão	22.053
Oiapoque	27.906
Pedra Branca do Amapari	17.067
Porto Grande	22.452
Pracuúba	5.246
Santana	123.096
Serra do Navio	5.488
Tartarugalzinho	17.769
Vitória do Jari	16.254

Source: Estimate of the resident population in the municipalities of Amapá State in the year 2020[16].

Thus, the values of the angular coefficient (β) and respective probability (p), were estimated, considering a significance level of 95% confidence interval (95% CI). The results of the log-ratios (β) of the PraisWinsten regression allowed us to estimate the Daily Percent Change (DPC), with the respective confidence intervals (CI 95%). The trends of the calculated rates were classified as increasing, decreasing, or stationary. The trend was considered stationary when the p-value was not significant, $p>0.05$.

RESULTS

A total of 99.936 cases (100.00%) and 1.468 deaths (100.00%) were found to have accumulated per COVID–19 in Amapá State from March 2020 to April 2021. The new cases and new deaths distributed per day are illustrated in figure 1. The number of cases and deaths and the accumulated gross incidence, mortality, and lethality rates according to the municipality, demographic density, and HDI are shown in table 3.

It was observed that cities with higher population density and HDI showed a high percentage of cases and deaths. Macapá presented 50.81% of cases and 75.14% of deaths by COVID-19, followed by Santana, which had 17.53% of patients and 8.38% of deaths (table 3). The cumulative number of cases and deaths from COVID-19 and the respective incidence rates (per 100,000 inhabitants), lethality (%), and mortality (per

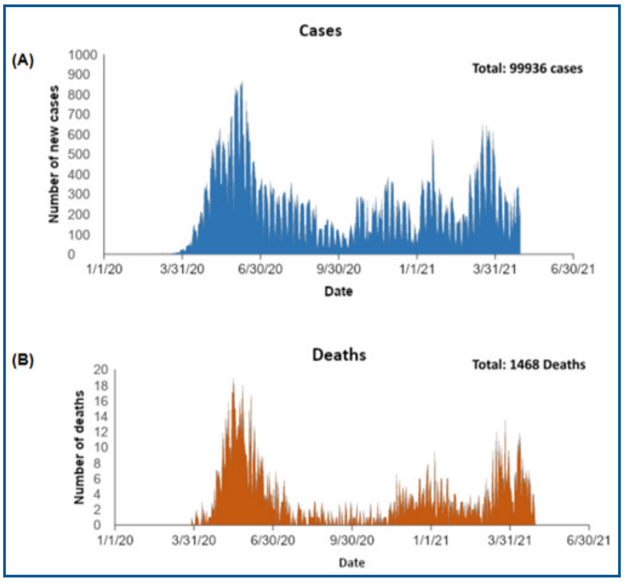

Figure 1: Number of daily cases and deaths from COVID-19 in Amapá state, from March 2020 to April 2021.
Source: Cases and deaths extracted from the Amapá State Health Secretariat[18].

Table 3: Distribution of cases, deaths, incidence, mortality, lethality, per municipality, according to demographic density and Human Development Index.

Municipality	Cases	Deaths	Incidence	Mortality	Lethality	Density	MHDI
	N (%)	N (%)	(Per 100.000 inhabitants)	(Per 100.000 inhabitants)	(%)	(Hab./ Km2)	
Amapá	1429 (1.43)	9 (0.61)	15554.59	97.96	0.63	0.88	0.642
Calcine	1598 (1.60)	10 (0.68)	14134.09	88.45	0.62	0.63	0.643
Cutias	781 (0.78)	5 (0.34)	12801.18	81.95	0.64	2.22	0.628
Ferreira Gomes	1309 (1.31)	5 (0.34)	16430.27	62.76	0.38	1.15	0.656
Itaubal	461 (0.46)	3 (0.20)	8207.23	53.41	0.65	2.50	0.576
Laranjal do Jari	7193 (7.20)	89 (6.06)	14004.52	173.28	1.24	1.29	0.665
Macapá	50779 (50.81)	1103 (75.14)	9900.33	215.05	2.17	62.14	0.733
Mazagão	2588 (2.59)	13 (0.89)	11735.36	58.95	0.50	1.30	0.592
Oiapoque	5028 (5.03)	35 (2.38)	18017.63	125.42	0.70	0.91	0.658
Pedra Branca do Amapari	2999 (3.00)	8 (0.55)	17571.92	46.87	0.27	1.13	0.626
Porto Grande	1436 (1.44)	20 (1.36)	6395.87	89.08	1.39	3.82	0.640
Pracuúba	295 (0.30)	6 (0.41)	5623.33	114.37	2.03	0.77	0.614
Santana	17521 (17.53)	123 (8.38)	14233.61	99.92	0.70	64.11	0.692
Serra do Navio	1099 (1.10)	5 (0.34)	20025.51	91.11	0.45	0.56	0.709
Tartarugalzinho	2010 (2.01)	13 (0.89)	11311.83	73.16	0.65	1.87	0.592
Vitória do Jari	3409 (3.41)	21 (1.43)	20973.30	129.20	0.62	5.01	0.619
Total	99935 (100.00)	1468 (100.00)	-	-	-	-	-

Dens.= Population density (Habitants/ Km2)[16]; MHDI = Municipal Human Development Index[16].

100,000 inhabitants) according to age group and sex were described in table 4. Among the 99812 (100.00%) cases and 1467 (100.00%) deaths by COVID-19, information regarding sex and age is presented. It was observed that in Amapá state, in the period March 2020 to April 2021, there were 54.90% (n= 54,799) female cumulative cases and 45,10% (45013 cases) in male individuals. Moreover, the highest incidence, lethality, and mortality rates were described in males' elderly (80 years or more) (table 4).

The monthly distribution of cases and deaths from COVID-19 in the state of Amapá, with the respective incidence rates (per 100.000 inhabitants), percentage lethality, and mortality (per 100.000 inhabitants) are shown in the table 5. The trend analyses of incidence, lethality, and mortality rates and their respective percentages of daily change were described in table 6.

We observed that the incidence rate per 100,000 inhabitants was increasing in both periods analyzed ($p<0.05$), with percentage lethality transitioning from decreasing during the first wave to stationary during the second wave ($p>0.05$) and increased mortality rate during the second wave ($p<0.05$) (table 6).

Table 4: Incidence rate (per 100,00 inhabitants), mortality (per 100,00 inhabitants), and lethality (%) of COVID-19 in Amapá State, by sex and age group.

Age group (years)	Cases		Deaths		Incidence (Per 100.000 inhabitants)		Mortality (Per 100.000 inhabitants)		Lethality (%)	
	M	F	M	F	M	F	M	F	M	F
0-19	6409	7736	2	6	3871.97	4698.14	1.21	3.64	0.03	0.08
20-29	8045	10633	18	20	9925.36	13356.19	22.21	25.12	0.22	0.19
30-39	10311	12983	51	26	15668.07	19723.81	77.50	39.50	0.49	0.20
40-49	8999	10994	113	62	17879.99	22240.20	224.52	125.42	1.25	0.56
50-59	5867	6759	169	78	17240.16	22034.23	496.61	254.28	2.88	1.15
60-69	3361	3590	210	122	18602.98	20663.06	1162.34	702.20	6.25	3.40
70-79	1435	1418	225	97	20476.60	18736.79	3210.62	1281.71	15.68	6.84
≥ 80										

Continuation - Table 4: Incidence rate (per 100,00 inhabitants), mortality (per 100,00 inhabitants), and lethality (%) of COVID-19 in Amapá State, by sex and age group.

Age group (years)	Cases		Deaths		Incidence (Per 100.000 inhabitants)		Mortality (Per 100.000 inhabitants)		Lethality (%)	
	M	F	M	F	M	F	M	F	M	F
586	686	167	101	23496.39	19878.30	6696.07	2926.69	28.50	14.72	
Total	45013	54799	955	512	10608.34	13091.11	225.07	122.31	2.12	0.93

Source: Cases and deaths extracted from Amapá State Health Secretariat[18], N= 99812 cases; N= 1467 deaths.

Table 5: Number of Cases, deaths, incidence rates (per 100,000 population), lethality (%) and mortality (per 100.000 inhabitants) of COVID-19 during the period March 2020 to April 2021.

Wave	Date	Cases	Deaths	Incidence (per 100.000 inhabitants)	Mortality (per 100.000 inhabitants)	Lethality (%)
1st Wave	March	107	1	12.69	0.12	0.93
	April	3731	58	442.63	6.88	1.55
	May	14238	366	1689.14	43.42	2.57
	June	16263	209	1929.38	24.79	1.29
	July	8063	73	956.56	8.66	0.91
	August	6496	39	770.66	4.63	0.60
	September	3586	24	425.43	2.85	0.67
2nd Wave	October	4165	25	494.12	2.96	0.60
	November	5725	59	679.19	7.00	1.03
	December	5406	117	641.35	13.88	2.16
	January	8049	102	954.90	12.10	1.27
	February	4732	58	561.38	6.88	1.23
	March	12373	179	1467.88	21.23	1.45
	April	7002	158	830.69	18.74	2.26

Source: Cases and deaths extracted from the Amapá State Health Secretariat[18].
First wave: March to October 2020. Second wave: November 2020 to April 2021.

Table 6: Prais-Winsten regression estimates and percent change per day (PCD) of incidence and mortality rate per 100.000 inhabitants and lethality (%) of COVID-19 in Amapá state during the first wave (March to October 2020) and second wave (November 2020 to April 2021).

Period	DPC (CI 95%) Incidence	p	Trend Incidence	DPC (CI 95%) Lethality	p	Trend Lethality	DPC (CI 95%) Mortality	P	Trend Mortality
1st Wave	2.43 (0.76: 4.12)	0.004	Crescent	-0.33 (-0.60: -0.06)	0.016	Descending	-0.35 (-0.78: 0.08)	0.113	Stationary
2nd Wave	0.34 (0.05: 0.62)	0.022	Crescent	0.14 (-0.18: 0.47)	0.383	Descending	0.49 (0.23: 0.74)	<0.001	Crescent

Source: Cases and deaths extracted from the Amapá State Health Secretariat[18].
DPC – Daily Percent Change (%); CI 95% – Confidence Interval 95%; * Statistical difference detected by Prais-Winsten Regression test, p<0.05. First wave: March to October 2020. Second wave: November 2020 to April 2021.

DISCUSSION

COVID-19 in Amapá state from March 2020 to April 2021 spread through all state municipalities, affecting 99,936 cases and 1.468 deaths accumulated by the disease. The cities with higher population density, such as Macapá and Santana, recorded the highest number of cases and deaths. The elderly males aged 70 or more presented high vulnerability for COVID-19, registering the highest incidence, lethality, and mortality rates. Moreover, there was a characteristic formation of two waves of the disease. The second wave (October 2020 to April 2021) presented a more alarming scenario, with increasing incidence and mortality rates trends. Given the global public health emergency due to the rapid increase in the number of cases of COVID-19 and the occurrence of oligosymptomatic cases of difficult identification, SARS-CoV-2 spread worldwide. The disease reached the state of Amapá in March 2020, with the first case confirmed on the 20th, in the city of Macapá, the state capital. The patient was a 36-year-old female with a history of travel to Para

State, where the patient had contact with a friend from São Paulo. Concomitantly, new cases were registered in other cities of the state[19]. Currently, the disease has impacted all cities in Amapá, with records of cases and deaths by COVID-19[18]. This study found that the cities with higher population density were the ones that presented a high percentage of cases and deaths.

The state capital, Macapá, registered 50,81% of cases and an alarming number of 75,14% of deaths from the disease, followed by Santana, which had 17,53% of cases and 8,38% of deaths. According to the scientific literature, demographic density can influence the epidemiological profile of COVID-19[20-23]. In a study that identified predictors of early until the beginning of May 2020 in municipalities in the interior of the state of São Paulo, southeastern Brazil, it was found that high population density is associated with early introduction of the disease and elevation in its incidence and mortality rates[20].

The relationship between COVID-19 and population density was also verified in counties of the United States of America (USA). Counties with higher population density had higher levels of SARS-CoV-2 transmission due to increased contact rates in these regions. Moreover, a population density limit of 22 people/km^2 was sufficient to sustain an outbreak[23].

It is noteworthy that this value is lower than that found in the current study in the Brazilian cities of Macapá (62,14 inhabitants/km^2) and Santana (64,11 inhabitants/km^2), which might be associated with maintenance of the outbreak that led to the higher number of cases and deaths observed in these cities. However, the impact of population density may vary according to the region and the pandemic period. During the period of intrusion or importation of COVID-19, the initial cases of the disease were found in places that were made up of large transportation networks and their surroundings, regions where travelers and vectors of the disease were located. These transportation centers and surrounding areas did not necessarily have the highest levels of population density. However, over time, as the virus began to spread, the most populated regions were more likely to register the highest number of cases of the disease[21,22].

However, divergent results were described by Hamidi, Sabouri, Ewing (2020) in a study that evaluated the impacts of population density on viral infection rates and COVID-19 mortality rates for 913 metropolitan counties in the USA. The authors reported that population density was not related to the infection rate due to greater adherence to social distancing guidelines in these regions. Furthermore, residing in a metropolitan area was one of the most significant predictors influencing infection rates. The authors found that when considering metropolitan population, and not only population density, it was observed that the county population density was no longer related to the infection rate. It is possible that the divergences between the studies verified in the scientific literature are associated with sociodemographic factors of each region.

According to Fortaleza *et al.,*[20] the distance between the municipalities and the State metropolitan area represented by its Capital is inversely associated with the time of introduction of COVID-19 in the region and its incidence rate. The authors reinforce the hypothesis that there are two patterns of geographical dissemination of the virus, one spatial (from the metropolitan area to the interior of the state) and the other hierarchical (from urban centers of regional relevance to the smaller and less connected municipalities).

Within this context, there is a need to consider sociodemographic variables for adequate planning and resource allocation to mitigate the impacts and dissemination of SARS-CoV-2[23]. Thus, it is possible to identify risk areas and intensify disease prevention strategies using non-pharmacological measures[20]. Social distancing represents one of the most promising means to prevent viral spread until the entire population is vaccinated.

However, the possibility of adopting this measure in practice is limited by population density and behavioral issues. Therefore, population density needs to be considered in the models used to estimate the spread of SARS-CoV-2[21,22]. It is evident that although, in theory, the most populated areas are those with greater chances of face-to-face interaction between individuals, making them more prone to viral infection, these places also have better access to health services and greater implementation of policies and practices of social distancing[24].

Thus, it is possible that the population has sought the most populous state regions, such as Macapá and Santana looking for a better health infrastructure. In the North of Brazil and the Northeast, there is great heterogeneity in the distribution of beds; new beds for COVID-19 were practically concentrated in the state capitals[24,25]. The state of Amapá had a 312.5% increase in the number of beds, but despite this expansion, this number is still low compared to other locations in the country. By the end of the first semester of 2020, Amapá had an average of 8,9 beds destined for COVID-19 patients per 100 thousand inhabitants, while Espírito Santo, Rio de Janeiro, Minas Gerais, and São Paulo, states of the southeastern region of the country, recorded higher indexes, with the respective numbers of COVID-19 beds per 100 thousand inhabitants: 18.8; 17.1; 16.7; e 15.6[25].

Amapá has six COVID-19 Care Centers that provide free assistance through Unified Health System (SUS) to patients affected by the pandemic. Among these Centers, three are located in Macapá with 80 beds, while 42 are offered by the Care Center located in Santana, followed by Laranjal do Jari (17 beds) and Oiapoque (2 beds). Overall, the state has available to care for patients with COVID-19, 129 adults, 17 pediatric clinical beds, and 146 adult and four pediatric ICU beds[11]. However, most of the beds for patients with COVID-19 are concentrated in Macapá, followed by Santana.

The current study found that the state capital had the highest notification of cases, deaths and the highest mortality and lethality rates among all municipalities. However, the incidence rates were not the highest in the region. Probably, many patients sought care in the state capital and, for fear of not being attended, they informed that they resided in this municipality. Moreover, the state capital receives patients from other cities and has a better infrastructure to care for severe disease cases.The cities of Macapá and Santana also presented the highest HDI scores of this state. It is known that HDI is an essential measure of the level of development of a municipality, for encompassing factors on income, education, and longevity conditions, but it has some limitations, such as not considering its social variations. According to the scientific literature, there are different results on the influence of HDI on the epidemiological indicators of COVID-19.

In a study that evaluated the spatial dynamics of COVID-19 and its relationship with living conditions in the state of Alagoas, northeastern Brazil, the authors highlighted that the highest incidence rates were observed in municipalities with better HDI and in those with greater social vulnerability. The high number of deaths was verified in poorer municipalities[26].

In research on the analysis of socio-spatial inequality and the impact of COVID-19 in residents of Rio de Janeiro, southeastern Brazil; it was verified that areas with higher HDI scores presented lower mortality rates when compared to areas with lower HDI[27]. However, it is known that HDI can also be related to a higher proportion of confirmed cases among the population and high lethality rates of COVID-19. In these regions, there may also be higher concentrations of individuals with comorbidities, which is what happens in countries like Italy, France, and Spain[28]. Besides Macapá and Santana, the municipality of Laranjal do Jarí stood out, presenting the second-highest mortality rate by COVID-19 with an index of 173,28 deaths per 100.000 inhabitants. It might be that its international border with French Guiana and Suriname[29], the low technological capacity, and deficiencies in healthcare staff in the southwestern region[19] contributed to the observed results.

Besides sociodemographic factors, sex and age influenced the epidemiological indicators of incidence, mortality, and lethality. During the analyzed period, most cases (n=54.799) and the highest gross incidence rate were verified in female individuals. However, male patients had the highest number of deaths (n= 955) and the highest gross mortality (255.07 deaths per 100,000 inhabitants) and lethality (2.12%) rates. Moreover, the older people, especially male individuals aged 70 years or more, were the most vulnerable to COVID-19, presenting the highest incidence, mortality, and lethality rates. It is noteworthy that the risk of contamination by COVID-19 does not differ according to sex.

However, older adults, mainly men and patients with comorbidities have a higher risk of developing severe disease and a worse prognosis[30,31]. Men also have behaviors that negatively impact their health, such as alcoholism, smoking, poor hygiene, and resistance to seek health services and adopt public health measures[8]. On the other hand, the female population has more protective health behaviors. They have greater adherence to non-pharmacological control measures, such as hand washing, that significantly reduces the risks of contamination[32].

In this sense, the higher number of cases observed in women may reflect the higher demand for health services in search of testing for the disease. Moreover, biological variations interfere in antiviral and antiinflammatory immune responses to SARS-CoV-2 among different biological sexes and age groups[28]. The impacts of COVID-19 on the population of Amapá are still uncertain; therefore, it is essential to recognize the most vulnerable groups so that prevention policies are intensified for this specific public, besides the acceleration of vaccination in the entire population.

Furthermore, analyzing temporal variations of epidemiological indicators of this disease is also essential to prevent the formation of new outbreaks and the dissemination of new variants. In the period analyzed, the formation of two waves of the disease was observed. The first wave (March to September 2020) recorded the highest cumulative incidence rate in June 2020 (1929.38 new cases per 100.000 inhabitants), with higher mortality rates (43.42 deaths per 100.000 inhabitants) and lethality (2.57%) of COVID-19, described in May of the same year. It is noteworthy that the incidence suffers limitations arising from the number of tests performed.

The increase in mortality and lethality seen in May 2020 may have contributed to an increase in testing to detect new cases observed in the following month, thus reflecting the higher incidence rate seen in this period. At the beginning of the pandemic, Amapá did not have the autonomy to perform exams for viral confirmation, so the patients' tests were sent outside the state, and the Evandro Chagas Institute Pará[18] performed the testing. This fact may have contributed to an initial delay in detecting and isolating cases, thus favoring the dissemination of SARS-CoV-2 in the region. Later, the state started to perform the virus detection tests, and measures to increase the testing capacity were adopted.

In June 2020, the State Government signed a partnership with the Oswaldo Cruz Foundation (Fiocruz), in Rio de Janeiro and the Evandro Chagas Institute (IEC), in Belém to perform mass testing and decrease the queue, which was responsible for the increased incidence observed in June 2020. In this period, Amapá stood out as one of the states that most evaluated its population; it also presented a lethality rate with lower values than the one observed in May 2020, similar to the findings of the current study, being the lowest lethality of COVID-19 among those verified in the states of the northern region of Brazil[33].

During the second wave of the disease, considering the period from October 2020 to April 2021, the month of March stood out for concentrating the highest rates of incidence (1467.88 new cases per 100,000 inhabitants), mortality (21.23 deaths per 100.000 inhabitants), and lethality (1,45%). According to the Ministry of Health, on April 3, 2021, 130,769,607 cases of COVID-19 were reported worldwide. During this period, Brazil ranked second in the world in cumulative cases (12,953,597) and deaths (330,193) due to the disease, behind only of United States. The number of cases and deaths of COVID-19 in the country were heterogeneous among the country's different regions.

It was noteworthy that the northern region reported the highest incidence of cases and deaths of the disease[34]. The peak of cases and deaths observed in March 2021 in the state of Amapá reflects the acceleration of the pandemic in the Brazilian territory. According to the epidemiological indicators analysis of COVID-19 conducted by FIOCRUZ[35], the pandemic moved to a new level, increasing the number of cases, deaths, and high permanence in the positivity of the tests. Furthermore, the country faced collapse in Health Systems, 70% of the country's Federal Units had an alert classified as critical for the occupation of hospital beds, and Amapá had an occupation rate of 100% of beds.

It is emphasized that the second wave analyzed in this study, which encompasses March 2021, presented a more aggravating profile, with incidence and mortality rates with increasing trends at the end of the analyzed period, suggesting a daily growth percentage of 0.34% and 0.49% respectively indicating that efforts are still needed to mitigate the impacts of COVID-19 in the state of Amapá. The dissemination of new SARS-CoV-2 variants in Amapá, as well as in Brazil, contributed to the scenario found.

There were found three types of coronavirus variants in viral genomic sequencing of samples from individuals from that state: P.1, P.2 (VOI), and N.9. The latter two variants are not considered an elevated risk but need attention and studies to assess their degree of transmissibility. However, the variant P1, also known as Gamma (501Y.V3), needs attention, as it has been responsible for health breakdowns in the state of Amazonas, where it was identified for the first time. Amapá identified the presence of this variant in March 2021, and it is already circulating throughout the national territory.

Currently, the country is concerned about the spread of the coronavirus delta variant, which has not yet been identified in Amapá state, Brazil, by mid-July 2021[36]. The presented scenario shows that the pandemic is not over yet and impacts Health Systems even in the most distant regions. Thus, non-pharmacological measures to control the disease, double masking and hand hygiene[35-37], must be strengthened in the entire population and maintained even after vaccination of Amapá until the spread of SARS-CoV-2 is controlled.

Studies are needed to evaluate this constantly changing pandemic scenario. Only with the development of public policies with a scientific basis can we create strategies to mitigate the impacts of the pandemic within this complex context, considering the regional variations presented in the most distinct regions of Brazil.

Limitations

The study has limitations arising from population database analysis. The data came from the Covid-19 Amapá Panel, which is subject to errors and delays in notifications. This region has technological difficulties related to internet access by municipalities in the state's interior.

CONCLUSION

There were reported 99.936 cases and 1.468 deaths by COVID-19 in Amapá State from March 2020 to April 2021. The cities with higher population density and higher HDI recorded the highest number of cases and deaths from the disease. The older males, aged 70 years or over, were the most vulnerable individuals to COVID-19. They presented higher incidence, lethality, and mortality rates. Considering the period from October 2020 to April 2021, the second wave of the disease showed a more aggravating scenario, with increasing incidence and mortality rates. For this reason, daily data are subject to revisions and updates.

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Resumo

Introdução: a COVID-19 impactou os sistemas de saúde em todo o mundo, rapidamente o vírus disseminou-se no Brasil, atingindo de modo distinto as 27 unidades Federativas do país. A região norte do Brasil registrou o menor número de casos e óbitos acumulados da doença. Entretanto, trata-se de região de grande extensão territorial e baixa densidade demográfica, marcada por desigualdades socioeconômicas, presença de população vulnerável como tribos indígenas, povos ribeirinhos e quilombolas. Os fatores sociodemográficos podem contribuir para a disseminação do coronavírus na região, assim, fazem-se necessários estudos que analisem os indicadores epidemiológicos relacionados à pandemia.

Objetivo: avaliar as tendências da incidência, mortalidade e letalidade da COVID-19 no estado do Amapá, durante o período de março de 2020 a abril de 2021.

Método: foi realizado um estudo ecológico de séries temporais, com dados de livre acesso, oriundos da Secretaria de Saúde do Estado do Amapá. Foi calculado a taxa de incidência e mortalidade por 100.000 habitantes e letalidade percentual. As taxas brutas foram calculadas por municípios, idade e sexo e por mês. Foi realizado o teste de regressão de Prais-Winsten, as tendências das taxas mensais foram classificadas em crescentes, decrescentes ou estacionárias.

Resultados: houve 99,936 casos e 1,468 óbitos acumulados por COVID-19 no Estado do Amapá durante o período estudado. As cidades de Macapá e Santana, que apresentaram densidades demográficas e Índice de Desenvolvimento Humano (IDH) mais elevados, apresentaram o maior número de casos e óbitos. A população mais vulnerável foi constituída pelos idosos do sexo masculino, com idade igual ou superior a 70 anos, estes indivíduos apresentaram as maiores taxas acumuladas de incidência, letalidade e mortalidade. A segunda onda da doença (outubro de 2020 a abril de 2021) ilustrou um cenário mais agravante, com crescentes nas taxas de incidência e mortalidade.

Conclusão: a pandemia da COVID-19 no estado do Amapá está em crescente evolução, o que ilustra que medidas de prevenção não farmacológicas e aceleração à vacinação devem ser fortalecidas para evitar o desenvolvimento de futuras ondas da doença.

Palavras-chave: COVID-19, incidência, letalidade, mortalidade, Amapá