DOI 10.18471/rbe.v35.42740 Original Article

SPACE-TIME ANALYSIS OF COVID-19 IN A BRAZILIAN STATE

ANÁLISE ESPAÇO-TEMPORAL DA COVID-19 EM UM ESTADO BRASILEIRO

ANÁLISIS ESPACIO-TIEMPO DE COVID-19 EN UN ESTADO BRASILEÑO

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How to cite this article: Almeida PD, Araújo TME, Araújo Filho ACA, Ferreira AF, Fronteira I, Melo Júnior EB, et al. Space-time analysis of COVID-19 in a Brazilian state. Rev baiana enferm. 2021;35:e42740.

Objective: to analyze the spatial-temporal distribution of COVID-19 in the state of Piauí. Method: ecological, retrospective study, with data available from the COVID-19 Epidemiological Panel - Piauí. A time series of cases and deaths accumulated monthly was constructed and incidence, mortality and lethality rates were calculated and choropleth maps were constructed using Quantum GIS, version 2.18.6. Results: in March 2020, three cases were recorded, without death, reaching September 2020 with 90,370 cases and 2,037 deaths, with a slight reduction in the growth of rates from August. Teresina presented the second lowest incidence coefficient of the state, the second highest mortality coefficient and the highest lethality. Conclusion: there was a wide growth of the pandemic in the state, especially until August 2020, with lethality within the expected, and the spatial distribution of cases and deaths concentrated in the capital and surroundings, evidencing the need for strong preventive measures.

Descriptors: Coronavirus Infections. Mortality. Incidence. Epidemiology.

Objetivo: analisar a distribuição espaço-temporal da COVID-19 no estado do Piauí. Método: estudo ecológico, retrospectivo, com dados disponíveis no Painel Epidemiológico COVID-19 – Piauí. Foi construída uma série temporal dos casos e óbitos acumulados mensalmente e calculadas as taxas de incidência, mortalidade e letalidade e construídos mapas cloropléticos utilizando-se o Quantum GIS, versão 2.18.6. Resultados: em março de 2020 foram registrados três casos, sem óbito, chegando a setembro de 2020 com 90.370 casos e 2.037 óbitos, com leve redução no crescimento das taxas a partir de agosto. Teresina apresentou o segundo menor coeficiente de incidência do estado, o segundo maior coeficiente de mortalidade e a maior letalidade. Conclusão: houve amplo crescimento da

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pandemia no estado, especialmente até o mês de agosto de 2020, com letalidade dentro do esperado, e a distribuição espacial dos casos e óbitos concentrada na capital e adjacências, evidenciando a necessidade de adoção de fortes medidas preventivas.

Descritores: Infecções por Coronavírus. Mortalidade. Incidência. Epidemiologia.

Objetivo: analizar la distribución espacial-temporal del COVID-19 en el estado de Piauí. Método: estudio ecológico y retrospectivo, con datos disponibles en el Panel Epidemiológico COVID-19 - Piauí. Se construyó una serie temporal de casos y muertes acumuladas mensualmente y se calcularon las tasas de incidencia, mortalidad y letalidad y se construyeron mapas coropléticos utilizando Quantum GIS, versión 2.18.6. Resultados: en marzo de 2020, se registraron tres casos, sin defunción, alcanzando septiembre de 2020 con 90.370 casos y 2.037 muertes, con una ligera reducción en el crecimiento de las tasas a partir de agosto. Teresina presentó el segundo coeficiente de incidencia más bajo del estado, el segundo coeficiente de mortalidad más alto y la mayor letalidad. Conclusión: hubo un amplio crecimiento de la pandemia en el estado, especialmente hasta agosto de 2020, con letalidad dentro de lo esperado, y la distribución espacial de casos y muertes concentrada en la capital y adyacencias, lo que evidencia la necesidad de fuertes medidas preventivas.

Descriptores: Infecciones por Coronavirus. Mortalidad. Incidencia. Epidemiología.

Introduction

SARS-CoV-2 is a virus that has simple tape Ribonucleic Acid (RNA) material, responsible for Coronavirus Disease-2019 (COVID-19), considered as the greatest public health challenge in the world of this century. It is an infectious disease capable of causing Severe Acute Respiratory Syndrome (SARS), with various complications and leading the individual to death. The first case was first identified in Wuhan, China, in December 2019. On March 19, 2020, despite the numerous efforts of the Chinese population, the country accumulated 81,174 confirmed cases of the disease and 3,242 deaths[1-2].

In Brazil, the first case of COVID-19 was reported on February 26, 2020, in an elderly man, living in São Paulo (SP) and coming from Italy. The disease spread rapidly throughout the country, and in less than one month, it was considered community transmission throughout the country[3].

The state of Piauí, located in Northeastern Brazil, had the first confirmed case of the disease on March 19, 2020. Until March 31 of the same year, the state accumulated 18 cases and 4 deaths caused by the new coronavirus, resulting in the lethality of approximately 22.2% and with the concentration of cases in the capital, Teresina[4].

In view of the above, it became necessary to analyze the current scenario of the disease in the State after six months of notification of the first case. Information on incidence, mortality and lethality, according to epidemiological and space-time characteristics, become fundamental to develop and direct policies and strategies to cope with the disease in a more positive way.

The present study aims to analyze the spatial-temporal distribution of COVID-19 in the state of Piauí.

Method

This is an ecological, retrospective study, with data from March (first record of the disease in Piauí) to September 2020, through data collection available from the "COVID-19 Epidemiological Panel - Piauí"[5]. The ecological study was chosen because it allows analyzing the occurrence of a given disease and exposure among populations to verify its possible association[6].

The study surveyed variables related to COVID-19 cases and deaths in the state of Piauí, accumulated per month, for the construction of the epidemic and deaths curve, and also month by month for the construction of choropleth maps, aiming to better present the evolution of the disease.

The distribution of cases and deaths was carried out by the eleven development territories

of the state of Piauí contained in its regionalization master plan. Among the 224 municipalities in the state of Piauí, the 10 with the highest number of cases were identified and cumulative incidences per 10,000 inhabitants were identified, mortality per 100,000/inhabitant, and lethality (%) of each of them. For characterization, deaths were distributed according to gender, age group and risk factors.

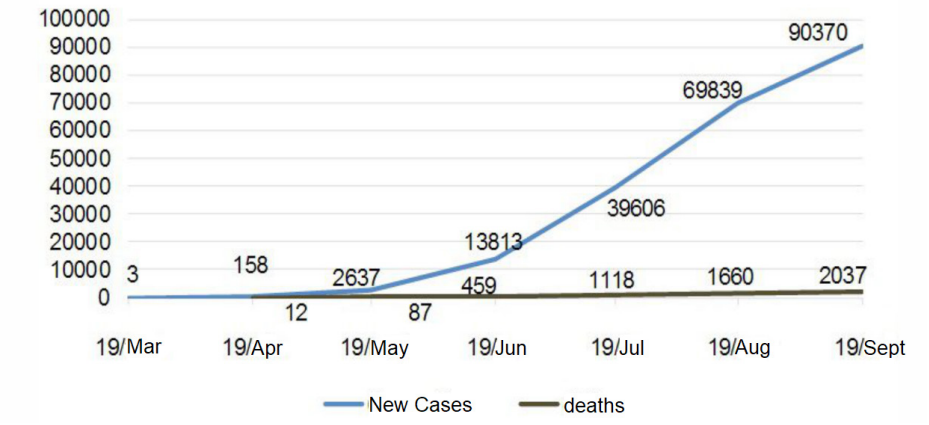
For the spatial distribution of cases and deaths, choropleth maps were constructed using Quantum GIS (QGIS), version 2.18.6. Thus, the sum of cases and deaths was organized by month and distributed by municipality of residence (n = 224, territorial division of 2013). To calculate the rates, the estimated population for 2020 was used, made available by the Department of Informatics of the Brazilian Unified Health System (DATASUS). The crude rates were calculated by dividing the cases and deaths by the estimated population, multiplying by 100,000 inhabitants. For the categorization of the spatial classes of crude rates, the method of natural breaks of the Jenks natural breaks classification algorithm was used.

The research was submitted to the Research Ethics Committee (REC), according to Resolution n. 466/12, of the National Health Council, and approved by Opinion n. 4.088.933 of the Universidade Federal do Piauí.

Results

The first notification of COVID-19 in Piauí was recorded on March 19, 2020, with 3 cases of the disease. Over six months, there was a significant increase in cases, totaling 90,370 cases on September 19, 2020. On April 19 of that year, there were already 12 deaths in the state, accounting for 2,037 deaths from COVID-19 in September 2020 (Figure 1).

Figure 1 – Cases and deaths accumulated after the first notification of COVID in the state of Piauí. Teresina, Piauí, Brazil – Mar. 19 2020- Sept. 23 2020



Source: SESAPI Epidemiological Panel [5].

From March 19 to September 23, 2020, 92,801 cases of COVID-19 were reported in Piauí. Among the 11 development territories of the state, the highest frequencies of cases and deaths occurred in the development territory Entre Rios (Table 1).

Table 1 – Distribution of COVID-19 cases and deaths per development territory of the state of Piauí. Teresina, Piauí, Brazil – 2020. (N = 92,081) (continued)

Development Territories	Cases		Deaths	
	n=92,801	%	n=2073	%
Entre Rios	41752	44.99	1196	57.69
Cocais	12666	13.65	231	11.14

Table 1 – Distribution of COVID-19 cases and deaths per development territory of the state of Piauí. Teresina, Piauí, Brazil – 2020. (N = 92,081)

(conclusion)

Development Territories	Cases		Deaths	
	n=92,801	%	n=2073	%
Planície Litorânea	9560	10.30	203	9.79
Vale do Rio Guaribas	6876	7.41	113	5.45
Tabuleiros do Alto Parnaíba	4256	4.59	48	2.32
Carnaubais	3987	4.30	75	3.62
Chapada das Mangabeiras	3325	3.58	60	2.89
Vale dos Rios Piauí and Itaueiras	3300	3.56	55	2.65
Vale do Canindé	2900	3.12	37	1.78
Serra da Capivara	2500	2.69	24	1.16
Vale do Sambito	1679	1.81	31	1.50

Source: Created by the authors.

Table 2 shows the ranking of the ten municipalities with the highest number of cases. The capital, Teresina, presented the highest number of cases (30,795) and deaths (989) and the highest lethality rate (3.21%). However, in relation to the incidence coefficient among the ten municipalities, Uruçuí presented the highest (739.86/10,000 inhabitants). As for the mortality coefficient, Barras had the highest (114.73/100,000 inhabitants).

Table 2 – COVID-19 epidemiological characterization in the municipalities with the highest number of cases in the state of Piauí. Teresina, Piauí, Brazil – Sept. 23, 2020. (N = 92,081)

Municipalities	Cases		Deaths		
	n	Incidence Coefficient*	n	Mortality Coefficient**	% lethality
Teresina	30795	356.08	989	114.36	3.21
Parnaíba	6673	435.92	135	88.19	2.02
Picos	3218	411.39	66	84.38	2.05
Barras	2551	542.00	54	114.73	2.12
Floriano	2493	415.95	35	58.40	1.40
Campo Maior	2295	490.04	43	91.82	1.87
Piripiri	2285	358.48	36	56.48	1.58
Uruçuí	1595	739.86	22	102.05	1.38
Luzilândia	1573	617.20	27	105.94	1.72
Altos	1436	354.36	23	56.76	1.60

Source: SESAPI Epidemiological Panel [5].

Notes:
*Incidence per 10.000 Inhab.

**Mortality per 100.000 Inhab.

Regarding the epidemiological characteristics of deaths from COVID-19 in the state of Piauí, the following prevalences stood out: female gender (57.6%), age group 80 years or more (32.66%), heart diseases, including hypertension as a risk factor (43.63%), followed by diabetes (25.4%) (Table 3).

Table 3 – Distribution of deaths from COVID-19 according to sex, age group and comorbidities in the state of Piauí. Teresina, Piauí, Brazil – Sept 23 2020. (N = 2,073)

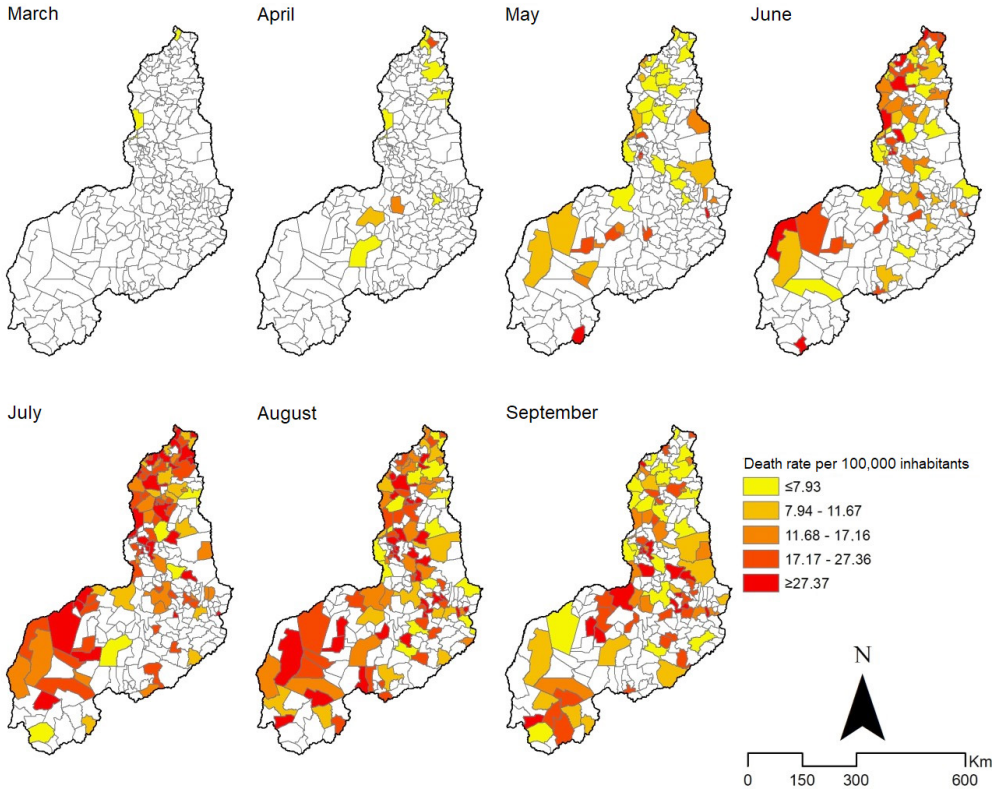
Variables	n	%
Sex		
Female	1195	57.6
Male	878	42.4
Age group (years)		
0 - 9	4	0.19
10 - 19	8	0.39
20 - 29	25	1.21
30 - 39	62	2.99
40 - 49	137	6.61
50 - 59	224	10.81
60 - 69	392	18.91
70 - 79	544	26.24
80 or more	677	32.66
Risk factors /comorbidity among the deaths*		
Heart diseases including hypertension	904	43.63
Diabetes	526	25.4
No comorbidity	129	6.21
Chronic neurological or neuromuscular disease	117	5.63
Lung disease	98	4.73
Kidney disease	98	4.73
Obesity	75	3.61
Neoplasm	62	2.98
Immunodepression	24	1.15
Liver disease	20	0.99
Asthma	14	0.67
Down Syndrome	3	0.13
Blood disease	2	0.11
Puerperal woman	1	0.03

Source: SESAPI Epidemiological Panel [5].

Note:
*Due to the access to the frequency only, there was as approximation to define the absolute number.

From March to the last day of September 2020, there were 2,127 deaths. The death rate showed a spread of the epidemic in the municipalities. The expansion began in the capital, moving towards the municipalities of the countryside. From June 2020, the state had a mortality rate of over 27 deaths per 100,000 inhabitants.

Figure 2 – Maps with the distribution of death rate per municipality according to the occurrence month. Teresina, Piauí, Brazil – 2020



Source: SESAPI Epidemiological Panel [5].

Discussion

In the period analyzed, the city of Teresina accumulated the highest absolute number of cases and deaths from COVID-19, as well as the highest lethality among the municipalities investigated and higher than in Brazil (3.-0%), according to data from the Coronavirus Panel of the Ministry of Health[7]. A Chinese study, with 44,672 confirmed cases, presented lethality of 2.3%, that is, lower than that recorded in Teresina[8].

A study that compared the lethality of reported cases of infection by the new coronavirus, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS-CoV), found that the lethality rate of COVID-19 is close to 3%, and does not appear to be as lethal as the other two. However, the total number of cases and deaths from COVID-19 is already much higher than SARS and MERS-CoV[9].

A study conducted in Piauí identified that the territory Entre Rios has 65% (149) of the intensive care unit (ICU) beds, and has the capital, Teresina, as the main city for the high complexity care of the territory. This research pointed out that the cited territory, even with the highest number of ICU, presented the highest number of COVID-19 deaths and cases. This can be explained by Teresina concentrating most cases, due to its capital characteristics, such as population quantity, access by highways and airport[4].

The lethality analyzed in this study by city and the mortality coefficient, by territory, present relevant differences depending on space, as evidenced in an ecological study on the variations in lethality by COVID-19 in Brazilian states, involving all deaths from COVID-19 per Federative Unit and Epidemiological Week. Therefore, this finding may be related to social, structural and economic inequalities and health

inequities, present in society, requiring policies directed to the characteristics of each location[10].

Moreover, the information regarding the number of deaths may be influenced by underreporting, which occur due to numerous factors, such as correct testing according to the time of presentation of symptoms and the appropriate test for each person, in addition to several other intrinsic factors of this new disease.

Also in relation to deaths from COVID-19, the female gender was predominant, a fact that differs from an international study[11], conducted in 169 hospitals in 11 countries, in which the findings suggest that women are more likely to survive the infection, due to innate and adaptive immunity, related to the X chromosome and sex hormones, which makes women stronger and more resistance to viral infections compared to men[11-12].

Advanced age (over 60 years) is a risk factor for mortality from COVID-19[12], which corroborates the findings of this study. On the other hand, children aged 0 to 9 years contributed with the lower frequency of cases, which is consistent with the reality of many other states and countries. Children have lower susceptibility to COVID-19 infection, due to multiple factors, such as the reduced cycle of friendships, not having labor activities, not attending school, not going shopping, determining a restricted social coexistence. The fact that children are considered potential candidates for infection has placed them in a situation of strong social distancing, even limiting contact with family members belonging to risk groups[13].

In this study, the most prevalent comorbidities among deaths due to COVID-19 were heart diseases (including hypertension), followed by diabetes. These findings corroborate a study conducted in the United States[14] and common to a meta-analysis[15], in which hypertension and diabetes were the most prevalent comorbidities among deaths from COVID-19.

Pre-existing conditions such as cardiovascular diseases, chronic kidney disease, chronic lung diseases (especially Chronic Obstructive Pulmonary Disease (COPD), Diabetes Mellitus, hypertension, immunosuppression, obesity and sickle cell disease are pointed out as factors that predispose individuals to an unfavorable clinical prognosis, as well as increase the risk of intubation and death[16].

A study conducted with 1,590 patients in China showed greater severity of COVID-19 in patients who have risk factors compared to those who do not. Moreover, it found that patients with two or more comorbidities presented a risk of poor prognosis, significantly higher than those who did not have or had only one comorbidity[17]. It is important to consider that these conditions and their susceptibility characteristics may be related to the pathogenesis of COVID-19[18].

There was a variation in the mortality rate in each month in the municipalities of Piauí, because a city that, at the beginning of the pandemic had high mortality rates, had this rate reduced in subsequent months, as well as the opposite was also identified. In March 2020, deaths were recorded only in Teresina and Parnaíba, but, with the internalization of the disease, there was an increase in deaths in other cities. A study conducted in Ceará observed a similar finding, with the arrival of COVID-19 in the most distant municipalities of the metropolises, requiring distributing intensive care beds for patients with the disease[19].

It is inferred that the high death rates in certain cities reveal the deficient situation of the health system to assist the growing demand of patients with COVID-19 in some municipalities. Therefore, measures are necessary to reduce the spread of the disease, expand available beds and organize health services in a regionalized way in the state, in order to reduce the distance traveled by the patient to reach the health service[20].

The main limitation of this study is the approach by using secondary data available from the Health Departments, which may present information bias, and for not allowing defining the behavior of the disease in the coming months. Studies working with spatial analysis of recovered patients may contribute to analyze the evolution of the disease in the state of Piauí.

Conclusion

The study allowed analyzing the situation of the disease by development territories and the random distribution of deaths in the municipalities of the state. A rapid and wide rise in the pandemic was observed, especially until August 2020, with lethality within the expected. The pattern of spatial distribution of cases and, especially, of deaths presented concentration in the capital and adjacencies, evidencing the need for strong preventive measures in this development territory.

There was prevalence of mortality in the elderly population, females and patients with heart disease, including hypertension. Relating epidemiological characteristics with deaths caused by COVID-19 in the state is essential to evaluate disease control measures, as well as the care applied thus far. It also allows defining new strategies, protocols and behaviors before those patients, aiming to reduce the symptoms of the disease, complications and deaths.

Plans considering the social, cultural and economic characteristics of the different development territories should be made, with the objective of reducing the impact of the pandemic and increasing the effectiveness of control actions.

Funding:

This research was funded by JBS through the "Doing Good Does Good: social impact during the pandemic" project.

Collaborations:

1 – conception, design, analysis and interpretation of data: Priscilla Dantas Almeida, Telma Maria Evangelista de Araújo, Augusto Cezar Antunes de Araújo Filho, Anderson Fuentes Ferreira, Eugênio Barbosa de Melo Júnior and Malena Gonçalves Almeida;

2 – writing of the article and relevant critical review of the intellectual content: Priscilla Dantas Almeida, Telma Maria Evangelista de Araújo, Augusto Cezar Antunes de Araújo Filho, Eugênio Barbosa de Melo Júnior and Malena Gonçalves Almeida;

3 – final approval of the version to be published: Priscilla Dantas Almeida, Telma Maria Evangelista de Araújo, Augusto Cezar Antunes de Araújo Filho and Inês Fronteira.

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Received: December 11, 2020

Approved: May 18, 2021

Published: June 8, 2021