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COVID -19 spatial distribution in the state of Paraíba: an association with demographic density

COVID -19 distribución espacial en el estado de Paraíba: una asociación con densidad demográfica
Distribuição espacial da COVID-19 no estado da Paraíba: uma associação com a densidade demográfica

ABSTRACT
Objective: To analyze and describe the spatial distribution of epidemiological data from COVID-19 cases in the state of Paraíba. Method: A descriptive ecological study was carried out, based on information from COVID-19 in Paraíba, with open access from the State Health Secretariat's dashboard, using confirmed case and death data. After analyzing the data obtained, they were transformed into rates, in order to compare them with the demographic density of the studied region. Results: Among the 223 municipalities in the State of Paraíba, those with a higher demographic density led the COVID-19 morbidity, incidence and lethality rates in the State, during the period studied. Conclusion: It was possible to observe the contribution of large cities as a source of the spread of the disease, due to its high demographic density, thus reaffirming the need and importance of preventive public health measures to be adopted, in order to guarantee a low level of spread of the virus.
DESCRIPTORS: Coronavirus Infections; Population Density; Epidemiology Descriptive.

RESUMEN
Objetivo: Analizar y describir la distribución espacial de datos epidemiológicos de casos de COVID-19 en el estado de Paraíba. Método: Se realizó un estudio ecológico descriptivo, con base en información del COVID-19 en Paraíba, con acceso abierto desde el tablero de la Secretaría de Salud del estado, utilizando datos de casos confirmados y defunciones. Luego de analizar los datos obtenidos, se transformaron en tasas, con el fin de compararlas con la densidad demográfica de la región estudiada. Resultados: Entre los 223 municipios del estado de Paraíba, los de mayor densidad demográfica lideraron las tasas de morbilidad, incidencia y letalidad del COVID-19 en el estado, durante el período estudiado. Conclusión: se pudo observar el aporte de las grandes ciudades como foco de propagación de la enfermedad, debido a su alta densidad demográfica, reafirmando así la necesidad e importancia de adoptar medidas preventivas de salud pública, a fin de garantizar un bajo nivel de propagación del virus.
DESCRIPTORES: Infecciones por Coronavirus; Densidad de Población; Epidemiología descriptiva.

RESUMO
Objetivo: Analisar e descrever a distribuição espacial dos dados epidemiológicos dos casos da COVID-19 no Estado da Paraíba. Método: Foi realizado um estudo ecológico descritivo, com base nas informações da COVID-19 na Paraíba, de acesso aberto do dashboard da Secretaria Estadual de Saúde, através dos dados de casos e óbitos confirmados. Após análise dos dados obtidos, foram transformados em taxas, a fim de compará-las com a densidade demográfica da região estudada. Resultados: Dentre os 223 municípios do Estado da Paraíba, aqueles com uma maior densidade demográfica lideraram as taxas de morbidade, incidência e letalidade da COVID-19 no Estado, durante o período estudado. Conclusão: Pôde-se observar a contribuição das grandes cidades como fonte de propagação da doença, por sua alta densidade demográfica, reafirmando assim, a necessidade e a importância das medidas preventivas de saúde pública a serem adotadas, a fim de garantir um baixo nível de disseminação do vírus.
DESCRITORES: Infecções por Coronavírus; Densidade Demográfica; Epidemiologia descritiva.

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INTRODUCTION

Coronavirus comes from a family of viruses that cause respiratory infections. The new coronavirus agent, which causes the disease CO-VID-19, was discovered on December 31st, 2019 after cases reported in Wuhan, China. [1]

COVID-19 is a disease caused by the SARS-CoV-2 coronavirus, its transmission occurs from close contact between an infected person and another, through droplets of saliva, handshake, sneeze, cough, secretions and through contaminated objects or surfaces. Symptoms can range from a simple cold to severe pneumonia, the most common of which are cough, sore throat, fever, runny nose and difficulty breathing. [1]

In Brazil, the first case of CO-VID-19 was confirmed almost two months after the first case registered in the world, occurring on February 26th, 2020. The first confirmed death occurred only on March 17th, 2020. After this first case, data already pointed to the trend that the disease would take on large proportions quickly. Just a month later, there was already community broadcasting in some cities in the country. With the State of São Paulo leading the number of cases in Brazil, in March 2020 the community transmission of COVID-19 was recognized throughout the national territory. [2]

The State of Paraíba, located in northeastern Brazil, had the first confirmed case of COVID-19 only on March 21st, 2020. He was a 60-year-old man, resident of the capital, João Pessoa/PB, with a report of a recent trip to Europe. The patient was seen in a private hospital and was in isolation during his treatment. [3]

The methodology of spatial analysis in public health is used, mainly to evaluate and monitor the environment to be applied to the planning and evaluation of health services. In the current situation of a pandemic, spatial analysis is an important tool, as it allows the identification of areas with the greatest spread of diseases, consequently of greater risk, which allows better targeting of public health policies. [4]

There are still no published records of analysis and description of the cases of COVID-19 in the State of Paraíba according to the Population Density (PD), thus, understanding the spatial distribution of these cases is essential to develop better public policies in the early stages of outbreaks of COVID-19.

The aim of this study was to analyze and describe the spatial distribution of epidemiological data from COVID-19 cases in the State of Paraíba.

METHOD

A descriptive ecological study was carried out, based on the epidemiological information from COVID-19 in the State of Paraíba. All data on confirmed open access SARS-CoV-2 cases and deaths from the Paraíba State Department of Health dashboard were used. The inclusion criterion was the use of data from the seven largest cities in the State of Paraíba, the capital João Pessoa/PB, preceded by Campina Grande/PB, Guarabira/PB, Cabedelo/PB, Santa Rita/PB, Patos/PB and Mamanguape/PB.

The State of Paraíba has a population of approximately 4.018.127 million inhabitants, divided among the 223 municipalities, according to the 2019 estimate of the Brazilian Institute of Geography and Statistics (IBGE), in an area of 56.467.242 km2, being the 13th most population in Brazilian territory.

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Paraíba has a PD of 66,7 inhabitants per km2. Also called Relative Population, PD takes into account the population distribution in certain areas, allowing the identification of the most and least occupied territories. Northeast Brazil has the highest density among the regions in the country, among the states in this region Paraíba occupies the fourth place in the country. [5]

The study population included all cases - accumulated and new, and the confirmed deaths of COVID-19 in the municipalities of Paraíba, between March 21st, date of the first confirmed case, and July 1st, 2020.

The variables analyzed were the number of confirmed cases and the number of deaths. The research was carried out with data recorded in the period from March 21, the day of the first confirmed case in the State, on July 1, 2020, extracted from the Coronavirus Panel of the State of Paraíba, which presents online monitoring of the cases of the disease in the country, reporting the occurrence of accumulated cases, new cases and deaths by region, municipality, epidemiological day and week.

In order to compose the results obtained, from the absolute number of accumulated cases, new cases and deaths confirmed by COVID-19, incidence rates (IR), morbidity (MR), and lethality (LR) were calculated. These were processed using the Excel for Windows 365 program. After analyzing the data obtained through the rates, a comparison of these results was made with the DM of the studied region.

A spatial analysis was also performed, through the geoprocessing of images were extracted from the Laboratory of Statistics Applied to Image Processing and Geoprocessing (Laboratório de Estatísticas Aplicada ao Processamento de Imagens e Geoprocessamento - LEAPIG) of the Federal University of Paraíba (UFPB).

It was not necessary to submit the study for approval by the Research Ethics Committee, as the data are in the public domain.

RESULTS

Confirmed Cases

In the territorial extension of the State of Paraíba, there are 223 municipalities, of which 218, until July 1st, 2020 presented confirmed cases for COVID-19. A certain proportionality was observed between the municipalities of Paraíba that have a higher PD, with a higher rate of cases confirmed by COVID-19 in the period studied, that is, the cities of João Pessoa/PB, Campina Grande/PB, Guarabira/PB, Cabedelo/PB, Santa Rita/PB, Patos/PB and Mamanguape/PB. From the date of confirmation of the first case until the period proposed for this study, more than 48 thousand cases of the disease were registered in the State, which came to represent a MR of 1,1%, that is, a higher mark of more than 1.190 cases of COVID-19, for every 100 thousand inhabitants in the State of Paraíba[5], which can be seen in Table 1 below.

It can also be seen in table 1, that the capital of Paraíba, João Pessoa/PB, until July 1st, 2020, came to present an MR of 1,6% for, that is, 1.680 confirmed cases of COVID-19 to every 100 thousand inhabitants in the territory. According to the last IBGE demographic census it is estimated that the population of the capital is approximately

809 thousand inhabitants, resulting in the largest of the PD of the State of Paraíba, 3.421,28 inhabitants/km ². [6]

Then, the city of Campina Grande/PB is observed, which until July 1st, 2020 had a MR of 1,6%, for cases of the disease. The city has a PD of 648,31 inhab/km², being the second largest in the state. [7]

It is also possible to observe in table 1, data from the municipality of Guarabira/PB, which presented one of the first confirmed cases in the State, on April 23rd, 2020, and reached, by July 1st, 2020, a 3,8% MR. , for a city with a PD of 333,8 inhabitants/km². [8]

Occupying the fourth place in the contamination ranking in Paraíba, Table 1 shows the municipality of Cabedelo/PB, which presented its first case of contamination by COVID-19 eight days after the first case was registered in Paraíba, occurred in on April 9th, 2020. The municipality is a port city, has a PD of 1.815,57 and showed a MR of 2,7% during the studied period. [9]

The municipality of Santa Rita/PB, the fifth in number of confirmed cases of COVID-19 in Paraíba, confirmed its two confirmed cases on April 8th, 2020, just seven days after the first case registered in the state. With a PD of 165,52 inhab/km2, during the study

Chart 1: COVID-19 Morbidity Rate in Paraíba up to July 1, 2020 and Population Density

TAXA DE MORBIDADE E DENSIDADE DEMOGRÁFICA DA COVID-19 NA PARAÍBA - 2020		
LOCAL	TAXA DE MORBIDADE (TM)	DENSIDADE DEMOGRÁFICA (DM)
Paraíba	1,1%	66,7
João Pessoa/PB	1,6%	3.421,28
Campina Grande/PB	1,6%	648,31
Guarabira/PB	3,8%	333,8
Cabedelo/PB	2,7%	1.815,57
Santa Rita/PB	0,8%	165,52
Patos/PB	1,30%	212,82
Mamanguape/PB	2,70%	124,23
(Source: SES/PB, 2020)		

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period, the municipality of Santa Rita/ PB presented a MR of 0,8%, out of a total of approximately 1.500 accumulated cases. [10]

Still in table 1, it is observed that the sixth place in number of cases of COVID-19 in Paraíba, until July 1st, 2020, was occupied by the municipality of Patos/PB, which presented three confirmed cases on April 10th, 2020.

The referred municipality has a PD of 212,82 inhabitants/km² and presented a MR of 1,3%. [11]

The municipality of Mamanguape / PB was in seventh place in the contamination ranking in the State of Paraíba, during the period studied. It presented its first two confirmed cases only on May 5th, 2020, but in just over 20 days it reached the mark

of more than 1.200 accumulated cases, representing a MR of 2,7%. The municipality has a relatively low PD, 124,23 inhabitants/km², but it is an important agricultural pole of the State, being a region of high traffic. [12]

In addition to the correlation between MR and PD, it is also possible to note, through the spatial distribution of confirmed cases of COVID-19, from the first day of a confirmed case in the State until July 1st, 2020, as described above, a process of interiorization of COVID-19, considering that a contamination ranking was established in the State of Paraíba, in which this trend is identified, of increasing large cities in the state, as shown in Figure 1, below:

New Cases

Daily, during the study period, new confirmed cases of COVID-19 were registered in the State of Paraíba, in the vast majority of municipalities in this State, which allowed the directing of public health policies, to guide the State and the country, on the release and relaxation of pandemic decisions. These new confirmed cases of COVID-19 in the State of Paraíba, can be seen, together with the IR, in table 2 below.

With regard to the municipalities that entered the object of this study, until July 1st, 2020, new cases were registered for COVID-19 only in the municipalities of João Pessoa/PB, Campina Grande/PB, Guarabira/PB, Cabedelo/PB and Mamanguape/PB. In the municipalities of Santa Rita/PB and Patos/PB, no new cases of COVID-19 were registered, presenting the first downward trends in the State of Paraíba.

As shown in the total of accumulated confirmed cases of COVID-19 in the State of Paraíba, it is also possible to observe, through the spatial distribution of the new confirmed cases during the period proposed for the study, once again the process of internalization of COVID-19, bearing in mind that a

FIGURE 1: Spatial Distribution of COVID–19 Confirmed Cases in Paraíba by July 1st, 2020
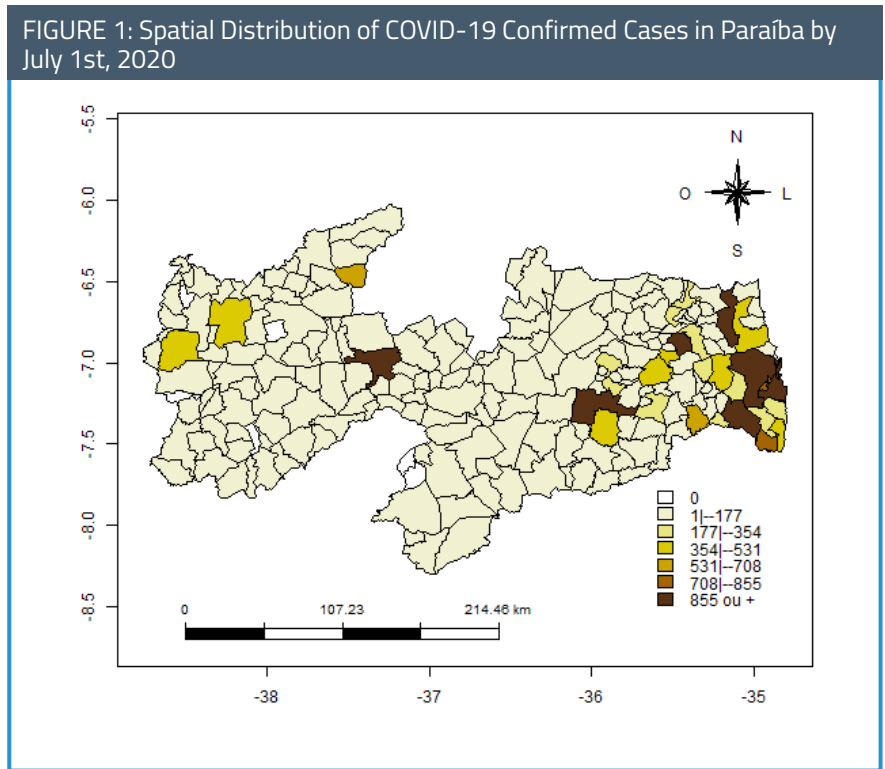
Source: LEAPIG, 2020

Chart 2: COVID–19 incidence rate in Paraíba until July 1st, 2020

TAXA DE INCIDÊNCIA DA COVID-19 NA PARAÍBA - 2020	
LOCAL	TAXA DE INCIDÊNCIA (TI)
Paraíba	30,3%
João Pessoa/PB	35,8%
Campina Grande/PB	11%
Guarabira/PB	105,3%
Cabedelo/PB	48,71%
Santa Rita/PB	0%
Patos/PB	0%
Mamanguape/PB	127%
(Source: SES/PB, 2020)	

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contamination ranking was established in the State of Paraíba, in which this tendency is identified, of an increase in IR in the most interior cities, after dissemination in the largest cities, or in the cities surrounding the large cities of the State as illustrated Figure 2, below:

Deaths

Between March 21st, 2020 and July 1st, 2020, over 1.00 deaths confirmed by COVID-19 were recorded in the State of Paraíba, which reached a total of 25 accumulated deaths per 100 thousand inhabitants, representing a TL of 2,08% throughout the State, as shown in Table 3 below:

The highest LR in the State of Paraíba during the studied period, was observed in the municipality of Santa Rita/PB, with 6,7%, while the lowest rate in the municipality of Guarabira/PB, which reached a TM of 0,90%. The cities of João Pessoa/PB and Campina Grande/PB had a median LR, which can be associated with the population's access to the diagnostic network for COVID-19, as well as hospitalization and highly complex treatment.

It is not possible to access the analysis of the spatial distribution of deaths confirmed by COVID-19 in the State of Paraíba, during the period proposed for this study, but one can perceive the same trend of increasing LR in the most inland cities, after dissemination in the largest cities, or the cities surrounding the large cities of the State according to table 3.

Of the deaths confirmed by COVID-19 in the State of Paraíba, during the study period, approximately 40% were women, but the majority of 60% were men. 30% of the fatal victims of COVID-19 in the State were aged 80 or over, 21,5% were aged between 70 and 79 years and 19% were aged between 60 and 69 years, that is, almost 70 % of deaths occurred among people over 60 years of age. Most of the people who died had some pre-existing disease, among them, hypertension, diabetes mellitus, heart disease and obesity.

DISCUSSION

Based on similar PD in the national territory and from the assessment of the spatial distribution of the epidemiological data of COVID-19, through the MR, IR and LR in the State of Paraíba, among the first case diagnosed until July 1st, 2020, it is possible to compare with the States of Ceará, Santa Catarina, and Rio Grande do Norte. The PD, as well as the MR, IR and LR of the States of Paraíba compared to Ceará, Santa Catarina and Rio Grande in the North, can be seen in Tables 4, 5 and 6 below.

Table 4 shows a correlation between the data from Paraíba and Santa Catarina, through the PD values of the seven largest cities in the State of Santa Catarina, being João Pessoa/PB x Florianópolis/SC, for being capitals, Campina Grande/PB x Joinville/SC, with an average of PD 552 inhab/km2, Guarabira/PB x Blume-

FIGURE 2: Spatial Distribution of New Cases of COVID-19 in Paraíba until July 1, 2020
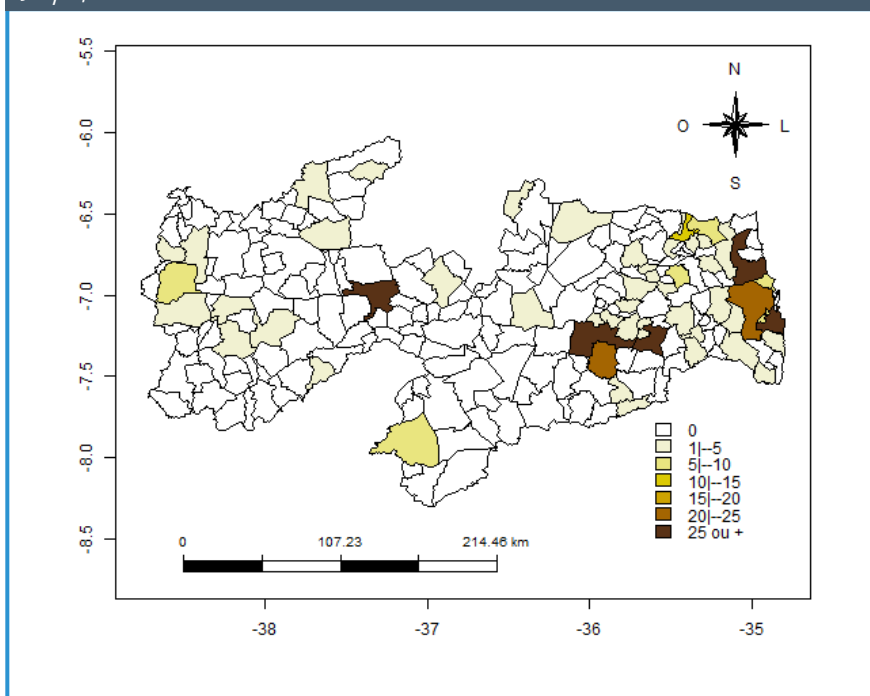
Source: LEAPIG, 2020

Chart 3: COVID-19 Lethality Rate in Paraíba until July 1, 2020

TAXA DE LETALIDADE DA COVID-19 NA PARAÍBA - 2020	
LOCAL	**TAXA DE LETALIDADE (TL)**
Paraíba	2,08%
João Pessoa/PB	2,70%
Campina Grande/PB	1,70%
Guarabira/PB	0,90%
Cabedelo/PB	1,00%
Santa Rita/PB	6,70%
Patos/PB	3,80%
Mamanguape/PB	1,30%
(Source: SES/PB, 2020)	

nau/SC, with an average PD 466 inhab/km2, Cabedelo/PB x São José/SC, with an average PD 1.595 inhab/km2, Santa Rita/PB x Chapecó/SC with a median DM of 311 inhabitants/km2. Patos/PB, Mamanguape/PB, Itajaí/SC and Criciúma/SC, did not reveal similarities between their PD. [13, 14,15, 16, 17, 18, 19, 20].

The State of Santa Catarina reached a COVID-19 RM of 0,3%, during the period proposed for the study, a much lower rate when compared to the 1,1% RM reached in the State of Paraíba in the same period. Continuing the analysis, in the seven largest cities in the state of Santa Catarina all presented lower MR compared to the seven largest cities in the state of Paraíba. However, the highest MR in Santa Catarina occurred in Chapecó/SC of 1,10%, surpassing the MR in Santa Rita/PB, taking into account the similarity between the PD of these municipalities, being the only occurrence in this sense.

The other municipalities of Paraíba included in this study, presented percentages with maximum COVID-19 TM of 3,8% and minimum of 0,8%, with an average of 2,0%, presenting values above Santa Catarina and the rate presented by the national federation.

With regard to COVID-19 IR in the State of Paraíba, the comparison was made with the State of Rio Grande do Norte, once again, due to the proportionality of the PD, however the rates showed quite divergent values, as shown shown in Table 5. The seven largest cities in the States of Paraíba and Rio Grande do Norte were compared, comparing their PD and the COVID-19 IR in the period proposed for the study. It is observed that, once again, the State of Paraíba, reveals a very high IR, mainly between the capitals João Pessoa/PB and Natal/RN, which diverged by 34,4% and the largest inland cities Campina Grande/PB and Mossoró/RN with a minor divergence of 10% between the COVID-19 IR. The cities of São Gonçalo do Amarante, Macaíba, Ceará-Mirim and Caicó did not have their rates revealed in the COVID-19 Panel of their state. [21]

Chart 4: Comparison between the Population Density and the Morbidity Rate of COVID-19 in Paraíba and Santa Catarina and their Municipalities until July 1st, 2020

COMPARATIVO ENTRE A DENSIDADE DEMOGRÁFICA E A TAXA DE MORBIDADE DA COVID-19 NA PARAÍBA E SANTA CATARINA E SEUS MUNICÍPIOS - 2020					
LOCAL	DM (HAB/KM2)	TM	LOCAL	DM (HAB/KM2)	TM
Paraíba	66,7	1,10%	Santa Catarina	65,27	0,30%
João Pessoa/PB	3.421,28	1,60%	Florianópolis/SC	623,68	0,30%
Campina Grande/PB	648,31	1,60%	Joinville/SC	457,58	0,20%
Guarabira/PB	333,8	3,80%	Blumenau/SC	595,97	0,50%
Cabedelo/PB	1.815,57	2,70%	São José/SC	1.376,78	0,20%
Santa Rita/PB	165,52	0,80%	Chapecó/SC	293,15	1,10%
Patos/PB	212,82	1,30%	Itajaí/SC	636,11	0,80%
Mamanguape/Pb	124,23	2,70%	Criciúma/SC	815,87	0,30%
(Source: IBGE, SES/PB E CIVIL DEFENSE/SC, 2020)					

Chart 5: Comparison between the Population Density and the Incidence Rate of COVID-19 in Paraíba and Rio Grande do Norte and their Municipalities until July 1st, 2020

COMPARATIVO ENTRE A DENSIDADE DEMOGRÁFICA E A TAXA DE INCIDÊNCIA DA COVID-19 NA PARAÍBA E RIO GRANDE DO NORTE E SEUS MUNICÍPIOS - 2020					
LOCAL	DM(HAB/KM2)	TI	LOCAL	DM	TI
Paraíba	66,7	30,3%	Rio Grande do Norte	59,99	21,1%
João Pessoa/PB	3.421,28	35,8%	Natal/RN	4.805,24	1,4%
Campina Grande/PB	648,31	11%	Mossoró/RN	123,76	1,0%
Guarabira/PB	333,8	105,3%	Parnamirim/RN	1.639,70	1,2%
Cabedelo/PB	1.815,57	48,71%	São Gonçalo do Amarante/RN	351,91	-
Santa Rita/PB	165,52	0%	Macaíba/RN	136,00	-
Patos/PB	212,82	0%	Ceará-Mirim/RN	94,07	-
Mamanguape/PB	124,23	127%	Caicó/RN	51,04	-
(Source: IBGE, SES/PB E COVID-19 PANEL/RN, 2020)					

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Still taking into account the proportionality of the DP, it was possible to correlate the LR of COVID-19 in the State of Paraíba with the State of Ceará. In this comparison, a large divergence was observed, as can be seen in Table 6. The State of Ceará presented a COVID-19 LR of 5,7%, during the studied period, maintaining an LR, even higher than the national average in the same period, which reached 4,0%. Between the capitals João Pessoa/PB and Fortaleza/CE the difference between the LR was even more notable, more than 6,5% divergence, which can be attributed to the difference in the DP, considering that Fortaleza/CE has a PD greater than double when compared to João Pessoa/PB.

Among the municipalities in the State of Ceará with the lowest LR, Crato/CE points 1,70%, as shown in Table 6, and has a PD of 103,21 inhab/km2, this same LR was observed, during the period of this study, in the second largest city from the State of Paraíba, Campina Grande/PB, which has a PD five times higher, showing that the State of Ceará was really hit by the pandemic. [22]

Ceará recorded deaths from CO-VID-19, during the first day of the disease until July 1st, 2020, of individuals under the age of one up to 109 years. Of these deaths by COVID-19 confirmed, 77,0% of those occurred with people aged 60 years or older, with an average of 72 years, similar to the age group of deaths registered in Paraíba. Regarding pre-existing comorbidities in consecutive deaths from complications of COVID-19, in the State of Ceará Cardiovascular Diseases, Diabetes and Chronic Kidney Disease prevailed, similar to the pathologies presented in individuals who were fatal victims of COVID-19 in the territory of Paraíba. [22].

CONCLUSION

In view of the results highlighted in the study, regarding the evaluation and description of the spatial distribution of epidemiological data in the cases of COVID-19 in the State of Paraíba, it was possible to observe the contribution of large cities as a source of disease spread, due to their high PD, as well as the similarity of the data found in Paraíba with other states of the same density pattern and territorial limits.

It can be seen that the COVID-19 IR was higher in the capital of Paraíba, João Pessoa/PB, as well as the highest number of deaths from the disease in

The State of Ceará presented a COVID-19 LR of 5,7%, during the studied period, maintaining an LR, even higher than the national average in the same period, which reached 4,0%.

Chart 6: Comparison between the Demographic Density and the Lethality Rate of COVID-19 in Paraíba and Ceará and their Municipalities until July 1st, 2020

COMPARATIVO ENTRE A DENSIDADE DEMOGRÁFICA E A TAXA DE LETALIDADE DA COVID-19 NA PARAÍBA E CEARÁ E SEUS MUNICÍPIOS - 2020					
LOCAL	DM (HAB/KM2)	TL	LOCAL	DM (HAB/KM2)	TL
Paraíba	66,7	2,08%	Ceará	56,76	5,70%
João Pessoa	3.421,28	2,70%	Fortaleza	7.786,44	9,40%
Campina Grande	648,31	1,70%	Caucaia	264,91	7,80%
Guarabira	333,8	0,90%	Juazeiro do Norte	1.004,45	5,60%
Cabedelo	1.815,57	1,00%	Maracanaú	1.960,25	6,00%
Santa Rita	165,52	6,70%	Sobral	88,67	3,60%
Patos	212,82	3,80%	Crato	103,21	1,70%
Mamanguape	124,23	1,30%	Itapipoca	71,90	7,30%

(Source: IBGE, SES/PB E CORONAVÍRUS-CE, 2020)

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the State, during the first day of the disease until July 1st, 2020. Despite this, João Pessoa/PB had a lower LR compared to the city of Santa Rita/PB, but the territorial boundary of these cities is commonly confused, with the municipality of Santa Rita/PB coming to be considered large João Pessoa/PB.

Understanding the dissemination patterns related to the number of inhabitants per km², it is possible to assist in the adoption of public health measures. Having the results of the study as a legitimizer of the need to maintain preventive measures, as is the case of social isolation, among other strategies, in order to guarantee a low level of contamination and spread of the disease, taking into account the existence of underreported cases and asymptomatic. ▪

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