

SPATIOTEMPORAL DISTRIBUTION OF SUICIDE IN NORTHEASTERN BRAZIL

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ABSTRACT

Objective: to analyze the spatial and temporal pattern of mortality by suicide in Northeast Brazil in the period 2008-2018. Method: ecological study that used data from the Mortality Information System, Ministry of Health - Brazil. The temporal trend was assessed by the Joinpoint method. The formation of spatial clusters of suicide was evaluated by the spatial autocorrelation function and purely spatial Scan statistical technique. Results: most deaths occurred among male (79.5%), brown (76.8%), single (59.2%), 20 to 49 years old (61.7%) individuals. Statistically significant growth of suicide was observed in six of the nine northeastern states ($p < 0.05$). According to the spatial autocorrelation function and Scan statistics, the spatial clusters of deaths were located predominantly in Piauí and Ceará. Conclusion: the findings reinforce the need to direct strategies for prevention of the grievance to the municipalities with the highest occurrence.

DESCRIPTORS: Suicide; Mortality; Spatiotemporal Analysis; Ecological Studies; Epidemiology.

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INTRODUCTION

Suicide is a complex phenomenon that occurs in several age groups, and it is the second leading cause of death among young people aged 15 to 29 years. About 800,000 people die every year by suicide, and for each act committed, there is an even greater number of individuals who attempt it⁽¹⁻²⁾.

Brazil is among the 10 leading countries in absolute numbers of suicides⁽²⁾. Although the Southern region of Brazil presents the highest coefficients in the country, the Northeast region has stood out for the significant increase in its rates of self-poisoning deaths, since there has been an increase of 125.0% in mortality for this grievance in recent years⁽³⁻⁴⁾. As a result, statistics indicate that 75.0% of the Northeastern municipalities present suicide rates of up to 7.19 deaths per 100 thousand inhabitants⁽⁵⁾.

The increasing trend in suicide mortality in the Northeast may be a result of the unfavorable socioeconomic indicators present in the region. Although poverty and income inequality have declined in recent decades, this territory still presents the worst social and economic indicators when compared to other regions of the country. Among these, the low level of education, high unemployment rates, and low economic development that depends mainly on agriculture, livestock, and fishing activities stand out⁽⁵⁻⁸⁾.

The present study is justified by the need to understand this epidemiological scenario to support the planning and implementation of public policies and intervention strategies that can reduce the occurrence of the grievance in the region⁽⁹⁾. Considering that studies that assess the temporal trend and spatial distribution of a disease or offense are effective epidemiological tools in the analysis of the health situation of a territory, this study aims to analyze the spatial and temporal pattern of mortality from suicide in Northeastern Brazil in the period 2008-2018.

METHOD

This is an ecological study with the Northeast region of Brazil as the area of interest. According to the 2010 demographic census, the population of the Northeast is 53,078,137 people, residing in 1,794 municipalities distributed across nine states: Maranhão (MA), Piauí (PI), Ceará (CE), Rio Grande do Norte (RN), Paraíba (PB), Pernambuco (PE), Alagoas (AL), Sergipe (SE) and Bahia (BA)⁽¹⁰⁻¹¹⁾.

The data of this study are of the secondary type, from Death Statements (DO) that feed the Mortality Information System (SIM) and, in turn, available on the portal of the Department of Informatics of the Unified Health System (DATASUS) of the Ministry of Health. Demographic data on the population of the Northeastern states were also obtained from DATASUS, where information collected in the last demographic census conducted in 2010, as well as intercensal projections (2008/2009 and 2011-2018) is available.

The information collected refers to deaths by suicide that occurred in the period from 2008 to 2018, selecting only those whose categories X60 to X84 were mentioned in the DO, according to the 10th International Classification of Diseases (ICD-10). The variables analyzed were: year of death, gender, age group, education by years of study, skin color, marital status, place of occurrence, and causes of death, according to the ICD-10.

In the univariate analysis of deaths, the categorical quantitative variables were distributed according to their absolute and relative frequencies. For the analysis of the temporal evolution of mortality in the nine states of the region, the Joinpoint Regression Program software version 4.6.0.0 was used. For this, the annual percentage change (APC)

was calculated using a 95% confidence interval (95% CI), in which a negative value of APC indicates a decreasing trend, and a positive value indicates an increasing trend⁽¹²⁾.

Each inflection point added to the temporal model represents a change in the linear trend, that is, there could be only one straight line in the analyzed period, or its change would indicate the insertion of an inflection point with the inclusion of a new straight-line segment to the temporal series. Thus, the model was adjusted assuming that the number of inflection points could vary from zero to two over the years. Thus, for the APC analysis, results with $p < 0.05$ or 95% CI only positive or only negative are significant⁽¹²⁾.

We defined as independent variable the year of occurrence of the suicide and as dependent variable the mortality rate in each year, calculated directly in the program and standardized according to the logarithm criteria logarithm previously exposed. For this, we selected the mortality rate as the numerator and the population of the chosen year as the denominator, considering the coefficient for 100,000 inhabitants.

The formation of spatial clusters of suicide deaths was assessed using the spatial autocorrelation function and the purely spatial Scan statistical technique. Initially, the Global Moran Index was applied to test the spatial dependence hypothesis and provide an overall measure of association for the entire study area. Once the presence of global spatial autocorrelation was verified, the Local Moran Index Spatial Analysis (LISA) was applied to verify the presence of spatial clusters and quantify the degree of spatial association in each county of the sample set. To establish the statistical validity of the Moran Index, the pseudo-significance test was performed with 999 permutations. The results of the Local Moran Index were represented by the Moran Map, which represents the Moran scatter plot, and the Lisa Map, which demonstrates the statistical significance of the spatial clusters identified by the Moran Map, considering $p < 0.05$ ⁽¹³⁾.

In turn, the spatial Scan statistic is characterized by a circular geographic window that moves through the area of interest in search of clusters of events. The scan window involved 30.0% of the population at risk and the probabilistic model used was Poisson. Besides the map of clusters, the Scan technique also subsidized the elaboration of the map of relative risk (RR), which represents the intensity of the occurrence of deaths by suicide in an area in relation to all other territories analyzed in the study. When $RR > 1$, it is said that the mortality risk of a specific area is higher than the risk of the entire region analyzed⁽¹³⁾.

For the calculation of the spatial autocorrelation function and the purely spatial Scan statistical technique, the software TerraView v.4.2.2® and SatScan v.9.6® were used, respectively. The maps were prepared in the software QuantumGis v.2.14.17®.

This study was approved by the Research Ethics Committee of the State University of Piauí under protocol number 3.286.816.

RESULTS

A total of 27,102 deaths by suicide were registered in the Northeast during the period studied, most of them among males ($n=21,542$; 79.5%), mixed race ($n=19,235$; 76.8%), single ($n=14,627$; 59.2%), and with seven years of schooling or less ($n=14,549$; 72.5%). About two out of five victims were aged 20 to 39 years ($n=11,931$; 44.1%). The main place of death was the home ($n=15,927$; 59.1%) and the most used method was hanging, strangulation, and suffocation ($n=18,010$; 66.4%) (Table 1).

Table 1 - Sociodemographic characterization of deaths by suicide that occurred in Northeast Brazil, in the period 2008-2018 (N =27,102†). Parnaíba, PI, Brazil, 2020 (continues)

Characteristics	n	%
Gender		
Male	21.542	79,5
Female	5.556	20,5
Years of schooling		
None	2.832	14,1
1 to 3 years	5.743	28,6
4 to 7 years	5.974	29,8
8 to 11 years	4.013	20
12 years or more	1.493	7,5
Age group		
≤ 9 years old	19	0,1
10 to 19 years	2.344	8,7
20 to 39 years	11.931	44,1
40 to 49 years	4.763	17,6
50 to 59 years	3.548	13,2
60 years and older	4.450	16,3
Place of occurrence		
Hospital or other health care facility	4.668	17,4
Home	15.927	59,1
Public road	2.089	7,8
Others	4.234	15,7
Color/Race		
White	4.150	16,6
Black	1.548	6,2
Yellow	55	0,2
Brown	19.235	76,8
Indigenous	60	0,2
Marital Status		
Single	14.627	59,2
Married	7.035	28,4
Other	3.061	12,4
ICD-10 Category		
Hanging, strangulation and suffocation (X70)	18.010	66,4
Shooting by firearm (X74)	1.194	4,4
Intentional exposure to pesticides (X68)	2.304	8,5
Precipitation from a high place (X80)	660	2,4

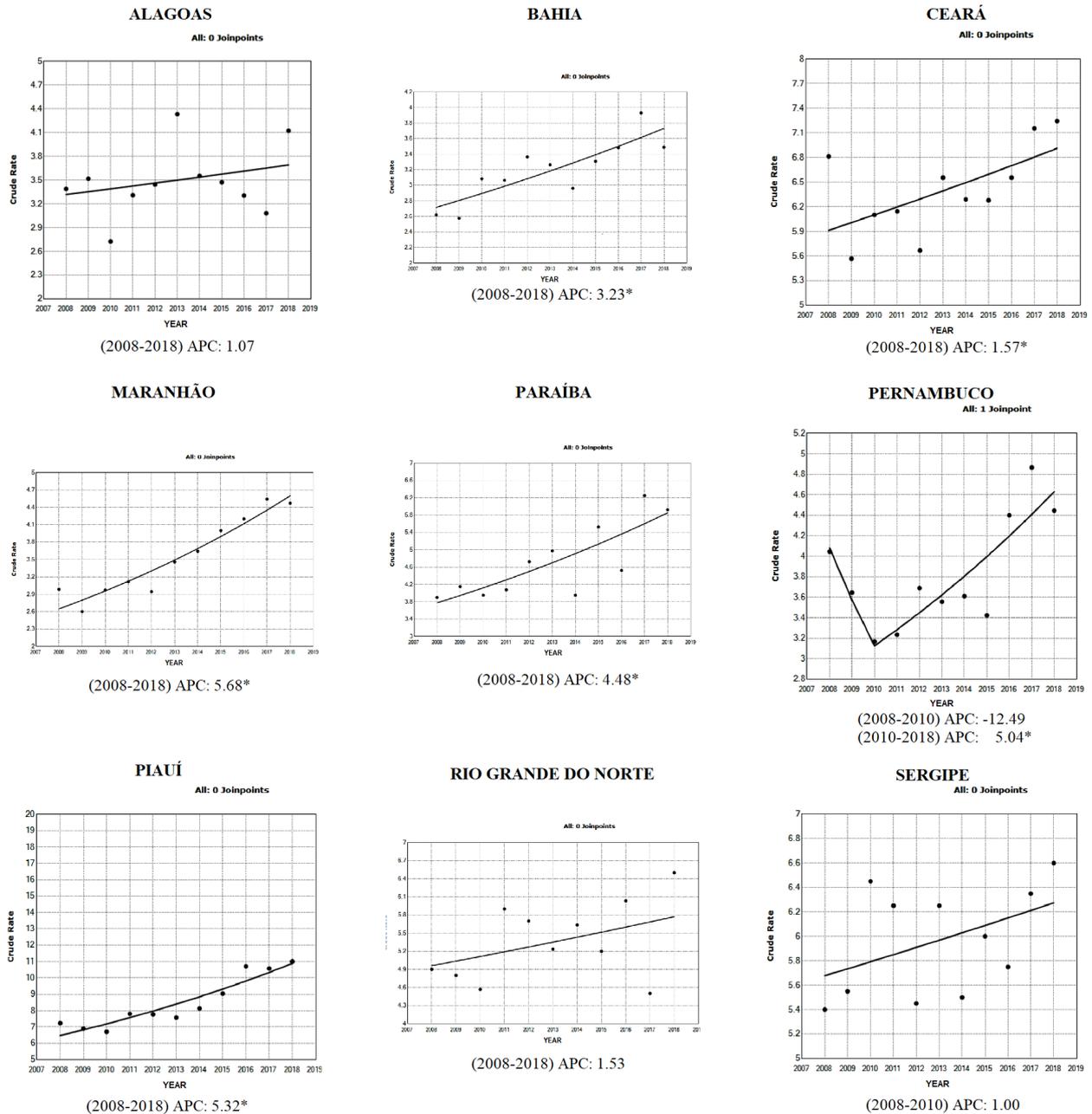
Other	4.934	18,3
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Legend: † Missing/ignored cases were excluded for the following variables: sex (n=4), years of education (n=7,047), age group (n=47), place of occurrence (n=184), color/race (n=2,054), and marital status (2,379).

Source: Authors (2020).

The temporal analysis by joinpoint revealed that in eight of the nine northeastern states, there is a single straight line with no inflection points, demonstrating a linear trend of increasing deaths over the years. However, the graph of the state of Pernambuco shows the appearance of two straight lines and an inflection point, demonstrating a change in trend from 2010. In the period 2008-2010 there was a decrease in the suicide rate of 12.5% per year, but without statistical significance. In contrast, the state showed significant growth of 5.0% per year (95% CI: 1.7-8.5; $p < 0.05$) in the period 2010-2018.

The most significant increases in deaths occurred in the states of Maranhão and Piauí, with increases of 5.7% (95%CI: 4.3-7.0; $p < 0.05$) and 5.3% (95%CI: 3.8-6.9; $p < 0.05$) per year, respectively. A significant increase ($p < 0.05$) in mortality was also recorded in Bahia (APC: 3.2; 95% CI: 1.7-4.8), Ceará (APC: 1.6; 95% CI: 0.1-3.1), and Paraíba (APC: 4.5; 95% CI: 2.1-6.9) (Figure 1).



*p<0,05. APC: Annual Percentage Change.

Figure 1 - Time trend analysis by Joinpoint of suicide mortality in the Northeast. Parnaíba, PI, Brazil, 2020. Source: Authors (2020).

Figure 2 shows in Map A the classification of Northeastern municipalities as to suicide clusters according to the Moran's scatter plot. The areas in red indicate municipalities with high rates and that are surrounded by municipalities with equally high rates, demonstrating a High/High spatial pattern. These are predominantly located in the states of Piauí, Ceará, Rio Grande do Norte, and Paraíba. The areas in green are municipalities that have low rates and are surrounded by municipalities with equally low rates (Low/Low), located in the North and West of Maranhão, the East coast of Alagoas and Pernambuco, and some regions of Bahia. The municipalities in yellow and blue show areas of epidemiological transition with the spatial pattern varying over time. Map B shows that the municipalities with High/High distribution pattern with the highest statistical significance ($p=0.001$) are located primarily in the central region of Piauí (Figure 2).

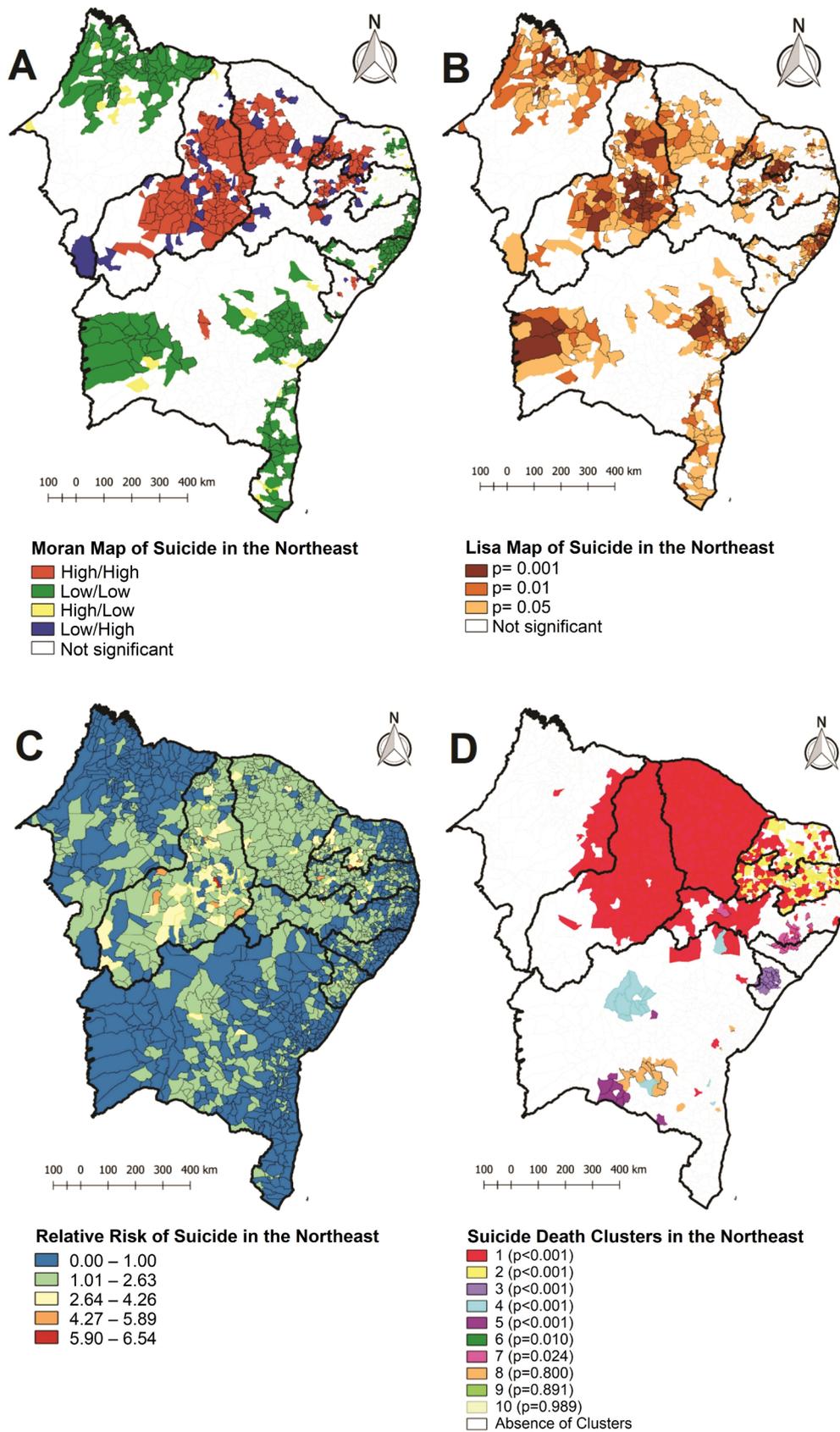


Figure 2 - Moran Map (Map A) and Lisa Map (Map B) of suicide, Relative risk of suicide deaths (Map C) and Clusters of suicide deaths (Map D) in the Northeast. Parnaíba, PI, Brazil, 2020
Source: Authors (2020).

Figure 2 also shows the maps of relative risk (Map C) and clusters (Map D) of suicide deaths in the Northeast calculated by the purely spatial Scan method. The municipality of

Santa Cruz do Piauí, located in the center of the state, showed the highest RR in the region, with 6.54 times the risk of suicide compared to the other Northeastern municipalities (Map C).

In total, 10 clusters were identified, however, only seven were statistically significant ($p < 0.05$). The cluster considered as primary (in red), that is, the one with the lowest probability of having occurred at random, included 561 municipalities, predominantly in the states of Piauí and Ceará, as well as in the backlands of Pernambuco and eastern Maranhão (Map D).

Table 2 presents the detailed information of the clusters of deaths by suicide identified by the purely spatial Scan method. The primary cluster had a radius of 385.20 km and its municipalities have, on average, 1.77 times higher suicide risk compared to the entire study area.

Table 2 - Spatial clusters of deaths by suicide, defined by purely spatial scan statistics. Parnaíba, PI, Brazil, 2020

Cluster	n° of municipalities	Radius (km)	n° of cases	expected n° of cases	RR [†]	LLR [‡]	Value of p
1	561	385,2	10.766	7.347,72	1,77	1009,99	<0,001
2	140	106,3	1.454	1.119,81	1,31	47,69	<0,001
3	27	51,43	424	264,81	1,61	40,86	<0,001
4	16	74,4	262	180,16	1,45	16,4	<0,001
5	9	56,08	170	106,61	1,59	16	<0,001
6	2	10,15	16	3,31	4,83	12,51	0,01
7	23	56,78	412	325	1,27	10,86	0,024
8	14	73,2	187	142,66	1,31	6,3	0,8
9	1	0	16	5,84	2,73	5,96	0,891
10	17	48,2	146	110,79	1,31	5,1	0,999

Legend: †RR: Relative risk for the cluster compared to the rest of the state. ‡LLR: Log-likelihood ratio test.

Source: Authors (2020).

DISCUSSION

The results of this study show that eight out of 10 deaths by suicide in the Northeast region of Brazil occurred among males, which is in accordance with other national^(3,14-15) and foreign⁽¹⁶⁻¹⁸⁾ investigations. A study that analyzed gender differences in suicide mortality in 182 countries showed that the average suicide rates among men were higher than the average observed among women in all continents, being higher in the Americas⁽¹⁹⁾.

This distinct mortality pattern between the sexes may be related to differences in the choice of methods to commit suicide. A study that analyzed gender differentials in suicide mortality in Northeastern Brazil found that men are more likely to use more aggressive methods to commit suicide, such as firearms, explosives, and hanging. In contrast, women, in their majority, attempt against their own lives using less lethal methods such as

autointoxication, which increases their chances of recovery if immediate care is provided⁽¹⁵⁾.

It was noted that the proportion of self-caused deaths was higher among individuals with seven years or less of education. Investigations point to a positive association between low schooling and suicide, since the low educational level of an individual can have negative repercussions on his social and financial life, increasing the risk of unemployment and economic problems, resulting in feelings of hopelessness and guilt, which can influence suicidal ideation^(6,14,20).

It was also observed that about three out of five individuals who committed suicide were single, which corroborates a study conducted in Italy, which observed a suicide risk almost three times higher among individuals who are not married and live alone⁽²¹⁾. Marriage has been reported as an important protective factor against suicidal behavior because it provides greater integration of the individual into a family unit. Thus, the conjugal union enables a more sentimental and welcoming environment, which prevents individualism, feelings of loneliness, and vulnerabilities that can result in suicidal ideation^(16,20-21).

The home was the most chosen place to commit suicide, with hanging being the most used method. This can be explained by the fact that, at home, the individual with suicidal thoughts has more privacy and, therefore, has easier access to time and resources to plan and execute the act, which makes its prevention difficult to control^(16-17,22).

The temporal analysis by joinpoint indicated an increasing trend in suicide mortality in all nine states of Northeastern Brazil, of which Bahia, Ceará, Maranhão, Paraíba, Pernambuco and Piauí showed statistically significant growth. These results are in accordance with studies that analyzed mortality by suicide in Brazilian regions, which also found a trend of progressive increase of self-poisoned deaths in all regions of the country, with emphasis on the Northeast^(8,14,23), with the highest growth rate in the period from 1996 to 2015⁽²³⁾.

Research that analyzed global trends in suicide mortality from 1990 to 2015, also using temporal analysis by Joinpoint, observed that throughout the 2000s, self-caused deaths registered a significant decrease in most countries, including Russia, Kazakhstan, Bulgaria, Finland, and Switzerland. However, upward trends continued to be observed in Brazil and countries such as Greece, the United Kingdom, Mexico, the United States, and Australia. The authors explain that while the favorable trends may be a result of better management of psychiatric disorders, several factors may have led to increased suicide in the cited countries, such as major socioeconomic and political changes, periods of financial crisis and social instability, increased unemployment and due to inadequate detection and treatment of mental disorders⁽²⁴⁾.

The states with the highest annual percentage variation in the suicide rate in this study were Maranhão and Piauí. These results were also found in a nationwide epidemiological survey, which showed that among the five Federal Units with the highest increase in mortality, three belonged to Northeastern Brazil: Piauí (+456.5%), Maranhão (+332.9%), Paraíba (+283.6%), Acre (+231.6%), and Tocantins (+200.4%)⁽³⁾.

Studies indicate that the increase of suicide in the Northeast region may be related to the high-income inequality, low level of education and increased unemployment rates in the region. The Northeast is also characterized by the concentration of many workers involved in agricultural activities, which have been associated with higher occurrence of suicide^(5-6,8).

Such results demonstrate the importance of mental health actions, of an interventionist and preventive nature, focused on reducing the occurrence of this grievance not only in the Northeast region, but in the Brazilian territory. It is important to emphasize that this problem is not only related to poor living conditions, but also receives strong influence from other psychological, sociodemographic, and behavioral factors, such as the prevalence of depression and anxiety, family history of psychiatric disorders, high alcohol consumption and use of psychotropic medications, among others^(21,25).

The mapping of suicide clusters allowed the identification of higher risk territories in Piauí, Ceará, eastern Maranhão, and the interior of Rio Grande do Norte and Pernambuco. Research that also evaluated the spatial distribution of suicide in Northeastern Brazil observed that among the 10 municipalities with the highest suicide rates, five belonged to the state of Piauí, with mortality ranging from 25.06 to 33.34 deaths per 100,000 inhabitants. In this same study, the spatial clusters of suicide of greatest epidemiological importance were found in municipalities in Piauí and Maranhão. These findings were related to the precarious living conditions of the populations of these states, since the municipalities of Piauí and Maranhão were characterized by having the worst socioeconomic conditions in the country, indicated by indicators such as the human development index, illiteracy rate, and vulnerability to poverty⁽⁵⁾.

On the other hand, a research conducted in Rio Grande do Norte observed that suicide was related to good socioeconomic indicators⁽²⁶⁾, which again shows that this grievance is not only associated with socioeconomic aspects, but also to a set of factors that involve the mental health policies of the territories, the absence of prevention programs or unpreparedness of health professionals and society in general during the approach and care of the patient victim of suicide attempt⁽²⁶⁾. Given this, the need to implement work strategies more consistent with the local reality and more effective policies, which seek to stimulate greater integrality in the assistance to individuals who attempt suicide, performing actions of promotion and prevention is highlighted, since this grievance can be avoided⁽²⁷⁾.

This study presents information of great relevance, since it shows the trend of mortality by suicide over the years and its geographical distribution, which contributes to the identification of areas of greater vulnerability and the development of more effective strategies aimed at at-risk populations. The findings reinforce the need to seek justifications for the differences in suicide rates in their local context, directing strategies to prevent the disease to the states with the highest occurrence, in order to make public health actions more effective.

Given this, it is recommended that more detailed studies be carried out, especially in the states that showed significant growth trends and clusters of the problem, for a more complete analysis of the factors that may be influencing mortality in these territories.

Among the limitations of the study, we highlight the use of secondary data from a system that is subject to underreporting, either by error in data collection or by incorrect filling out the DO^(8,22). However, this limitation did not hinder the conduct of the study and did not diminish its importance.

CONCLUSION

It is concluded that, in the period analyzed, mortality by suicide in the Northeast region occurred predominantly among males, brown skin color, single, aged 20 to 39 years, and with low education. The main place of occurrence was the home, and hanging, strangulation and suffocation were the most used methods.

A statistically significant increase in suicide mortality was found in the states of Bahia, Ceará, Maranhão, Paraíba, Pernambuco and Piauí. In turn, the spatial analysis identified significant spatial clusters of suicide, predominantly in Piauí and Ceará and in inland municipalities of Rio Grande do Norte, Pernambuco and Maranhão.

The results of this study contribute to the creation and reformulation of public health policies and strategies aimed at the prevention of the grievance, especially among the most vulnerable individuals who live in the states and municipalities indicated as being at higher risk for the problem. Furthermore, it is expected that the findings of this investigation will

draw the attention of managers and health professionals to the importance of searching for risk factors for the problem, to enable early intervention and, consequently, the reduction of suicide rates in the region.

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Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work - Silva IG da, Silva TL, Sousa GJB; Drafting the work or revising it critically for important intellectual content - Silva IG da, Silva TL, Sousa GJB, Lira Neto JCG; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved - Maranhão TA. All authors approved the final version of the text.

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