







SPATIAL ANALYSIS OF SUICIDE IN NORTHEASTERN BRAZIL AND ASSOCIATED SOCIAL FACTORS

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ABSTRACT

Objective: to analyze the spatial pattern of mortality due to suicide and social factors associated with its occurrence.

Method: an ecological study that used data from the Mortality Information System (*Sistema de Informação sobre Mortalidade*, SIM) from 2008 to 2018. The unadjusted and Bayesian mean mortality rates were calculated for each northeastern municipality and the Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) non-spatial and spatial regression models were used.

Results: the highest mortality rates due to suicide are especially concentrated in the municipalities of Piauí and Ceará. The predictive variables of suicide were as follows: Gini Index ($p < 0.001$), unemployment rate ≥ 18 years old ($p < 0.001$), Municipal Human Development Index ($p < 0.001$), illiteracy rate ≥ 18 years old ($p < 0.001$), *per capita* income ($p < 0.001$), percentage of people in homes with inadequate walls ($p = 0.003$), percentage of people in homes with inadequate water supply and sewage ($p < 0.001$), and percentage of people vulnerable to poverty who commute for more than one hour to work ($p < 0.001$).

Conclusion: eight predictive variables of mortality due to suicide in the Northeast region were identified that act as risk or protective factors, depending on the municipality under study.

DESCRIPTORS: Suicide. Mortality. Spatial analysis. Ecological studies. Epidemiology.

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ANÁLISE ESPACIAL DO SUICÍDIO NO NORDESTE DO BRASIL E FATORES SOCIAIS ASSOCIADOS

RESUMO

Objetivo: analisar o padrão espacial da mortalidade por suicídio e fatores sociais associados à sua ocorrência.

Métodos: estudo ecológico que utilizou dados do Sistema de Informação sobre Mortalidade (SIM) no período de 2008 a 2018. As taxas médias de mortalidade brutas e bayesianas foram calculadas para cada município nordestino e os modelos de regressão não espacial *Ordinary Least Squares* (OLS) e espacial *Geographically Weighted Regression* (GWR) foram utilizados.

Resultados: as maiores taxas de mortalidade por suicídio concentram-se, especialmente, em municípios do Piauí e Ceará. As variáveis preditoras do suicídio foram: Índice de Gini ($p < 0,001$), taxa de desocupação ≥ 18 anos ($p < 0,001$), Índice de Desenvolvimento Humano Municipal ($p < 0,001$), taxa de analfabetismo ≥ 18 anos ($p < 0,001$), renda per capita ($p < 0,001$), percentual de pessoas em domicílios com paredes inadequadas ($p = 0,003$), percentual de pessoas em domicílios com abastecimento de água e esgotamento sanitário inadequados ($p < 0,001$) e percentual de pessoas vulneráveis à pobreza que gastam mais de uma hora até o trabalho ($p < 0,001$).

Conclusão: foram identificadas oito variáveis preditoras da mortalidade por suicídio no Nordeste que agem como fatores de risco ou de proteção, dependendo do município investigado.

DESCRITORES: Suicídio. Mortalidade. Análise espacial. Estudos ecológicos. Epidemiologia.

ANÁLISIS ESPACIAL DEL SUICIDIO EN EL NORDESTE DE BRASIL Y FACTORES SOCIALES ASOCIADOS

RESUMEN

Objetivo: analizar el patrón espacial de la mortalidad por suicidio y los factores sociales asociados a su ocurrencia.

Métodos: estudio ecológico que utilizó datos del Sistema de Información de Mortalidad (SIM) de 2008 a 2018. Se calcularon las tasas de mortalidad media bruta y bayesiana para cada municipio del noreste y se utilizaron los modelos de regresión no espacial de mínimos cuadrados ordinarios (OLS) y el modelo de regresión espacial geográficamente ponderado (GWR).

Resultados: las mayores tasas de mortalidad por suicidio se concentran, especialmente, en las ciudades de Piauí y Ceará. Las variables predictoras de suicidio fueron: índice de Gini ($p < 0,001$), tasa de desempleo ≥ 18 años ($p < 0,001$), Índice de Desarrollo Humano Municipal ($p < 0,001$), tasa de analfabetismo ≥ 18 años ($p < 0,001$), renta per cápita ($p < 0,001$), porcentaje de personas en hogares con paredes inadecuadas ($p = 0,003$), porcentaje de personas en hogares con suministro de agua y saneamiento inadecuado ($p < 0,001$) y porcentaje de personas vulnerables a la pobreza que demoran más de una hora en llegar al trabajo ($p < 0,001$).

Conclusión: se identificaron ocho variables predictoras de mortalidad por suicidio en el Nordeste que actúan como factores de riesgo o protectores, según el municipio investigado.

DESCRIPTORES: Suicidio. Mortalidad. Análisis espacial. Estudios ecológicos. Epidemiología.

INTRODUCTION

Suicide is a complex and universal human phenomenon that represents a serious public health problem worldwide¹. It is estimated that, annually, more than 800,000 people die due to suicide, and that at least for every adult who consummates self-provoked death, another twenty attempt suicide².

Most of the self-provoked deaths globally occur in low- and middle-income countries³, such as Brazil. In this context, the United Nations (UN) has released strategic documents such as the Sustainable Development Goals (SDGs). One of the goals in this document is to reduce by one third premature mortality due to non-communicable diseases and to promote mental health and well-being⁴.

Brazil is among the ten countries with the highest number of suicides worldwide². Among the Brazilian regions with the highest rates, the Northeast and the Midwest stand out⁵. In this scenario, Piauí is the state with the highest suicide rate in the Northeast region, as it presented a 221.7% increase in deaths from this cause in the last ten years, and the state capital, Teresina, has the second highest mortality rate due to suicide in young individuals among all the Brazilians capitals (14.4 deaths per 100,000 inhabitants)⁶.

It is important to emphasize that there are few regional studies on the theme of suicide, especially in the Northeast region, where there is an increase in the occurrence of this event⁷. Considering the assumption that high suicide rates can be related to the socioeconomic characteristics of the municipalities⁸⁻⁹, there is a need to seek explanations for the differences in the rates of the problem in the northeastern territory. Thus, the importance of epidemiological surveillance and of developing research studies aimed at identifying the municipalities with the highest occurrence and the socioeconomic factors associated with the problem is highlighted, in order to favor their understanding and the prevention possibilities⁹.

Therefore, given the high rates of deaths due to suicide in the country, it is necessary that studies of this nature are carried out in order to collaborate with the understanding of the problem and with the achievement of the international goals proposed by the UN⁴. Therefore, in order to understand how suicide is distributed and affects the health of the population in the Northeast region, the use of geoprocessing tools is essential, as it allows mapping the problem, establishing an association between indicators, cluster visualization and the possibility of reinforcing preventive actions¹⁰. In view of that, this study aims at: analyzing the spatial pattern of mortality due to suicide and social factors associated with its occurrence.

METHOD

This is an ecological study that used spatial analysis tools in health. This research has the Brazilian Northeast region as geographic area of interest. According to the last demographic census of 2010, the Northeast region has a population of 53,078,137 inhabitants, which corresponds to nearly 28% of the resident population in Brazil. It is the Brazilian region with the largest number of states, namely: Alagoas (AL), Bahia (BA), Ceará (CE), Maranhão (MA), Paraíba (PB), Pernambuco (PE), Piauí (PI), Rio Grande do Norte (RN) and Sergipe (SE), totaling 1,794 municipalities. As for its territorial extension, it has 1,554,257.0 km², corresponding to 18.2% of the total area of the country¹¹.

The data of this study were obtained from death certificates registered in the Mortality Information System (SIM) of the Information Technology Department of the Unified Health System (DATASUS) of the Ministry of Health. All deaths registered between 2008 and 2018 whose underlying cause was suicide were included. Therefore, only deaths whose codes X60 to X84 were cited according to the 10th International Classification of Diseases (ICD-10) were selected.

The socioeconomic and demographic data of the population of the northeastern municipalities were obtained from the Atlas of Human Development in Brazil¹², the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE) and the DATASUS websites. The indicators collected were as follows: Gini Index, illiteracy rate, Municipal Human Development Index (MHDI), unemployment rate \geq 18 years old, dependence ratio, aging rate, percentage of people \geq 18 years old with complete elementary education, percentage of poor people, percentage of people aged from fifteen to twenty-four years old who neither study nor work and are vulnerable, percentage of people in homes with inadequate water supply and sewage, percentage of homes with inadequate walls, percentage of people vulnerable to poverty who commute for more than one hour to work, *per capita* Gross Domestic Product, and *per capita* income.

To analyze the time evolution of mortality, the unadjusted suicide data recorded in each year were tabulated in a Microsoft Office Excel spreadsheet. The mean mortality rates obtained with the Tabwin software were used to draw a linear regression line that showed the time evolution of deaths.

For the spatial analysis, the mortality rates due to suicide were calculated for each municipality in the Northeast region. The unadjusted mortality rates were calculated using the number of deaths due to suicide in the municipalities in each year as numerator and, as denominator, standardization by the indirect method was used, in which the population of the central year of the study period (2013) was used, multiplied by 100,000 inhabitants. However, in order to reduce the instability of the unadjusted rates, they were later smoothed using the Local Empirical Bayesian method to correct casual random fluctuations. For such purpose, a spatial proximity matrix (or neighboring matrix) was constructed applying the first order contiguity criterion¹⁰.

Finally, to identify factors related to mortality due to suicide, the socioeconomic indicators selected were entered into an Ordinary Least Squares (OLS) non-spatial regression model using the *step forward* method with an entry value of 0.1. Those that remained in the final model were also entered into a Geographically Weighted Regression (GWR) spatial model. This spatial method was used to verify the variables related to the living conditions of the northeastern population that can be associated with mortality in each municipality of the region. GWR is able to analyze phenomena that vary according to the area in which they are studied since, in addition to using values corresponding to the indicators of a given municipality, it also considers the values of the neighboring municipalities, using a spatial proximity matrix by the contiguity criterion¹³.

The result of the GWR regression is presented in this study in the form of two thematic maps for each socioeconomic indicator: one map for the value of the regression coefficient and another map that represents the statistical significance of each municipality, considering $p < 0.05$.

The choice of the best model occurred through the evaluation of the Akaike Information Criterion (AIC) and the coefficient of determination (R^2), in which the lower the AIC value and the higher the R^2 value, the better the model's fit¹⁴.

The TerraView v.4.2.2[®] software was used to obtain the neighboring matrix and to calculate the Bayesian statistics. The OLS non-spatial regression was performed using the Stata 12[®] software and the GWR spatial regression using the GWR4.0.9[®] software. The maps were created using the QGIS[®] software, v.2.14.17.

It is noteworthy that all the ethical and legal aspects were respected as recommended by Resolutions 466/12 and 510/2016 of the National Health Council.

RESULTS

In the Northeast, 27,033 deaths due to suicide were reported from 2008 to 2018, with a mean mortality rate in the study period of 4.87 deaths per 100,000 inhabitants. There was a trend towards an increase in mortality over time (from 4.52 deaths per 100,000 inhabitants in 2008 to 5.64 deaths per 100,000 inhabitants in 2018) with the linear regression line (R^2) being able to explain 82.75% of the model's variability (Figure 1).

The spatial distribution of the unadjusted and Bayesian mortality rates due to suicide for the 2008-2018 period is shown in Figure 2. It can be seen that, even though it is a map showing unadjusted rates, Map A presents an apparent spatial pattern, with the distribution of the highest coefficients, especially in the municipalities of Piauí, Ceará and Rio Grande do Norte. To reduce dispersion, the local empirical Bayesian method was used to smooth the unadjusted mortality rates due to suicide, making them more stable (Map B). Thus, clusters of deaths (in red and wine color) were found which covered a significant portion of the municipalities in the states of Piauí and Ceará, as well as the Southwest region of Rio Grande do Norte and some municipalities in Paraíba, with rates varying from 7.72 to 15.48 deaths per 100,000 inhabitants.

Table 1 presents the adjustment of the OLS and GWR models for the mortality rate due to suicide. The OLS model indicated the following variables as predictors of mortality due to suicide in the Northeast: Gini Index ($\beta=10.22$; $p<0.001$), unemployment rate ≥ 18 years old ($\beta=-0.11$; $p<0.001$), MHDi ($\beta=24.81$; $p<0.001$), illiteracy rate ≥ 18 years old ($\beta=0.13$; $p<0.001$), *per capita* income ($\beta=-0.01$; $p<0.001$), percentage of people in homes with inadequate walls ($\beta=-0.02$; $p=0.003$), percentage of people in homes with inadequate water supply and sewage ($\beta=-0.04$; $p<0.001$) and percentage of people vulnerable to poverty who commute for more than one hour to work ($\beta=-0.17$; $p<0.001$).

In the OLS model, the coefficient of determination (R^2) was 0.125105 and the Akaike Information Criterion (AIC) was 9,426.91, while in the GWR model, the R^2 coefficient was 0.315880 and the AIC value was 9,056.97. Therefore, GWR proved to be better adjusted, as it has a lower AIC value and higher R^2 than those presented by the OLS model.

Subsequently, the spatial regression model (GWR) of the mortality rate due to suicide was adjusted for the variables that were found to be significant in the OLS model. Thus, Figures 3 and 4 show the association of socioeconomic variables on mortality due to suicide in the northeastern municipalities.

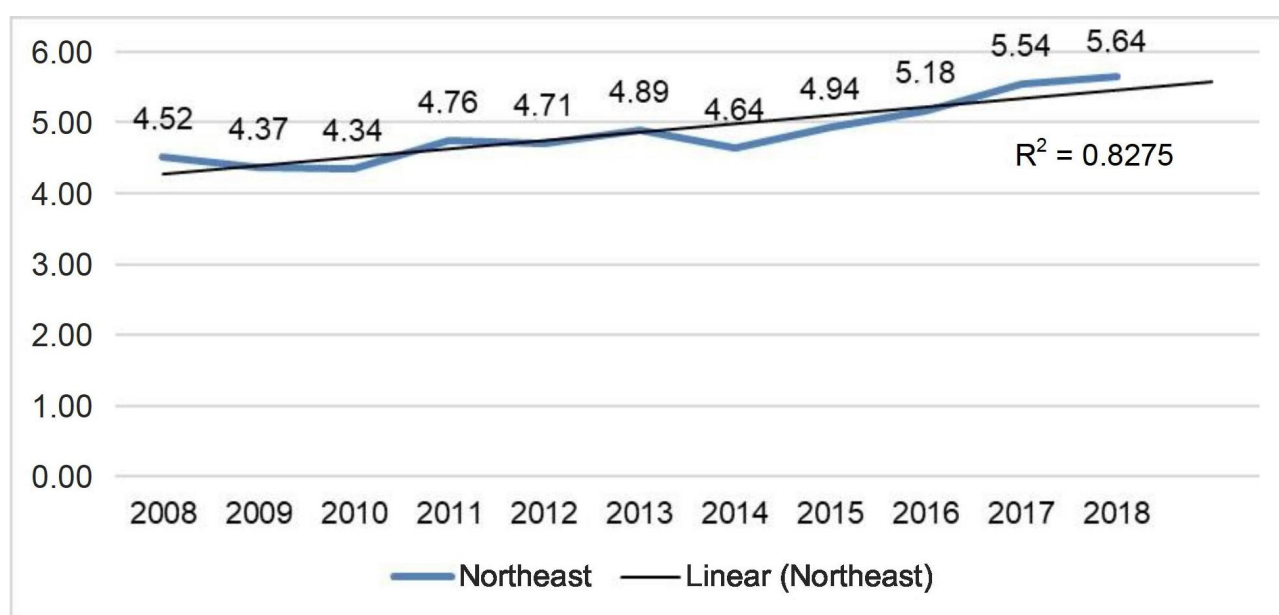


Figure 1 – Time evolution of the mortality rates due to suicide. Northeast region, Brazil, 2008-2018.

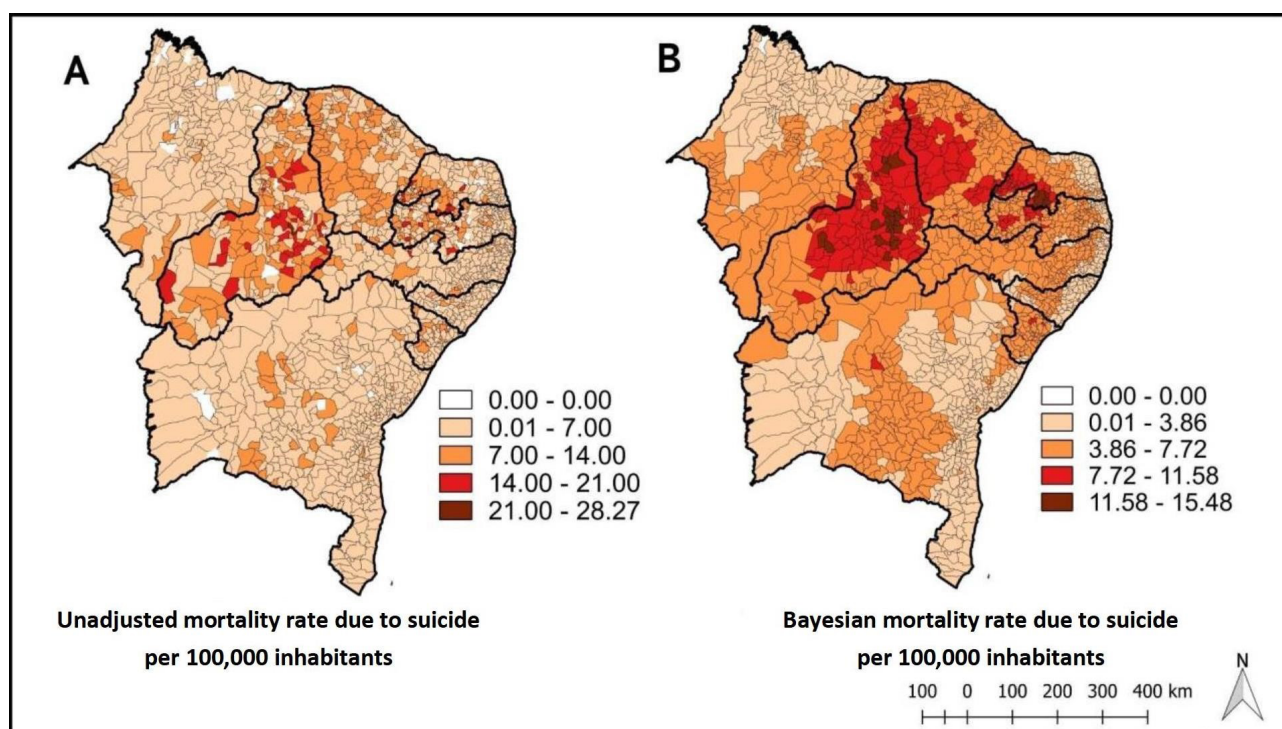


Figure 2 – Unadjusted mortality rate due to suicide per 100,000 inhabitants (Map A) and Bayesian mortality rate due to suicide per 100,000 inhabitants (Map B). Northeast region, Brazil, 2008-2018.

Table 1 – Ordinary Least Squares and Geographically Weighted Regression models of the socioeconomic indicators influencing the mortality rate due to suicide. Northeast region, Brazil, 2008-2018.

Socioeconomic Indicators	Ordinary Least Squares model			Geographically Weighted Regression model	
	Coefficient	Standard error	p	Coefficient	Standard error
Intercept	-	-	-	-10.283.930	3.001.412
Gini's Index	10.22	1.89	<0.001	10.222.935	1.889.251
Unemployment rate - ≥ 18 years old	-0.11	0.02	<0.001	-0.114315	0.021106
Municipal Human Development Index	24.81	3.99	<0.001	24.813.882	3.992.622
Illiteracy rate ≥ 18 years old	0.13	0.02	<0.001	0.129660	0.018127
<i>Per capita</i> income	-0.01	0.00	<0.001	-0.008146	0.001536
People in homes with inadequate walls (%)	-0.02	0.01	0.003	-0.022630	0.007693
People in homes with inadequate water supply and sewage (%)	-0.04	0.01	<0.001	-0.039660	0.006914
People vulnerable to poverty who commute for more than one hour to work (%)	-0.17	0.05	<0.001	-0.174276	0.052695

It was found that, in municipalities located in eastern Ceará and in some municipalities from Rio Grande do Norte, Pernambuco, Paraíba and northern Bahia, there was a positive and significant association between the Gini Index and mortality due to suicide. This shows that the higher the Gini Index, and therefore inequality, the higher the mortality rate due to suicide in these areas (Figure 3 – Maps A and B).

In municipalities located in the northern region of Piauí, Maranhão and Ceará, in addition to some municipalities from Rio Grande do Norte and Paraíba, it was evidenced that the higher the MHDl, the higher the mortality rate due to suicide. Conversely, in some municipalities in the *sertão* located on the limit between Ceará and Pernambuco, the higher the MHDl, the lower the mortality rate due to suicide (Figure 3 – Maps C and D).

A significant negative association was observed between the unemployment rate variable - in people aged ≥ 18 years old - and the mortality rate due to suicide in a significant portion of the municipalities of Alagoas and Rio Grande do Norte, in addition to municipalities from Piauí, Ceará, Pernambuco and Bahia (Figure 3 – Maps E and F). Maps G and H (Figure 3) indicate that the Jaguaribe region, in the state of Ceará, and some municipalities in the central region of Bahia, also presented a significant negative association with the *per capita* income variable, showing that the lower the *per capita* income, the higher the mortality rate due to suicide.

Illiteracy rate in people aged ≥ 18 years old is a risk factor for mortality due to suicide, especially in municipalities from the North of Maranhão and in most of those located in Rio Grande do Norte and Paraíba (Figure 4 – Maps A and B).

It was observed that, in a significant part of northern Maranhão, Piauí and Ceará, there was a significant negative association between the percentage of people in homes with inadequate walls variable and the mortality rate due to suicide. In these territories, the lower the percentage of people in homes with inadequate walls, the higher the mortality rate due to suicide (Figure 4 – Maps C and D).

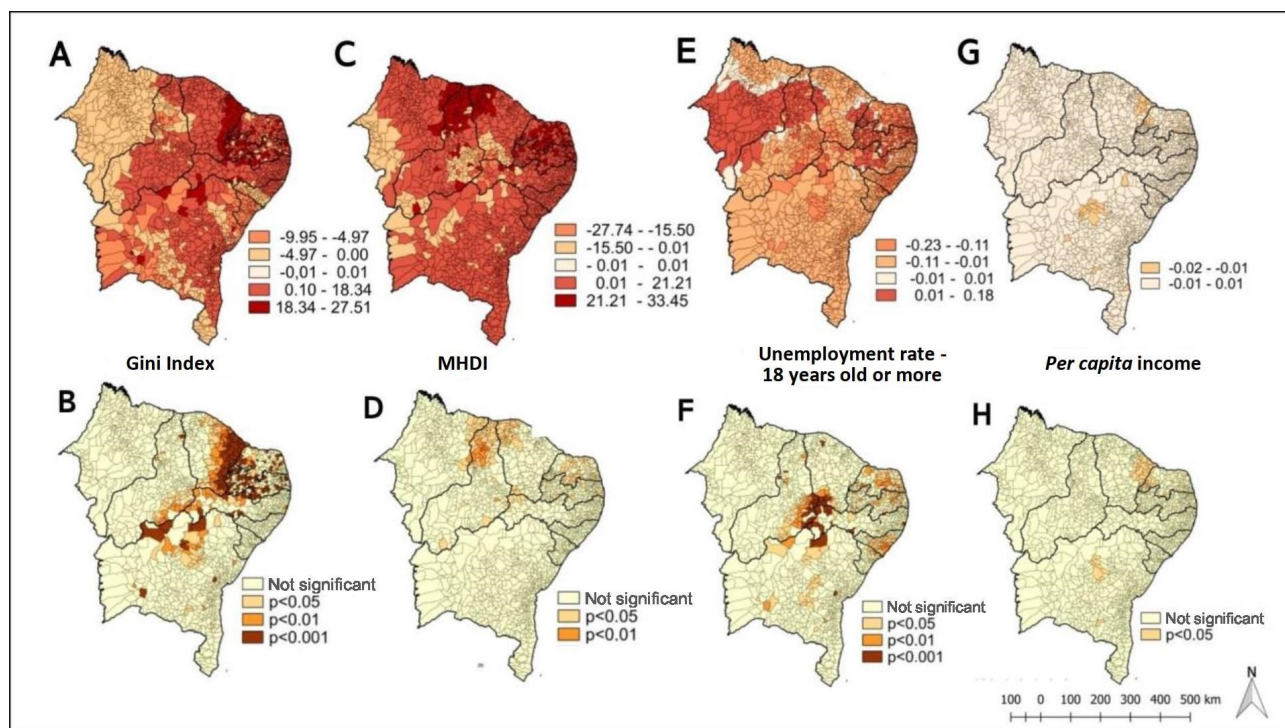


Figure 3 – Spatial distribution of the estimated coefficients and of the statistical significance of the independent variables associated with suicide in the GWR spatial regression model. Northeast region, Brazil, 2008-2018.

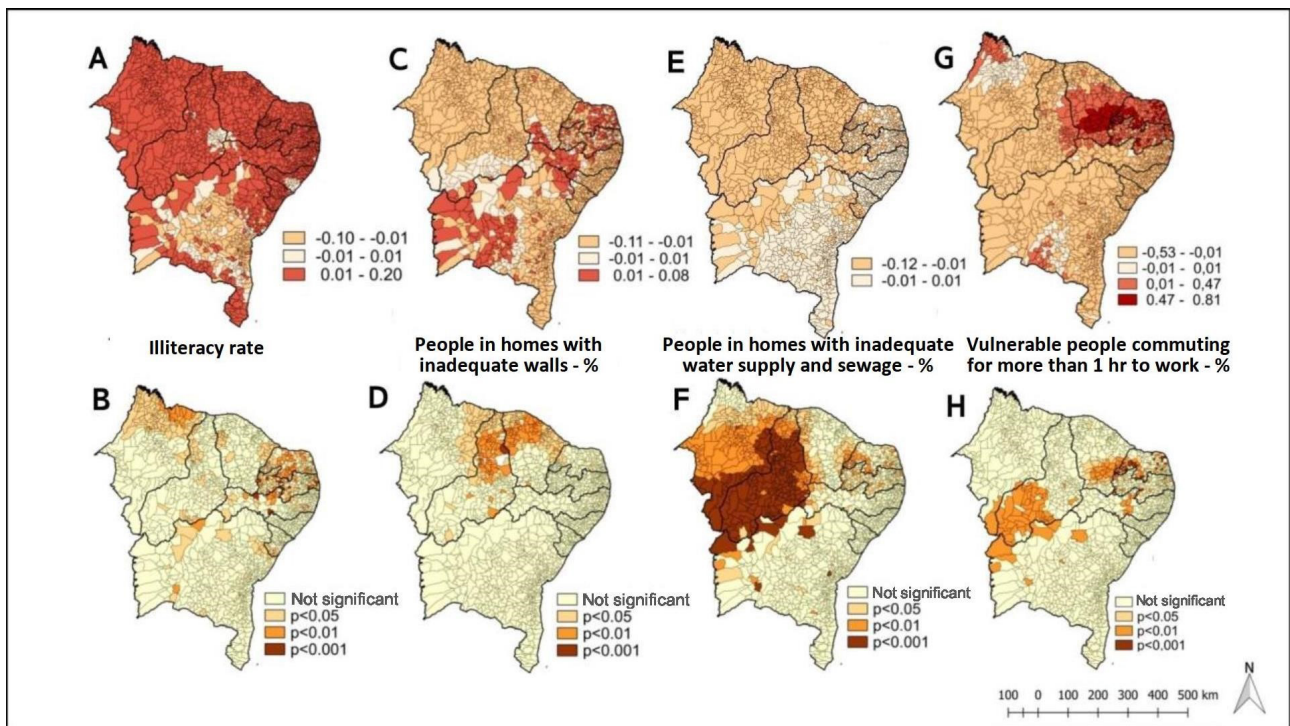


Figure 4 – Spatial distribution of the estimated coefficients and of the statistical significance of the independent variables associated with suicide in the GWR spatial regression model. Northeast region, Brazil, 2008-2018.

The percentage of people in homes with inadequate water supply and sewage was a protection factor in almost the entire state of Piauí and in municipalities in Eastern Maranhão (Figure 4 – Maps E and F). In turn, maps G and H show that, in southern Piauí, there was a significant negative association, indicating that the lower the percentage of people vulnerable to poverty who commute for more than one hour to work, the higher the mortality rate due to suicide. However, in some municipalities from Ceará, Rio Grande do Norte and Paraíba, the same variable has a positive association with the mortality rate due to suicide, and therefore acts as a risk factor in these territories.

DISCUSSION

In this study, it was possible to identify the spatial distribution of suicide in the Northeast region and its association with socioeconomic indicators. The maps of the local empirical Bayesian analysis indicate that the states of Piauí and Ceará, as well as some municipalities in Rio Grande do Norte and Paraíba, presented higher mortality due to suicide in the Northeast. In a research study that also assessed the spatial distribution of mortality due to suicide in northeastern Brazil, it was noticed that, among the ten cities with the highest rates, five belonged to Piauí. These municipalities were characterized by terrible socioeconomic conditions, pointed by indicators such as MHD, illiteracy rate and vulnerability to poverty, among others⁷.

It was found that, in municipalities from Rio Grande do Norte, Paraíba, Bahia and East Ceará, the Gini Index, an important indicator that measures social inequality, proved to be a risk factor for deaths due to suicide. Thus, the greater the inequality in these territories, the greater the rate of self-provoked deaths. This finding is in consonance with a research study conducted with young individuals which revealed that suicidal acts are more frequent in geographical clusters that are associated with socioeconomic deprivation¹⁵. Likewise, findings from a systematic review with studies conducted in the European continent point to strong evidence of an increased risk of suicidal behavior in areas that experience high levels of socioeconomic disadvantage⁹. In this context, it is to be noted that the

history of the Northeast region still presents patterns of persistent socio-spatial inequalities; however, the achievements made by the region in recent years are undeniable, such as reduction of poverty, increase in income, strong growth and transformations in its economic activity¹⁶.

In turn, the MHDl was positively associated with high mortality rates due to suicide in cities in the North of the states of Piauí, Ceará and Maranhão, in the inland of Rio Grande do Norte and Paraíba, showing that the problem is more serious in more developed cities. An ecological study that evaluated the association between the suicide rates and the HDI in 91 countries found that the rates of self-provoked death increased with increasing HDI levels, since the rates observed were 11.64 and 13.94 deaths per 100,000 inhabitants in extremely and very developed countries, and only 7.93 deaths per 100,000 inhabitants in medium-developed countries. In addition to that, there was also a direct and significant correlation between mortality due to suicide and the percentages of urbanization and Gross Domestic Product of the countries, as well as with women's life expectancy, indicators which, in turn, also show the development level of a territory and the quality of life of its population¹⁷.

On the other hand, some municipalities in southwestern of Ceará and in the Pernambuco's hinterland presented a negative association with the MHDl, that is, the worse the population's living conditions, the higher the mortality rate due to suicide. In this context, a research study conducted in the United States showed that adolescents living in socioeconomically disadvantaged areas presented a higher risk of suicide attempts. This can be associated with stressors caused by exposure to violence and with the perception of insecurity, as well as with the lack of social support resources¹⁸.

These opposing results may have occurred due to some confounding factors, such as variables related to religion and race, which are different in different societies. In addition to that, the use of unequal scales to assess socioeconomic status, the type of methodological design of the studies and the size of the population they studied could partially justify this contradiction¹⁷.

It was found that the higher the illiteracy rate, the higher the mortality rate due to suicide, mainly in municipalities from Rio Grande do Norte, Paraíba and Maranhão. In view of this result, it is to be noted that, although the proportion of illiterate people in the Northeast has been decreasing over time, the region still presents the highest illiteracy rates and the lowest schooling levels in the country, when compared to other Brazilian regions¹². In particular, the illiteracy rates in Rio Grande do Norte (19.74%), Paraíba (23.39%) and Maranhão (22.51%) are mentioned, which are above the national mean: 10.19%^{7,19}.

Findings similar to those of this paper were found in a study carried out in Iran, which showed that lower literacy rates were associated with higher suicide rates, as well as with lower socioeconomic status, demonstrating the synergy between low socioeconomic and schooling levels and the suicidal act in this territory²⁰. A research study that evaluated educational interventions on suicide suggests that actions focused on the school, in which didactic materials that address the risk factors for suicide are distributed, are effective both in gaining knowledge about the problem and in prevention of suicidal ideation and suicide attempts²¹.

In this study, some paradoxical results were also verified, in which social problems described by the indicators constitute protective factors for the mortality rate due to suicide, contrary to the findings of a significant part of the literature on this topic. In a significant part of the municipalities from Alagoas and Rio Grande do Norte, in addition to some municipalities in Piauí, Ceará, Pernambuco and Bahia, the unemployment rate of people aged ≥ 18 years old presented a negative association with mortality due to suicide, being considered a protective factor. This finding was also observed in an ecological study with data from 91 countries that showed an association between unemployment and lower suicide rates. This can be related to the fact that working populations may have easier access to means for suicide attempts¹⁷. In addition, the stress triggered by some professions, unbridled competition and the increasing demand for results and attaining ambitious goals in the work environment can compromise mental health and lead to suicidal ideation and behaviors^{17,22}.

The association between mortality due to suicide and work variables suggests that working in precarious situations worsens the quality of life of the working population, causes physical and psychological distress and increases the risk of self-aggression²². Work-related emotional distress and overload can reach such severity that the risk of suicide among workers can be greater than that observed among the unemployed²³. Given the above, it is noteworthy that the relationship between unemployment and suicide is complex and should be interpreted with caution, as it can be influenced by numerous other variables such as age, gender and the moment of the country's economic cycle²⁴.

In some municipalities from Piauí, Ceará and Maranhão, the lower the percentage of people in homes with inadequate walls, the higher the mortality rate due to suicide, that is, suicide is associated with better housing conditions in these territories. This result can be related to better socioeconomic conditions in the territories analyzed, in which there may be higher proportions of houses with adequate walls. This can also be due to the housing programs implemented in the country in recent years, which promoted improvements in the quality of housing designed for the population with low purchasing power. However, this policy promoted the displacement of the poorest groups of the population from the most centralized areas and, consequently, their entire structural support, to the peripheries, where the precariousness and/or scarcity of public health and education services stand out. In this way, many housing complexes that were built ended up not guaranteeing social rights to the population assisted. Therefore, it is inferred that the improvement in housing quality did not necessarily translate into improvements in people's quality of life²⁵.

In all the municipalities from Piauí and in a significant portion of the municipalities from Maranhão, the increase in the proportion of homes with inadequate water supply and sewage influences the reduction in mortality due to suicide. This result must be interpreted with caution, as it can be justified due to the low population occupation of these states, whose demographic density is only 12.40 inhabitants/km² in Piauí and 19.81 inhabitants/km² in Maranhão²⁶. Therefore, the installation of sewage collection and water supply networks is less suitable due to the low density of buildings, being more convenient to implement individual sanitation solutions such as artesian wells and septic tanks. In view of this, the low coverage of water and sewage networks does not necessarily mean that these places are extremely poor and unhealthy¹⁹.

A number of municipalities in Ceará and Bahia presented a negative association with the *per capita* income variable, indicating that, in these locations, the lower the income, the higher the mortality rate due to suicide. On the contrary, research studies conducted both in Brazil^{15,27} and in other countries^{18,28} state that the greater purchasing power of people provides greater availability of essential services such as health, education, culture, employment and housing which, in turn, are protective factors against hopelessness, persistent stress and anxiety, which can lead to suicidal ideation. In this sense, a study conducted in India indicates that more economically developed Indian states presented suicide rates almost four times higher for men and almost three times higher for women when compared to less economically developed states²⁹.

The percentage of vulnerable people who commute for more than one hour to work was a protective factor against mortality due to suicide in southern Piauí. This is probably due to the peculiar characteristics of this region, which includes territories from the *cerrado* of Piauí. These territories stand out for their soybean production and expansion of agricultural employment, leading them to take the first place on the list of exports from Piauí. As a result, they also presented strong dynamism in civil construction, commerce and the service sector, in addition to the increase in the GDP, factors that can be related to improvements in the quality of life of the population in these places and, at the same time, imply a reduction in the complications related to the home-work commute³⁰.

On the other hand, in municipalities from Ceará, the same variable appeared as a risk factor. In this situation, commuting can be exhausting and compromise the individual's quality of life¹⁹. In addition, excessive commuting time becomes a limiting factor for the individual's social growth, which may compromise the personal search for better living conditions and professional development that directly affect the worker's schooling and income levels. This contributes to not reducing inequalities, especially among the young population, who face the constant lack of social, economic and cultural opportunities from the state or society³¹. It is relevant to clarify that it is necessary to be cautious when interpreting some results presented in this study. Although some predictive variables such as *per capita* income, percentage of homes with inadequate water supply and sewage and percentage of people in homes with inadequate walls, have presented statistical significance in the OLS and GWR models, their estimated coefficients are very close to zero, showing that the effect of these indicators on the outcome variable is small.

One of the limitations of this study refers to its ecological design, as the analysis of the variables in the population scope does not necessarily represent an association in the individual scope. In addition to that, the use of secondary data can present inconsistencies regarding the amount and quality of the information. However, such limitations did not make the research unfeasible and do not diminish its importance.

CONCLUSION

It is concluded that there was a trend towards an increase in mortality due to suicide over the period studied. In addition to that, the Bayesian method was able to point out the location of clusters of self-provoked deaths in a significant portion of the municipalities from Piauí and Ceará and in the Southwest of Rio Grande do Norte and Paraíba.

Eight social factors associated with mortality due to suicide in the Northeast region were identified, namely: Gini Index, unemployment rate of people ≥ 18 years old, MHD, illiteracy rate of people ≥ 18 years old, *per capita* income, percentage of people in homes with inadequate walls, percentage of people in homes with inadequate water supply and sewage, and percentage of people vulnerable to poverty who commute for more than one hour to work. The GWR spatial regression model showed how these factors influence suicide in different territories of Northeastern Brazil and that, depending on the municipality under study, they behave as risk or protective factors.

Given such findings, it is concluded that prevention of mortality due to suicide is not the exclusive responsibility of the health sector, but that it should be considered in the development of public policies for the most diverse sectors of society. In this context, it is worth emphasizing the need for interventions on the social factors associated with suicide in specific municipalities from the Northeast region as an efficient method of preventing mortality due to suicide. Therefore, the strategies to prevent the problem must be directed to the municipalities with the highest occurrence in order to make public health actions more effective.

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NOTES

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