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ORIGINAL ARTICLE

Analysis of suicide mortality in Brazil: spatial distribution and socioeconomic context

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Objective: To perform a spatial analysis of suicide mortality and its correlation with socioeconomic indicators in Brazilian municipalities.
Methods: This is an ecological study with Brazilian municipalities as a unit of analysis. Data on deaths from suicide and contextual variables were analyzed. The spatial distribution, intensity and significance of the clusters were analyzed with the global Moran index, MoranMap and local indicators of spatial association (LISA), seeking to identify patterns through geostatistical analysis.
Results: A total of 50,664 deaths from suicide were registered in Brazil between 2010 and 2014. The average suicide mortality rate in Brazil was 5.23/100,000 population. The Brazilian municipalities presenting the highest rates were Taipas do Tocantins, state of Tocantins (79.68 deaths per 100,000 population), Itaporã, state of Mato Grosso do Sul (75.15 deaths per 100,000 population), Mampituba, state of Rio Grande do Sul (52.98 deaths per 100,000 population), Paranhos, state of Mato Grosso do Sul (52.41 deaths per 100,000 population), and Monjolos, state of Minas Gerais (52.08 deaths per 100,000 population). Although weak spatial autocorrelation was observed for suicide mortality (I = 0.2608), there was a formation of clusters in the South. In the bivariate spatial and classical analysis, no correlation was observed between suicide mortality and contextual variables.
Conclusion: Suicide mortality in Brazil presents a weak spatial correlation and low or no spatial relationship with socioeconomic factors.

Keywords: Suicide; epidemiology; social and political issues; community mental health; statistics

Introduction

Suicide is the act of taking one's life in a deliberate and voluntary manner in the full knowledge of its fatal outcome.[1] Suicidal behavior ranges from the ideation of killing oneself to forming a plan and obtaining the means to execute the act; it is currently a major public health problem worldwide, causing more deaths than homicides and wars together.[2] Ingestion of pesticides, hanging and firearms are among the most common suicide methods.[3]

It is estimated that about one million people committed suicide in the year 2000, with suicide among the ten leading causes of death in all countries. One in three of these suicides was in the 15 to 35 age group.[4] In 2012, there were approximately 800,000 deaths from suicide worldwide, representing an annual global age-standardized rate of 11.4 per 100,000 population (15.0 for males and 8.0 for females).[3] In Brazil, suicide rates are low compared to most countries, ranging from 3.50 to 4.00 per 100,000 population, in contrast with its much higher homicide rates.[5]

The literature indicates that suicide statistics are unevenly distributed around the world, within countries, between genders, and between age groups.

In richer countries, the suicide rate is three times higher among men, but in low- and middle-income countries, the male-to-female ratio is much lower, at 1.5 men to each woman.[3] There is a discrepancy between the number of suicides and attempted suicides, with one possible explanation being the preferred methods of each gender: despite more suicide attempts, women use less efficacious methods than men.[6]

Although suicide rates are higher among young people, ranking as the second leading cause of death among 15- to 29-year-olds, a considerable increase has recently been observed among the elderly in almost every region of the world.[5]

The suicide rate is significantly higher among men than women in Brazil, with a 3.7:1 ratio in 2012. People over 60 have the highest suicide rate in Brazil: in 2012, the mortality in this group was 8.0/100,000 population. The greatest rise in mortality, however, occurred in the 25 to 59 and the 10 to 24 age groups, increasing 22.7% and 21.8, respectively, over rates from year 2000. The major causes of suicide in Brazil are hanging, firearm injury, and

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deliberate self-poisoning with pesticides, which account for approximately 80% of the cases.[7]

According to official statistics, Brazil's suicide rate is far below the world's highest, which is over 16/100,000 population in France, China, Switzerland, Belgium, Austria, the United States, Eastern Europe and Japan. Its current world raking is 71st in rate and 9th in absolute number of deaths from suicide.[8] However, even in countries with good vital registration data, suicide can often be mistakenly attributed to accidents or other causes of death. Although it is relatively easy to measure mortality in a well-organized country, including mortality from injury, diagnosing suicide involves determining intent, which makes unambiguous statistical data more difficult to obtain.[9]

To a large extent in Brazil, only the mode of death (e.g. falls or drownings) – not the intent – is recorded for deaths from external causes. Such recordkeeping practices can mask a considerable proportion of suicide cases, especially among young male adults.[7] However, national mortality records show that the incidence of suicides among young adults, particularly males, is increasing, even considering possible underreporting.[8]

The risk of suicidal behavior is usually calculated according to sociodemographic and clinical indicators.[10] There are also genetic factors, whose accuracy is still subject to speculation, though such data can be considered in light of an individual's family history.[11] Risks associated with community and relationships include war and disasters, acculturation stress (e.g. among indigenous or displaced people), discrimination, affective separation, isolation, abuse, violence, and conflicting relationships.[3]

Among the individual risk factors, mental disorders stand out as an important cause of suicide.[12] Patients with a long history of mental or physical illness are at higher risk of committing suicide. Other risk factors on an individual level include previous suicide attempts, alcohol abuse, financial loss, chronic pain, and a family history of suicide.[13]

Social, psychological, cultural, and other factors may interact to lead a person to suicidal behavior, but the stigma associated with mental disorders and suicide prevents many people from seeking help. In recent decades, and particularly since 2000, a number of suicide prevention strategies have been developed.

In 1999 the WHO launched its Suicide Prevention Program (Supre), which is a worldwide suicide prevention initiative aimed at reducing the morbidity and mortality associated with suicidal behavior.[4] In in 2006, the Brazilian Ministry of Health inaugurated its National Strategy for Suicide Prevention, whose purpose is to reduce deaths, attempts, associated damage and impacts on families. Also in 2006, a Suicide Prevention Handbook for Mental Health Professionals was published in Brazil, whose objective is early detection of associated conditions and implementation of preventive measures.[14] Short-term measures have also been proposed, such as expanding mental health service coverage and increasing social and spatial accessibility to Psychosocial Care Centers (Centros de Atenção Psicossocial – CAPS). Long-term proposals include educational initiatives promoting holistic health for individuals and communities.[15] In 2009, the Brazilian Ministry of Health began its National Strategy for Suicide Prevention, whose purpose is to reduce the incidence of cases in Brazil, thus reducing the suicide death rate and the damage caused to those directly and indirectly involved.[8]

Studies on suicide in Brazil have described different scenarios and associated factors that, taken together with other results, may contribute to a better understanding of the phenomenon. Nevertheless, few studies have addressed the phenomenon's spatial behavior or its geographic relationship with extrinsic factors, data that could be applied to health services management and contribute to strategies for reducing the morbidity/mortality of the population. Considering both the importance of suicide as a cause of death in Brazil and the need to strengthen understanding of this phenomenon, this study's purpose was to evaluate the distribution of mortality from suicide in Brazilian municipalities and correlate it with socioeconomic indicators.

Methods

This is an ecological study of multiple groups, using Brazilian municipalities as a unit of analysis. The dependent variable or response was mortality from self-inflicted injuries, represented by the standardized mortality rate (SMR). Deaths occurring from January 1, 2010 to December 31, 2014 were used to calculate the SMR. The number of deaths was obtained from the Mortality Information System of the Brazilian Unified Health System's IT Department (Sistema de Informação sobre Mortalidade, Departamento de Informática, Sistema Único de Saúde – SIM/DATASUS).

Municipal population and age data were obtained from the 2010 Census and projections published on the Brazilian Institute of Geography and Statistics website. The gross rates were standardized through the direct method, considering the total Brazilian population and expressed per 100,000 population per year.[16]

The independent variables were the socioeconomic indicators of the Brazilian municipalities: (V1) Municipal Human Development Index (HDI-M); (V2) dependency ratio; (V3) aging rate; (V4) illiteracy rate among those $\geqslant$25 years of age; (V5) percentage of vulnerable poor; (V6) income ratio between the richest 10% and the poorest 40%; (V7) Gini index; (V8) unemployment rate among those $\geqslant$18 years of age; (V9) percentage of the population living in households with a density $>$2. The socioeconomic indicators for the year 2010 were collected from the United Nations Development Programme's (UNDP) Atlas of Human Development in Brazil (www.atlasbrasil.org.br).

A descriptive analysis of the variables used in the study was conducted and, to evaluate of the relationship between the selected socioeconomic indicators and the suicide SMR in Brazil, Pearson's correlation and Simple Linear Regression tests were applied. SPSS version 22.0 was used for data processing and statistical analysis.

The spatial dependence analysis was performed with the global Moran index, which estimates the spatial autocorrelation on a scale of -1 to +1. After the general

analysis, the presence of clusters was evaluated using local indicators of spatial association (LISA), which were then presented in BoxMap regardless of their statistical significance. To validate the global Moran index, a random permutation test with 99 permutations was employed.[17]

Bivariate LISA analysis was performed to evaluate the spatial correlation between the outcome variable (suicide SMR) and the independent variables. To do this, thematic maps were constructed with each pair of variables and their autocorrelation value was verified. These analyses were performed in GeoDa version 1.6.61.

Since this study used secondary data available on Brazilian Ministry of Health official websites, which does not identify individuals, it was exempt from evaluation by a research ethics committee, in accordance with Resolution 466/2012 of the National Health Council.

Results

The mean suicide mortality rate in Brazil from 2010 to 2014 was 5.23/100,000 population. The five Brazilian municipalities with the highest rates were: Taipas do Tocantins, state of Tocantins (79.68 deaths per 100,000 population); Itaporã, state of Mato Grosso do Sul (75.15 deaths per 100,000 population); Mampituba, state of Rio Grande do Sul (52.98 deaths per 100,000 population); Paranhos, state of Mato Grosso do Sul (52.41 deaths per 100,000 population); and Monjolos, state of Minas Gerais (52.08 deaths per 100,000 population).

The Midwest and the South had the highest mean suicide mortality rates. Of the socioeconomic indicators analyzed, the worst conditions were concentrated in the North and Northeast, which are characterized by low life expectancy, income inequalities, low education and low income. The most developed regions of the country, South and Southeast, were considerably different from the poorest ones (Table 1).

A weak correlation, very close to zero, was found between all independent variables and the dependent variable (Table 2).

The bivariate linear regression analysis between sociodemographic variables and suicide SMR confirmed that these variables have low explanatory power over SMR, as evident in the adjusted R^2 values obtained. On the other hand, in the spatial autocorrelation analysis, all sociodemographic variables had global Moran index values above 0.5, which shows a moderate to strong spatial autocorrelation distributed in clusters. The highest autocorrelation values were recorded for illiteracy rate among those $\geqslant$25 years of age (I = 0.87359) and percentage of vulnerable poor (I = 0.87359) (Table 3).

A pattern of spatial autocorrelation was not confirmed for suicide SMR. The global Moran index values showed a weak spatial autocorrelation (I = 0.2608) (Figure 1). Figure 1A shows that the highest municipal suidcide SMRs were in the Midwest and the South, along with a grouping in the Northeast and the North. In the mortality rate cluster analysis, shown as a MoranMap in Figure 1B,

Table 1 Descriptive analysis of socioeconomic indicators and suicide SMR (per 100,000 population) in Brazil and its macroregions: 2010-2014

Variables*	Geographical area					
	Brazil	North	Northeast	Midwest	Southeast	South
suicide SMR	5.23	5.43	5.14	7.34	6.13	10.74
V1 – HDI-M	0.727	0.607	0.590	0.689	0.698	0.714
V2 – Dependency	45.92	63.35	57.39	47.55	47.05	45.83
V3 – Aging	7.36	5.23	8.08	7.14	9.08	9.58
V4 – Illiteracy	11.82	22.38	34.97	15.38	13.58	9.76
V5 – Vulnerable poor	32.56	61.99	66.93	33.46	32.04	23.43
V6 – Income ratio	22.78	25.35	17.13	13.66	11.20	11.01
V7 – Gini	0.600	0.567	0.525	0.495	0.465	0.459
V8 – Unemployment	7.29	7.36	8.30	5.52	6.00	3.09
V9 – Density	27.83	45.13	33.06	20.78	20.45	13.83

HDI-M = Municipal Human Development Index; SMR = standardized mortality rate.
* Mean observed values.

Table 2 Correlation between suicide SMR (per 100,000 population) and socioeconomic variables in Brazil from 2010-2014

	SMR suicide	HDI-M	Dependency	Aging	Illiteracy	Vulnerables	Income ratio	Gini	Unemployment	Density
SMR suicide	1									
HDI-M	0.163	1								
Dependency	-0.144	-0.811	1							
Aging	0.222	0.238	-0.285	1						
Illiteracy	-0.181	-0.889	0.720	-0.134	1					
Vulnerables	-0.210	-0.936	0.832	-0.279	0.883	1				
Income ratio	0.048	-0.391	0.544	-0.308	0.330	0.455	1			
Gini	-0.113	-0.424	0.551	-0.345	0.401	0.562	0.775	1		
Unemployment	-0.260	-0.322	0.285	-0.299	0.342	0.445	0.189	0.296	1	
Density	-0.259	-0.645	0.774	-0.605	0.554	0.709	0.532	0.552	0.442	1

HDI-M = Municipal Human Development Index; SMR = standardized mortality rate.
All results were statistically significant ($p < 0.001$).

Table 3 Global Moran index and bivariate linear regression between socioeconomic indicators and suicide SMR (per 100,000 population) in Brazil from 2010-2014

	Bivariate analysis					
Variable	Coefficient	Default error	p-value	F	Adjusted R^2	Moran Index
HDI-M	14.303	1.162	< 0.001	151.5	0.026	0.71075
Dependency	-0.102	0.009	< 0.001	117.7	0.021	0.77160
Aging	0.508	0.034	< 0.001	289.0	0.049	0.63707
Illiteracy	-0.090	0.017	< 0.001	189.4	0.033	0.87359
Vulnerables	-0.059	0.004	< 0.001	14.009	0.044	0.88896
Income ratio	3.016	0.350	< 0.001	74.2	0.013	0.44526
Gini	-10.84	1.27	< 0.001	72.3	0.013	0.46629
Unemployment	-0.449	0.022	< 0.001	402.6	0.067	0.51899
Density	-0.126	0.006	< 0.001	400.4	0.067	0.85111

HDI-M = Municipal Human Development Index.

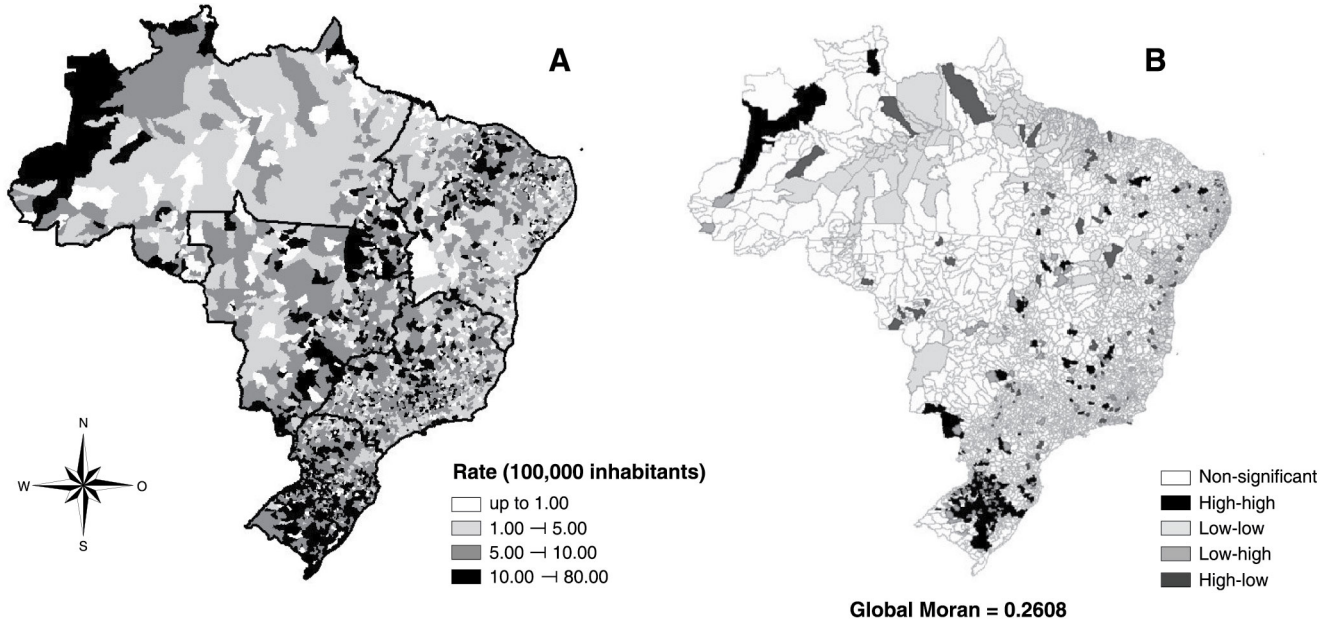

Figure 1 Analysis of suicide mortality in Brazil. A) Spatial distribution of suicide SMR in Brazilian municipalities; B) Spatial distribution of clusters of suicide SMRs with statistically significant local indicators of spatial association (LISA) (MoranMap), Brazil, 2010-2014.

a cluster of high mortality rates was identified in the South.

In the bivariate spatial analysis, the LISA/Moran's I value of all variables was close to zero, which indicates no spatial autocorrelation between the socioeconomic variables and suicide SMR (Figure 2). Even without spatial autocorrelation, cluster formations were observed in the distribution pattern of these variables. Outstanding among these cluster results was the formation of high mortality rate clusters with the variables dependency ratio, HDI-M, and aging rate, all in the South. Conversely, in the Northeast, SMR clusters were formed with the variables illiteracy, vulnerabe poor and Gini.

Discussion

Although this study on the spatial distribution of suicide mortality in Brazil found high mortality cluster formations in the South, there were neither significant spatial autocorrelation values nor associations with the analyzed socioeconomic factors.

Results that corroborate the findings of the present study were observed in a study on the spatial and socioeconomic determinants of suicide in Brazil between 1998 and 2002. This exploratory analysis found a strong global spatial association for mean suicide rate, with the Moran index values indicating a positive spatial autocorrelation that included cluster formation in the South and Midwest, where the two highest mortality rates in the country are found.[18]

However, it should be noted that in recent years different regional suicide mortality trends have been observed, especially in the Northeast and the North. Machado & Santos found that between 2000 and 2012, suicide mortality increased by 37.2% in the North, from 3.8 to 5.3 per 100,000 population. The Northeast, however, had the highest increase in suicide rate during the same period,

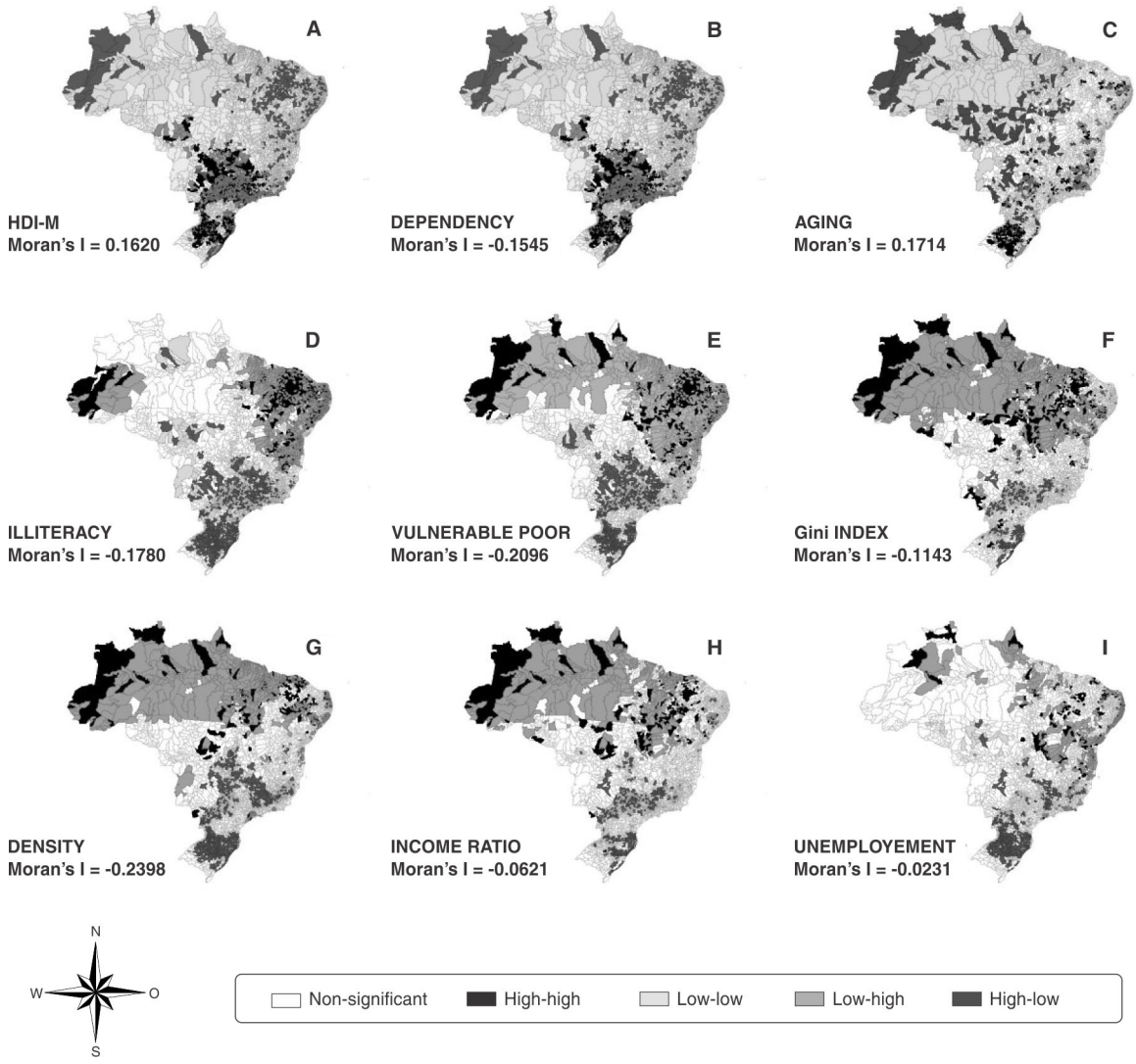

Figure 2 Bivariate local indicators of spatial association (LISA)/Moran's I between suicide SMR and socioeconomic variables in Brazilian municipalities, 2010-2014. A) Municipal Human Development Index (HDI-M); B) dependency ratio; C) aging rate; D) illiteracy rate; E) vulnerable poor; F) Gini index; G) population in households with density >2; H) income ratio between the richest 10% and the poorest 40%; I) unemployment rate.

rising 72.4% (from 3.0 in 2000 to 5.2 in 2012).[19] This is reinforced by the Map of Violence in Brazil (2014), which shows that suicide has been progressively increasing in the country: the rate rose 2.7% between 1980 and 1989, another 18.8% by 1999, and a further 33.3% by 2012.[20]

These data were corroborated in a study by Mota that mapped suicide in Brazil.[15] The author's spatiotemporal analysis of suicide considered groupings of deaths in three-year periods from 1979 to 2011, finding that the highest suicide rates were concentrated in the South and Southeast between 1979 to 1990, which subsequently expanded to the Northeast and Midwest in the following triennia and increased in certain microregions of the North and Northeast beginning in 2004-2006. These results indicate that suicide has become an important public health problem the Northeast and North, which was also demonstrated in the present study.

The suicide phenomenon is studied in several fields, being approached with two main types of analysis: the first involves factors related to the social and interpersonal contexts of the victims, i.e., the intrinsic determinants, while the second focuses on extrinsic determinants such as social and economic factors; the latter are the main focus of the present study.

One point to be considered is that no consensus exists in the literature about the relationship between suicide and socioeconomic status. High quality studies have proposed a direct relationship between high suicide rates and high regional socioeconomic status, while others have proposed an inverse relationship (low suicide rates in an area of high socioeconomic status) or no relation.[21]

The ecological proposal of the present study emphasizes multiple causes of violence and an interaction of risk factors that operates in a broader community context,

including social, cultural and economic dimensions. In such a developmental context, the ecological model shows how violence can stem from different factors at different stages of life.

Other ecological studies conducted in Brazil present important contextual factors related to suicide mortality. One study conducted in the state of Rio de Janeiro found an inverse correlation between suicide mortality rates and factors such as the percentage of Pentecostal residents, an individual's mean years of schooling, the percentage of people living on minimum wage, and the percentage of unmarried individuals.[1]

Lovisi et al.[22] claimed that sociodemographic characteristics such as poverty, unemployment and low education level are important factors that may be associated with suicide, especially in countries with serious socioeconomic problems, such as Brazil. These authors found that suicide was associated with sociodemographic characteristics such as low education level and lack of a partner.

In a study using data from Porto Alegre (state of Rio Grande do Sul), Recife (state of Pernambuco), Salvador (state of Bahia), Belo Horizonte (state of Minas Gerais), Rio de Janeiro and São Paulo – all with populations over one million and among the ten largest metropolitan areas of the country – a correlation was observed between suicide and certain work-related variables, such as occupation, sub-minimum wage income, and employment in the private sector or in construction, i.e., the suicide rate was inversely associated with unemployment.[23]

According to Durkheim,[24] society plays a fundamental role in the construction of the individual. Social factors[24] such as family, school, social groups, and friends have an acute positive or negative influence on the occurrence of suicidal episodes. The proposition that individuals are integrated into a social group regulated by norms and conventions has influenced the development of control theory. Durkheim's work is often referred to as a classic sociological study on suicide.

A relationship between lower education level and suicide was found in one Brazilian study,[19] which agrees with the findings of the present study, mainly due to the relationship between suicide SMR and illiteracy. In different regions of the world, there has been an increase in suicide rates among younger[9] and older populations,[5] data that may be related to the income and dependency ratios. Loureiro et al.[25] emphasize that purely economic factors, such as unemployment and income, have a greater impact on the suicide rate of younger people in society and that high occupational pressure and job market competitiveness are factors that make the young Brazilian population particularly vulnerable to the risk of suicide.

However, according to Durkheim,[24] there is a positive relationship between advancing age and suicide. He explained that old age is associated with the highest suicide rate due to the fact that devastating situations, such as social isolation, unemployment, economic setbacks and loss of loved ones, are experienced in this period.

A study carried out in Campinas, SP found a higher suicide mortality rate among men. In deaths from suicide, although the victim's underlying mental health is frequently compromised, family or economic relationship problems are often present. In situations of economic crisis and unemployment, a man's failure to perform as a provider could lead to family friction, exacerbated alcohol and drug consumption and even to family dissolution, which could be associated with suicide.[26]

The results of a study on the economic determinants of suicide suggest that economic factors are relevant as an explanation for suicide in Brazil. It is noteworthy that income was found to have a negative effect on the suicide rate, while inequality and unemployment had a positive impact. Poverty, moreover, was negatively correlated with suicide.[25]

Some analyses point out that the higher the income, the greater the consumerism, which creates a high degree of personal satisfaction and lowers the risk of suicide.[27] Durkheim, however, refuted this idea, claiming that increased income intensifies the suicide rate, since it increases personal independence and, thus, family degeneration.[28]

Mapping the distribution of suicide cases in Brazil by municipality makes it possible identify suicide risk areas, an approach currently relevant in the social determinants of health field, which seeks explanations for suicide index variations in their local context. There is a need for more organized epidemiological surveillance and research focused on higher occurrence areas to better understand this serious public health problem, as well as to improve the possibility of prevention.

In this perspective, when analyzing the spatial distribution results for suicide in Brazil and their relationship with social and economic indicators, it should be considered that there are multiple risk factors for suicide, which may be defined through epidemiological studies that utilize individualized information, such as suicide method, demographic factors, psychiatric factors, medical factors, factors related to suicidal behavior, hospitalization and medical treatment; further research addressing other aspects not identified in the present study can thus be developed.

This study's main limitation the use of secondary mortality data, which is subject to underreporting, although in recent years it has been recognized that the Mortality Information System in Brazil has substantially increased in quality. Other limitations involve the study design: although an ecological association may correctly reflect a causal association between exposure and a health-related condition/disease, the possibility of ecological bias is always perceived as a limitation on the use of ecological correlations.

This study's contribution, however, lies in the data provided for preventive territorially-determined campaigns that can more equitably distribute public resources by prioritizing regions with the worst indicators.

Disclosure

The authors report no conflicts of interest.

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