Original Article

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SPATIAL-TEMPORAL DISTRIBUTION AND FACTORS ASSOCIATED WITH HIV/AIDS MORTALITY AMONG YOUNG PEOPLE IN NORTHEASTERN BRAZIL

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ABSTRACT

Objective: to analyze the spatial-temporal distribution and factors associated with HIV/AIDS mortality among young people in the Northeast from 2001 to 2020.
Method: ecological study with 2,509 deaths from HIV/AIDS from northeastern residents aged between 10 and 24 years of age, reported in the Mortality Information System. Temporal analysis techniques (Joinpoint) and detection of spatial clusters (Spatial Autocorrelation, Gets-Ord *Gi** and Scan were used. Three spatial error and spatial lag (Spatial Error and Spatial Lag) and non-spatial regression models (*Ordinary Least Squares-OLS*) were used to identify the factors associated with mortality in northeastern municipalities, considering $p<0.05$.
Results: the HIV/AIDS mortality rate among young people in the northeast was 0.4 deaths per 100,000 inhabitants. Maranhão (APC:7.1; CI95%:2.3-12.1), Sergipe (PcA:6.9; CI95%:1.8-12.2), Rio Grande do Norte (PcA:6.4; CI95%:1.8-11.2), Ceará (PcA:4.2; CI95%:1.5-7.0) and Alagoas (APC:3.2; CI95%:0.1-6.4) showed a significant increasing trend of deaths. Cluster detection techniques indicated clusters of deaths mainly on the coast of Pernambuco and north-central Maranhão. The indicators proportion of the population in households with density >2 ($\beta=0.012$; $p<0.001$) and per capita transfer of the continued benefit ($\beta=0.000$; $p<0.001$) showed a positive relationship with the outcome. On the other hand, the proportion of extremely poor people ($\beta=-0.011$; $p=0.029$) and the Brazilian Deprivation Index ($\beta=-0.195$; $p=0.009$) were negatively associated with mortality.
Conclusion: there was a trend of increased mortality in five of the nine northeastern states. The spatial clusters were located mainly in Pernambuco and North-Central Maranhão. Interventions aimed at socioeconomic factors should be established to prevent HIV infections and deaths among young people.

DESCRIPTORS: Acquired Immunodeficiency Syndrome. Spatial analysis. Mortality. Epidemiology. Ecological Studies.

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DISTRIBUIÇÃO ESPAÇO-TEMPORAL E FATORES ASSOCIADOS À MORTALIDADE POR HIV/AIDS ENTRE JOVENS NO NORDESTE BRASILEIRO

RESUMO

Objetivo: analisar a distribuição espaço-temporal e os fatores associados à mortalidade por HIV/Aids entre jovens no Nordeste de 2001 a 2020.
Método: estudo ecológico com 2.509 óbitos por HIV/Aids de nordestinos de 10 a 24 anos notificados no Sistema de Informação sobre Mortalidade. Empregou-se técnicas de análise temporal (*Joinpoint*) e de detecção de aglomerados espaciais (Autocorrelação espacial, *Gets-Ord Gi** e varredura *Scan*). Empregou-se três modelos de regressão espacial (*Spatial Error and Spatial Lag*) e não espacial (*Ordinary Least Squares-OLS*) para identificação dos fatores associados à mortalidade nos municípios nordestinos, considerando-se p<0,05.
Resultados: a taxa de mortalidade por HIV/Aids entre jovens no Nordeste foi de 0,4 óbitos por 100.000 habitantes. Maranhão (APC:7,1; IC95%:2,3-12,1), Sergipe (APC:6,9; IC95%:1,8-12,2), Rio Grande do Norte (APC:6,4; IC95%:1,8-11,2), Ceará (APC:4,2; IC95%:1,5-7,0) e Alagoas (APC:3,2; IC95%:0,1-6,4) apresentaram tendência crescente significativa de mortes. As técnicas de detecção de *clusters* apontaram aglomerados de óbitos principalmente no litoral de Pernambuco e Centro-Norte maranhense. Os indicadores proporção da população em domicílios com densidade >2 (β=0,012; p<0,001) e transferência *per capita* do benefício de prestação continuada (β=0,000; p<0,001) apresentaram relação positiva com o desfecho. Em contrapartida, a proporção de pessoas extremamente pobres (β=-0,011; p=0,029) e o Índice Brasileiro de Privação (β=-0,195; p=0,009) apresentaram associação negativa com a mortalidade.
Conclusão: houve tendência de aumento da mortalidade em cinco dos nove estados nordestinos. Os *clusters* espaciais estiveram localizados, majoritariamente, no Pernambuco e Centro-norte maranhense. Intervenções direcionadas aos fatores socioeconômicos devem ser firmadas para prevenir as infecções e mortes por HIV entre jovens.

DESCRITORES: Síndrome da Imunodeficiência Adquirida. Análise espacial. Mortalidade. Epidemiologia. Estudos ecológicos.

DISTRIBUCIÓN ESPACIO-TEMPORAL Y FACTORES ASOCIADOS A LA MORTALIDAD POR VIH/SIDA ENTRE JÓVENES DEL NORESTE DE BRASIL

RESUMEN

Objetivo: analizar la distribución espacio-temporal y los factores asociados a la mortalidad por VIH/SIDA entre jóvenes del Nordeste de 2001 a 2020.
Método: estudio ecológico con 2.509 muertes por VIH/SIDA de residentes del noreste con edades entre 10 y 24 años, reportadas en el Sistema de Información de Mortalidad. Se utilizaron técnicas de análisis temporal (Joinpoint) y detección de conglomerados espaciales (Spatial Autocorrelation, Gets-Ord Gi* y Scan).) fueron utilizados para identificar los factores asociados a la mortalidad en las ciudades del noreste, considerando p<0,05.
Resultados: la tasa de mortalidad por VIH/SIDA entre los jóvenes del nordeste fue de 0,4 muertes por cada 100.000 habitantes. Maranhão (APC:7,1; IC95%:2,3-12,1), Sergipe (PcA:6,9; IC95%:1,8-12,2), Rio Grande do Norte (PcA:6,4; IC95%:1,8-11,2), Ceará (PcA:4,2 ; IC95%:1,5-7,0) y Alagoas (APC:3,2; IC95%:0,1-6,4) mostraron una tendencia significativamente creciente de muertes. Las técnicas de detección de conglomerados indicaron conglomerados de muertes principalmente en la costa de Pernambuco y el centro-norte de Maranhão. Los indicadores proporción de población en hogares con densidad >2 (β=0,012; p<0,001) y transferencia per cápita del beneficio de continuidad del beneficio (β=0,000; p<0,001) mostraron una relación positiva con el resultado. Por otro lado, la proporción de personas extremadamente pobres (β=-0,011; p=0,029) y el Índice de Carencia Brasileño (β=-0,195; p=0,009) se asociaron negativamente con la mortalidad.
Conclusión: hubo una tendencia de aumento de la mortalidad en cinco de los nueve estados del noreste. Los conglomerados espaciales se ubicaron principalmente en Pernambuco y en el centro-norte de Maranhão. Deben establecerse intervenciones dirigidas a los factores socioeconómicos para prevenir las infecciones por el VIH y las muertes entre los jóvenes.

DESCRIPTORES: Síndrome de Inmunodeficiencia Adquirida. Análisis espacial. Mortalidad. Epidemiología. Estudios ecológicos.

INTRODUCTION

Acquired Immunodeficiency Syndrome (AIDS) is a chronic disease caused by the human immunodeficiency virus (HIV) that mainly affects the immune system. This disease is treated with antiretroviral therapy (ART) provided free of charge by the Unified Health System (SUS). However, despite the availability of treatment, it is considered a relevant public health problem due to the high number of deaths and other related biopsychosocial factors, such as: functional disabilities that affect activities of daily living and productivity, reduced quality of life and social isolation that trigger mental disorders and psychological distress. In addition, the disease still leads to significant discussions about health service expenditures[1–3].

The magnitude of the epidemic is such that in 2020, there were 1.5 million new infections, adding to the total of 37.7 million people living with HIV/AIDS (PLWHA) worldwide[1–2] In addition, according to global statistics, in the same year about 680,000 people died from AIDS-related causes,10,500 registered in Brazil[4]. Of the total number of deaths in the country, the northeastern region stands out for being the second region with the highest proportion of deaths, since approximately one in four people who died (23.6%) were from this region[5].

In the period from 2010 to 2020, there was a significant decrease in the mortality rate from AIDS, from 5.7 to 4.0 deaths per 100,000 inhabitants[5]. However, some states in the northeastern region showed an increase in the death rate: Piauí (28.5%), Ceará (27.1%), Paraíba (15.4%) and Maranhão (2.5%)[5].

In the past two decades, the majority of individuals who have died from AIDS-related causes have been young individuals in their prime of life. A study carried out on the mortality of adolescents and young adults through an analysis of the global burden of diseases in Brazil, highlighted that in 2019 HIV/AIDS infection ranked seventh as a cause of death among women aged 10 to 24 years with a rate of 1.28 deaths per 100,000 inhabitants and, among men in the same age group, ranked ninth with a rate of 1.8 deaths per 100,000 inhabitants[6].

National data show that new cases of HIV among adolescents and young people have been increasing continuously, since in 2018 one in five cases occurred in adolescence (21.0%), mostly men[7]. This population is particularly vulnerable to illness and death due to the disease, as they are more susceptible to unprotected sexual practice, inadequate use or non-use of condoms in sexual relations, multiple sexual partners and more frequent use of alcohol and drugs[8].

Thus, the importance of developing epidemiological studies that identify the factors associated with mortality from HIV/AIDS-related causes among adolescents and young people is highlighted[3]. In order to understand how the disease behaves in the northeastern region, it is essential to use geoprocessing tools that map the problem, the association between indicators and the visualization of the most affected areas, in order to allow the adoption of preventive strategies. Therefore, the present study aimed to describe the spatial-temporal distribution and identify the factors associated with HIV/AIDS mortality among adolescents and young people under 24 years in northeastern Brazil from 2001 to 2020.

METHOD

This is an epidemiological ecological study, which uses geoprocessing tools and the municipalities of the northeastern region as the unit of analysis. According to the last Brazilian demographic census carried out in 2010, the population of the northeast was 53,078,137 people, of which 15,433,104 were adolescents and young people between 10 to 24 years of age. The northeast has 1,794 municipalities

spread over nine states, these are: Alagoas (AL), Bahia (BA), Ceará (CE), Maranhão (MA), Paraíba (PB), Pernambuco (PE), Piauí (PI), Rio Grande do Norte (RN) and Sergipe (SE)[9].

Data from this study are of the secondary type, recorded in the Mortality Information System (MIS), which are available on the website of the Department of Informatics of the Unified Health System (DATASUS), through the Tabnet portal. Deaths from HIV/AIDS among adolescents and young people between 10 to 24 years of age from 2001 to 2020, were selected according to the northeastern municipality of residence. According to the World Health Organization, adolescence corresponds to the second decade of life, from 10 to 19 years old and, in addition, considers that youth extends from 15 to 24 years old[10].

Univariate statistics were used to describe the sociodemographic characteristics of deaths. Subsequently, crude data on mortality from HIV/AIDS in each year investigated were imported into the free software Joinpoint Regression Program version 4.6.0.0 for analysis of temporal trends using regression methods based on inflection points. This analysis pinpoints whether one or more line segments should be added in a linear regression to indicate any change in the time trend, which opposes the null hypothesis that no points should be added. The results of this analysis estimate the annual percentage change (APC) of the studied trend, as well as its 95% confidence interval (95%CI) and its statistical significance, considering $p<0.05$[11].

For spatial analysis, the average crude mortality rates of the northeastern municipalities were initially calculated using indirect method standardization. As numerator of the formula, the total number of deaths from HIV/AIDS was used in the population studied divided by the total years investigated (20) and, as denominator, the average of the sum of the population of adolescents and young people in the northeastern municipalities of the central years of the period studied (2010 and 2011) was used, multiplied by 100,000 inhabitants. However, in order to reduce the instability of crude rates, these were later mitigated by the Local Empirical Bayes method to correct random fluctuations, especially in municipalities with a small number of inhabitants. For this purpose, a spatial proximity matrix was constructed by applying the criterion of first-order contiguity[12].

In order to identify spatial clusters, some methods were used, such as spatial autocorrelation, Scan and the Gertis-Ord Gi* technique. The spatial autocorrelation function was applied using the global and local Moran index. The global index was used 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 (Local Index Spatial Analysis – LISA) was calculated to verify the presence of spatial aggregates and quantify the degree of spatial association in each municipality of the sample set, considering $p<0.05$. The results of the local Moran index are presented using the Moran map and LISA map. The first allows to graphically visualize the degree of similarity between neighbors and is represented by four spatial patterns: municipalities with high rates and that are close to municipalities with equally high rates (high/high); municipalities that have low rates and are surrounded by municipalities that also have low rates (low/low); and municipalities that have areas of epidemiological transition and that exhibit high and low rates, but are very close to municipalities that have low and high rates (high/low and low/high)[13].

In addition, using the same contiguity matrix already mentioned, the Gertis-Ord Gi* technique was used. This analysis creates z-scores for each municipality based on the desired indicator. In the case of this study, the crude mortality rate due to HIV/AIDS was used among adolescents and young people in each municipality to create these scores. High z-scores values show areas of high cluster rates with areas of similar rates (hot areas – hotspots); already low z-score values show areas of low mortality rates surrounded by similar areas (cold areas – coldspots). In addition, the analysis shows the significance of these clusters, assuming significance of 5%[14].

A purely spatial scan analysis was also performed with the objective of detecting spatial clusters, as well as areas that are at higher risk for HIV/AIDS mortality among adolescents and young people, called Scan Statistics. For cluster identification, the discrete Poisson model was adopted. The Scan Statistic also allowed the calculation of relative risk (RR) in each northeastern municipality. Those with values >1 present a relative risk for HIV/AIDS mortality higher than the risk in the northeastern region as a whole.

To identify the factors that influence the HIV/AIDS mortality rate among adolescents and young people in the northeastern region, the selected socioeconomic indicators were inserted into a non-spatial Ordinary Least Squares (OLS) regression model, using the step forward method with an input value of 0.1. Those indicators that remained in the final multivariate OLS model with $p<0.05$ were also inserted into two global spatial regression models (spatial lag and spatial error). The three methods were compared, and the one with the best fit was selected by means of the highest value of the adjusted coefficient of determination (R^2) and the lowest value of the Akaike Information Criterion (AIC). It is worth mentioning that the significant variables in the OLS model were only inserted in global geographic models after the OLS residuals had shown spatial autocorrelation.

The indicators that comprised the final multivariate regression model were: Proportion of extremely poor (PIND), average per capita income (CPRD), Theil-L Index (THEIL), percentage of the population living in households with density greater than 2 people per dormitory (T_DENS), Transfer per capita of *Bolsa Família* (R_TRPCBF), Transfer per capita Continued Benefit (R_TRPCBPC) and Brazilian Deprivation Index (IBP).

The indicators that made up the final multivariate regression model were: Proportion of extremely poor (PIND), Average per capita income (RDPC), Theil-L index (THEIL), Percentage of the population living in households with a density of more than 2 people per dormitory (T_DENS), per capita *Bolsa Família* transfer (R_TRPCBF), Transfer per capita of Continued Benefit (R_TRPCBPC) and Brazilian deprivation index (IBP).

The local empirical Bayes rate and the spatial autocorrelation test were calculated using TerraView 4.2.2 software. Purely spatial scan analysis was performed using the SaTScan 9.7 program. The analysis of Gertis-Ord Gi* spatial clusters, and the spatial lag and spatial error regressions were performed in the GeoDa 1.14 program. Classic non-spatial OLS regression analysis was performed using Stata v.12® software. All maps were produced using the QGIS 3.16 software.

RESULTS

A total of 2,509 deaths from HIV/AIDS were identified among adolescents and young people in the period 2001-2020. Most of these were young people between 20 and 24 years of age (n=1,989; 79.2%), male (n=1,590; 63.3%), single (n=2016; 91.5%), with 4 to 7 years of study (n=669; 40.0%). It was also observed that deaths due to HIV/AIDS predominated among brown people (n=1,498; 65.6%) and only three deaths were recorded among indigenous people (0.1%) (Table 1).

The temporal analysis by Joinpoint shows that the state of Maranhão had the most significant increase in mortality, with a statistically significant increase of 7.1% per year (95%CI: 2.3 – 12.1; p=0.006) from 2001 to 2013. However, after this period, it showed a non-significant decrease and a stationary trend (APC:-7.0; 95%CI:-16.3 – 3.4; p=0.167). There was also a significant increase in mortality from HIV/AIDS in the states of Sergipe (APC: 6.9; 95%CI: 1.8-12.2; p=0.010), followed by Rio Grande do Norte (APC: 6.4; 95%CI: 1.8-11.2; p=0.009), Ceará (APC: 4.2; 95%CI: 1.5-7.0; p=0.004) and Alagoas (APC: 3.2 ;95%CI: 0.1-6.4;p=0.041) (Table 2).

Table 1 – Sociodemographic characterization of HIV/AIDS deaths among adolescents and young people in northeastern Brazil in the period 2001-2020. Parnaíba, Piauí, Brazil, 2022. (N=2,509)

Variables	n	%
Age group		
10 to 14 years	111	4.4
15 to 19 years	409	16.3
20 to 24 years old	1,989	79.2
Sex		
Male	1.590	63.3
Female	919	36.6
Color/Race*		
White	487	21.3
Black	289	12.6
Yellow	5	0.2
Mixed	1,498	65.6
Indigenous	3	0.1
Schooling†		
None	112	6.6
1 to 3 years	392	23.4
4 to 7 years	669	40.0
8 to 11 years	399	23.8
12 years or more	100	5.9
Marital Status‡		
Single	2016	91.5
Married	94	4.2
Widower	6	0.2
Separated	9	0.4
Other§	76	3.4

*Missing cases were excluded (ignored): n=227; † Missing cases (ignored): n=837 were excluded; ‡Missing cases (ignored): n=308) were excluded; §Nomenclature used by DATASUS which corresponds to marital situations other than those presented

Table 2 – Annual percentage change in HIV/AIDS mortality among adolescents in northeastern Brazil in the period 2001-2020. Parnaíba, Piauí, Brazil, 2022. (N=2,509)

State	Period	Annual Percentage Change (IC95%)	p-value	Tendency
Alagoas	2001 – 2020	3.2 (0.1 – 6.4)	**0.041**	Increasing
Bahia	2001 – 2020	0.2 (-1.4 – 1.7)	0.832	Stationary
Ceará	2001 – 2020	4.2 (1.5 – 7.0)	**0.004**	Increasing
Maranhão	2001 – 2013	7.1 (2.3 – 12.1)	**0.006**	Increasing
	2013 – 2020	-7.0 (-16.3 – 3.4)	0.167	Stationary
Paraiba	2001 – 2020	0.2 (-1.8 – 2.3)	0.822	Stationary
Pernambuco	2001 – 2020	-0.9 (-2.8 – 1.1)	0.377	Stationary
Piauí	2001 – 2020	0.6 (-2.4 – 3.8)	0.666	Stationary
Rio Grande do Norte	2001 – 2020	6.4 (1.8 – 11.2)	**0.009**	Increasing
Sergipe	2001 – 2020	6.9 (1.8 – 12.2)	**0.010**	Increasing

Figure 1 shows the results of the spatial analysis techniques employed in this study. The map of crude mortality rates (Map A) points to irregular dispersion, forming an image with the appearance of a mosaic and with most municipalities presenting rates ranging from 0.0 to 1.13 deaths per 100,000 inhabitants. After mitigation by the local empirical Bayes method, a decrease in dispersion and greater stability of rates were observed. Thus, clusters of deaths were found that predominantly covered municipalities in Pernambuco, Maranhão, Bahia, Alagoas and Paraíba, with death rates ranging from 0.73 to 6.39 per 100,000 inhabitants. However, the highest rates verified (from 2.52 to 6.39 per 100,000 inhabitants) are found in municipalities on the coast of Pernambuco and central Maranhão (Map B).

The Local Moran Index was calculated after verifying the significant global spatial autocorrelation (I=0.106; p=0.001). The classification of northeastern municipalities in terms of mortality from HIV/AIDS in the Moran scatter plot showed that the high/high distribution pattern (in red) is located mainly on the coast of the state of Pernambuco and Central-North of Maranhão (Map C). In turn, map D shows the intensity of statistical significance of municipalities that showed some spatial pattern in the Moran map. It shows that the municipalities with a high/high pattern of distribution and statistical confidence of 99.9% are found primarily on the coast of Pernambuco.

Through the Gertis-Ord Gi* technique, the spatial pattern already visualized on the Moran map can be highlighted, which points out hot areas (hotspots) in all the states of the region (in red), with special emphasis on the coast of Pernambuco and north-central Maranhão and some municipalities in Paraíba, Alagoas and Bahia (Maps E and F).

Maps G and H show spatial clusters and relative risk (RR) of HIV/AIDS mortality among adolescents and young people in the region, calculated by the purely spatial Scan scan. Sixteen clusters were identified, however, only ten presented statistical significance ($p<0.05$). The primary cluster (in red), that is, the one with the lowest probability of random occurrence, included 66 municipalities, being mainly located in Pernambuco. Secondary clusters, which are also statistically significant, are especially located on the northern coast of Alagoas and in the metropolitan regions of Imperatriz and São Luiz (Maranhão), Fortaleza (Ceará) and Salvador (Bahia) (Map G).

It was found that all states in the Northeast, except Ceará, presented at least one municipality with the highest relative risk values (RR= 4.72 – 10.25), with Várzea, in Paraíba, being the municipality with the highest RR in the region (RR=10.26) (Map H).

Table 3 describes the detailed information of the 14 clusters of deaths identified in the scan. The primary cluster has a radius of 79.60 km covering municipalities in the states of Pernambuco and Alagoas. This cluster has, on average, 2.63 times higher risk of HIV/AIDS mortality compared to other municipalities in the entire region studied.

To test the influence of socioeconomic indicators on the HIV/AIDS mortality rate among adolescents and young people, the results of the analysis of the regression models OLS (R2= 0.062; AIC=4471.79), Spatial Lag (R2=0.074; AIC=4458.11) and Spatial Error (R2= 0.073; AIC=4457.09) were compated. Thus, it was identified that the global spatial models were better adjusted, since the Spatial Lag presented a higher R2 and the Spatial Error presented a lower AIC.

Table 4 shows the results of the three regression models. The global spatial models indicate that the indicators proportion of population in households with density >2 (T_DENS) and per capita transfer of the benefit of continued provision (R_TRPCBPC) showed a positive relationship with the outcome. On the other hand, the proportion of extremely poor people (PIND) and the Brazilian Index of Deprivation (IBP) showed a negative association with the dependent variable.

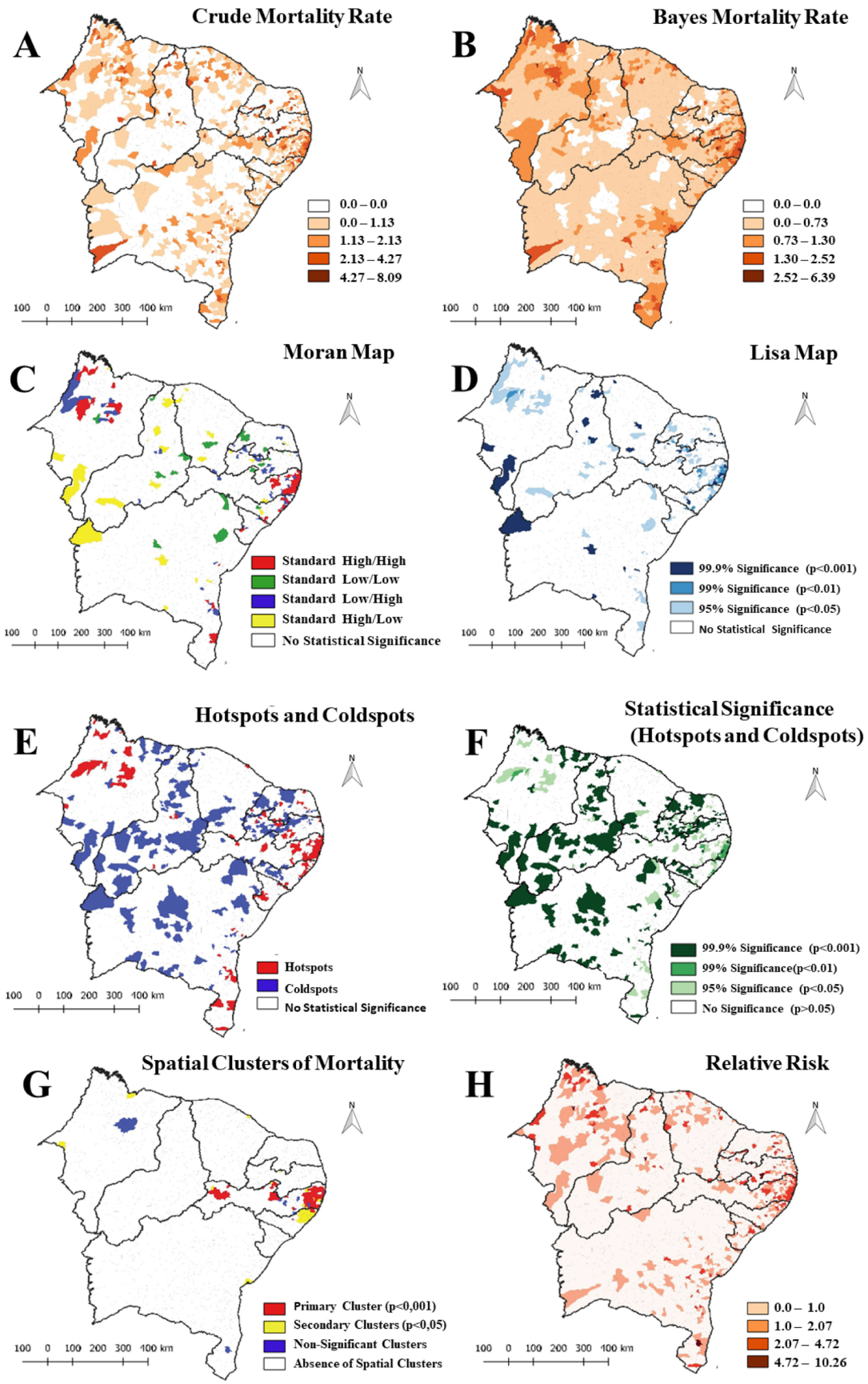

Figure 1 – Crude mortality rate (A), Mitigated rate by local empirical Bayes method (B), Moran Map (C), Lisa Map (D), High and Low Clusters (E), Statistical significance of hot and cold areas (F), Spatial clusters of mortality (G) and Relative risk according to scan (H). Northeast, Brazil, 2001-2020. Parnaíba, Piauí, Brazil, 2022.

Table 3 – Spatial clusters of HIV/AIDS mortality among adolescents and young people, defined by purely spatial scan statistics. Northeast, Brazil, 2001-2020. (N=2,509)

Cluster	Number of Municipalities	States	Radius (Km)	Number of cases	Expected number of cases	RR	LR†	p value
1	66	PE, AL	79.60	478	206.26	2.63	146.84	**<0.001**
2	19	PE, PB	34.94	262	105.77	2.65	86.65	**<0.001**
3	6	PE	29.20	134	44.65	3.11	59.55	**<0.001**
4	4	MA	20.20	147	60.63	2.51	45.36	**<0.001**
5	4	BA	21.25	238	127.48	1.95	40.68	**<0.001**
6	3	BA	12.47	225	120.25	1.95	38.56	**<0.001**
7	1	CE	0.00	192	105.65	1.88	29.92	**<0.001**
8	2	PE	18.07	21	5.42	3.89	12.89	**0.003**
9	47	PE, AL	68.94	137	87.10	1.60	12.66	**0.004**
10	1	MA	0.00	31	12.28	2.54	10.05	**0.038**
11	4	PE	15.68	18	5.65	3.19	8.52	0.158
12	4	PE	18.02	35	16.19	2.17	8.23	0.211
13	9	MA	42.68	35	16.58	2.12	7.78	0.311
14	1	BA	0.00	7	1.37	5.08	5.75	0.888

*Relative Risk; † Likelihood Ratio

Table 4 – Table with the OLS, spatial lag and spatial error regression models of socioeconomic indicators that influence the mortality rate among adolescents and young people in the northeast, in the period 2001-2020. Parnaíba, Piauí, Brazil, 2022. (N=2,509)

Indicators	OLS			*Spatial Lag*			*Spatial Error*		
	Coef.	Standard Error	p	Coef.	Error Pattern	P	Coef.	Standard Error	p
CONSTANT	0.083	0.183	0.650	0.144	0.035	<0.001	0.113	0.187	0.544
STICK	-0.012	0.005	0.027	-0.011	0.005	**0.035**	-0.011	0.005	**0.029**
RDPC	6.302	0.000	0.893	5.844	0.000	0.900	-3.493	0.000	0.940
THEIL	0.216	0.329	0.511	0.265	0.326	0.416	0.312	0.329	0.342
T_DENS	0.013	0.002	<0.001	0.011	0.002	**<0.001**	0.012	0.002	**<0.001**
R_TRPCBF	0.000	0.000	0.105	0.000	0.000	0.098	0.000	0.000	0.112
R_TRPCBPC	0.000	0.000	<0.001	0.000	0.000	**<0.001**	0.000	0.000	**<0.001**
IBP	-0.182	0.074	0.013	-0.178	0.073	**0.015**	-0.195	0.075	**0.009**
LAMBDA (*Spatial Error*)	-	-	-	-	-	-	0.145	0.036	<0.001

DISCUSSION

The majority of AIDS deaths in this population occurred among males between 20 and 24 years of age. It is known that, historically, men do not have the habit of seeking medical attention[2], which makes them less likely to undergo the anti-HIV test, to seek antiretroviral treatment and, consequently, more likely to fall ill and die due to the illness[15].

It was also found that a significant portion of deaths were in single people. This result reflects a peculiar characteristic of this age group, since in Brazil only 39.9% of adolescents and young people are married or in a stable relationship. On the other hand, the high proportion of single people among the individuals in this study may also suggest the practice of risky sexual behaviors, such as having multiple partners and not using barrier methods for the prevention of Sexually Transmitted Infections (STIs)[16].

Mixed race was the most prevalent among individuals in this investigation. This fact may be associated both because Brazil is mostly composed of individuals with brown skin[17], as well as due to the social exclusion of this specific population, which, for the most part, is in places that have scarcity of resources and precarious sanitation, education, housing and work conditions, which increases the vulnerability of these individuals to various diseases[18].

The present study highlights increasing mortality rates in the states of Maranhão, Sergipe, Rio Grande do Norte, Ceará and Alagoas. This increase is associated with the expansion of the disease observed in northeastern Brazil in recent years. This is due to the region suffering historical weaknesses in the transfer of financial resources, which exposes infected individuals to precariousness and scarcity of specialized services, resulting in late diagnosis and access to treatment[19–20]. These results are moving towards the 90-90-90 target of The Joint United Nations Programme on HIV/AIDS (UNAIDS) aimed at reducing the number of HIV/AIDS-related deaths[21].

Clusters of deaths were identified in major socioeconomic centers, especially in municipalities on the coast of Pernambuco and Alagoas and in the metropolitan regions of Imperatriz and São Luiz (Maranhão), Fortaleza (Ceará) and Salvador (Bahia). Meanwhile, the irregular distribution of the disease in the Brazilian territory stands out, in which the concentration of cases occurs in metropolitan regions, urban centers and cities with greater demographic density and socioeconomically more developed[18–19].

A study conducted in the northeast that analyzed the epidemiological profile of HIV/AIDS deaths in the general population presented results similar to those obtained in this study, as it showed that the states with the highest death rates in the period from 2006 to 2016 were, respectively, Pernambuco, Maranhão and Bahia[16]. In addition, the municipalities of the coast of Pernambuco and the North-Central region of Maranhão presented the highest mortality rates, especially in the pernambuco coast the municipalities of Olinda, Cabo de Santo Agostinho, Jaboatão dos Guararapes and Recife[22], as well as the municipalities of north-central Maranhão Bacabal, Igarapé Grande, São Luís and São José de Ribamar[23].

The literature highlights that the concentration of HIV/AIDS cases in more urbanized locations with high population densities can be explained by the constant migration of people from the countryside and even from other states in search of specialized medical treatments when the disease is already established. Furthermore, the more densely populated coastal areas are also considered potential territories that harbor clusters of HIV cases, since they allow for a greater flow of people through tourism, increasing the spread of the virus. In short, it is assumed that if there are more AIDS cases in the capitals compared to the interior of the states, it is expected that more deaths occur where there are more people infected by the disease[18,23].

In the present study, it can be observed that the living condition is indicated as a risk factor for mortality from HIV/AIDS, since the higher the average number of residents per household, the higher the occurrence of deaths from the disease. According to research conducted in the state of Piauí, in the municipality of Guadalupe, it can be observed that this indicator is interconnected with the high rates of incidence and mortality from AIDS[18].

The housing indicator is associated with the living conditions of the population, since housing and the environment have an important impact on the health and socioeconomic status of the individual[18–24]. In this sense, it is necessary that government investments focus on housing programs,

with the objective of reducing excessive household density, since it has proved to be an important reducer of social problems and deaths from HIV/AIDS[18–25].

Inconsistent results were also identified in this study, in which social and economic problems were configured as protective factors for AIDS mortality rates, in contrast with most of the results available in the literature on the subject.

In this sense, the per capita transfer indicator of the continued transmission benefit was positively associated with mortality. Research carried out in Ceará with individuals who attend the unit of the National Network of people living with HIV/AIDS showed that 44.6% of respondents received this benefit, being presented as an alternative income for this population. This is particularly important given that, depending on the level of viral load, many infected people are unable to work or have been fired due to their pathology. Thus, this benefit is described as a financial aid for families, in addition to representing an essential income for survival[24].

This research also pointed out that the higher proportion of extremely poor people and the increase in the Brazilian Index of Deprivation were associated with lower AIDS mortality rates in the investigated population. These results corroborate with studies carried out in African countries and in Chinese provinces, which showed that socioeconomic development influenced the increase in AIDS mortality rates, that is, the better the economic situation of individuals in these countries, the higher the mortality rates due to HIV/AIDS in this population[26–29].

A study carried out in Malawi identified a high prevalence of HIV in the most urbanized areas, namely the central and southern regions of the country. This finding showed that these regions have the largest cities in the country and that, together, they comprise most of the high-income population. The study justifies the high rates of HIV in these regions because they are home to the main universities, places where many university students with good socioeconomic conditions are involved in casual sexual relations and with multiple partners, increasing the risk of HIV/AIDS infection and, consequently, the risk of death from this disease[27].

In addition, another study also carried out in Malawi showed that wealthy men are susceptible to dying from AIDS-related illnesses due to the practice of exchanging sex for money. Furthermore, mortality from the disease in this African country occurs predominantly among the more affluent members of communities, since infections are still concentrated among the wealthiest, urban employees and members who move within society[29].

The data from international studies presented here are extremely relevant to explain AIDS mortality among young people from the northeast. However, it is necessary to analyze other aspects of life to determine the epidemic in the world, such as, for example, the behavioral and cultural factors of each region, since these factors can be decisive for acquiring the disease and for the deaths related to it[18].

In addition to findings similar to those observed in the African and Asian continents, another justification for the contradictory data found in this investigation is the use of municipalities as a unit of analysis. These have very unequal areas in their interior, as they are divided into several neighborhoods that have different characteristics, being separated by better or worse living conditions. In this way, one can find specific associations closer to the social and economic reality when the analysis is concentrated in smaller regions and with less disparities.

It is important to clarify that caution is necessary in the interpretation of some results presented in this study. Although some predictor variables such as the proportion of the population in households with density >2, per capita transfer of the benefit of continuous transmission, proportion of extremely poor people and the Brazilian Deprivation Index have presented statistical significance in global spatial models, their estimated coefficients are very close to zero, demonstrating that the effect of these indicators on the outcome variable is small.

The problem of the disease is multifactorial, which requires a reflective professional approach to comprehensive practices in the work of professionals, especially nurses, who care for the population living with HIV/AIDS. In this perspective, it is essential to formulate innovative public health policies focused on the dissemination of health information for this target audience, measures on pre-exposure to the virus, and incentives to perform tests[30]. Thus, the results of this investigation show the dynamics of the disease in time and space, focusing on the most affected areas, which can help direct actions, minimize the impact of the infection and support further studies on the subject.

One of the limitations presented in this investigation refers to the type of evaluation of social and environmental contexts that can affect the health of the population, because in this analysis, the variables of the population set do not necessarily represent an association in the individual field. In addition, the use of secondary data may present instabilities in relation to the quantity and quality of information and, in relation to vulnerability indicators, the data used are related to the 2010 census, and may have changed over time.

CONCLUSION

There was a trend of increased mortality from HIV/AIDS among adolescents and young people in the Northeast. Specifically in Maranhão, this increase occurred until 2013 and, in the states of Sergipe, Rio Grande do Norte and Alagoas, there was a linear trend of increase throughout the period studied. Furthermore, the spatial methods used in this study identified clusters of deaths primarily in the states of Pernambuco and Maranhão.

Socioeconomic indicators associated with HIV/AIDS mortality among adolescents and young people in the Northeast were identified through regression models. The indicators proportion of the population in households with density greater than two people and per capita transfer of the continued benefit presented a positive association with the dependent variable. On the other hand, the indicators proportion of extremely poor people and the Brazilian Deprivation Index presented a negative association.

Using the results of this research, it is suggested to conduct studies with other design and methods of analysis, especially those at the individual level, which can provide theoretical-scientific basis for interventions directed to socioeconomic factors that influence the health of people living with HIV/AIDS. Thus, it is expected to prevent infections and deaths from HIV/AIDS among adolescents and young people, in addition to aids-related diseases. From this perspective, it is necessary to consolidate actions aimed at this public that involve the different sectors of society. Thus, it is necessary for the health professional to know the influence of territorial characteristics, identifying the vulnerabilities in the health-disease process of this population in order to make health actions more effective.

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NOTES

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Study design: Ribeiro LM, Maranhão TA, Sousa GJB.
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Data analysis and interpretation: Ribeiro LM, Sousa GJB, Maranhão TA, Pereira MLD, Frota MMC, Rocha MIF.
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APPROVAL OF ETHICS COMMITTEE IN RESEARCH

All ethical and legal aspects recommended by Resolution 510/16 of the National Health Council were respected. It is emphasized that, due to the study using secondary data from the public domain, it was not necessary to submit this study to a Research Ethics Committee.

CONFLICT OF INTEREST

There is no conflict of interest.

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