

## **INFLUENCE OF THE SOCIAL DETERMINANTS ON THE INCIDENCE OF AIDS IN PIAUÍ: AN ECOLOGICAL STUDY**

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### **ABSTRACT**

**Objective:** to identify the social factors that determine the incidence of aids in the Piauí territory.

**Method:** an ecological study that uses geoprocessing techniques in which 2,908 aids cases of individuals residing in Piauí were considered, notified to the Notifiable Disease Information System (*Sistema de Informações de Agravos de Notificação*, SINAN), from 2007 to 2015. Gross and Bayesian incidence rates were calculated using the population of the central year (2011), multiplied by 100,000 inhabitants, with Bayesian statistics used to identify spatial clusters. The non-spatial *Ordinary Least Squares Estimation* (OLS) and spatial *Geographically Weighted Regression* (GWR) regression models were used to identify the social determinants of the incidence of aids in the state, with 5% of significance.

**Results:** the highest rates of the disease are concentrated in cities near the capital Teresina, with a Bayesian incidence of over 11.27 cases/100,000 inhabitants. The predictor variables of the incidence of ADIS in Piauí cities were the following: the percentage of individuals in houses with inadequate walls ( $p=0.0139$ ), the mean number of residents per household ( $p=0.0309$ ), and the percentage of individuals in households vulnerable to poverty and in which no one has completed elementary school ( $p=0.0051$ ).

**Conclusion:** according to GWR, the social factors that influence the incidence of aids in the cities of Piauí are the percentage of individuals in houses with inadequate walls, the mean number of residents per household, and the percentage of individuals in houses vulnerable to poverty and in which no one has completed elementary school. Given the above, interventions on the health social determinants of a structural nature should be established as effective methods for the prevention of HIV/ aids.

**DESCRIPTORS:** HIV. Acquired Immunodeficiency Syndrome. Social Determinants of Health. Spatial analysis. Geographical mapping. Epidemiology. Incidence.

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# INFLUÊNCIA DOS DETERMINANTES SOCIAIS SOBRE A INCIDÊNCIA DE AIDS NO PIAUÍ: UM ESTUDO ECOLÓGICO

## RESUMO

**Objetivo:** identificar os fatores sociais que determinam a incidência de aids no território piauiense.

**Método:** estudo ecológico com uso de técnicas de geoprocessamento em que se considerou 2.908 casos de aids de residentes no Piauí notificados no Sistema de Informações de Agravos de Notificação (SINAN) no período 2007-2015. As taxas de incidência brutas e bayesianas foram calculadas utilizando-se a população do ano central (2011), multiplicado por 100.000 habitantes, sendo a estatística bayesiana empregada para identificação de clusters espaciais. Os modelos de regressão não espacial *Ordinary Least Squares Estimation* (OLS) e espacial *Geographically Weighted Regression* (GWR) foram usados para identificar os determinantes sociais da incidência de aids no estado, com significância de 5%.

**Resultados:** as maiores taxas da doença se concentram especialmente em municípios próximos à capital Teresina, com incidência bayesiana acima de 11,27 casos/100.000 habitantes. As variáveis preditoras da incidência de aids nos municípios piauienses foram: percentual de pessoas em domicílios com paredes inadequadas ( $p=0,0139$ ), média de moradores por domicílio ( $p=0,0309$ ) e percentual de pessoas em domicílios vulneráveis à pobreza e em que ninguém tem ensino fundamental completo ( $p=0,0051$ ).

**Conclusão:** de acordo com o GWR, os fatores sociais que influenciam a incidência de aids nos municípios piauienses são percentual de pessoas em domicílios com paredes inadequadas, média de moradores por domicílio e percentual de pessoas em domicílios vulneráveis à pobreza e em que ninguém tem ensino fundamental completo. Diante disso, Intervenções sobre os determinantes sociais da saúde de caráter estrutural devem se fixar como métodos efetivos de prevenção do HIV/aids.

**DESCRITORES:** HIV. Síndrome da Imunodeficiência Adquirida. Determinantes sociais da saúde. Análise espacial. Mapeamento geográfico. Epidemiologia. Incidência.

# INFLUENCIA DE LOS DETERMINANTES SOCIALES SOBRE LA INCIDENCIA DEL SIDA EN PIAUÍ: UN ESTUDIO ECOLÓGICO

## RESUMEN

**Objetivo:** identificar los factores sociales que determinan la incidencia del SIDA en el territorio de Piauí.

**Método:** estudio ecológico en el que se emplearon técnicas de geoprosesamiento donde se consideraron 2.908 casos de SIDA de residentes de Piauí notificados al Sistema de Información de Enfermedades Notificables (*Sistema de Informações de Agravos de Notificação*, SINAN) en el período 2007-2015. Los índices brutos y Bayesianos de incidencia se calcularon utilizando la población del año central (2011), multiplicada por 100.000 habitantes, empleándose la estadística Bayesiana para identificar agrupamientos espaciales. Se utilizaron los modelos de regresión no espacial *Ordinary Least Squares Estimation* (OLS) y espacial *Geographically Weighted Regression* (GWR) para identificar los determinantes sociales de la incidencia del SIDA en el estado, con una significancia del 5%.

**Resultados:** los índices más elevados de la enfermedad se concentran especialmente en municipios próximos a la capital Teresina, con incidencia Bayesiana superior a 11,27 casos/100.000 habitantes. Las variables predictoras de la incidencia del SIDA en los municipios de Piauí fueron las siguientes: porcentaje de personas que viven en domicilios con paredes no adecuadas ( $p=0,0139$ ), media de moradores por domicilio ( $p=0,0309$ ) y porcentaje de personas que viven en domicilios vulnerables a la pobreza y en los que ninguno de los moradores ha completado la educación primaria ( $p=0,0051$ ).

**Conclusión:** De acuerdo con el modelo GWR, los factores sociales que influyen la incidencia del SIDA en los municipios de Piauí son los siguientes: porcentaje de personas que viven en domicilios con paredes no adecuadas, media de moradores por domicilio y porcentaje de personas que viven en domicilios vulnerables a la pobreza y en los que ninguno de los moradores ha completado la educación primaria. Frente a esta situación, se deben instaurar intervenciones sobre los determinantes sociales de la salud de carácter estructural como métodos efectivos de prevención del VIH/SIDA.

**DESCRITORES:** VIH. Síndrome de Inmunodeficiencia Adquirida. Determinantes Sociales de la Salud. Análisis espacial. Mapeo geográfico. Epidemiología. Incidencia.



## INTRODUCTION

Acquired Immunodeficiency Syndrome (aids) is a chronic disease that, despite more than 30 years of having been identified, still worries and challenges the world. Many devastating consequences have emerged from the disease, including increased impact on health sector spending and stigmatization.<sup>1</sup> The magnitude of the epidemic is such that, in 2017, there were 1.8 million new infections, adding to a total of 36.9 million people living with HIV/aids (PLWHA) in the world.<sup>2</sup>

In general, the aids detection rate in Brazil has been stable in the last decade, with a mean of 18.5/100,000 inhabitants. However, there are significant differences between the Brazilian regions since, as a decreasing tendency has been perceived in the Southern and Southwest regions of the country, in the Northern and Northeastern regions, a linear increase stands out in the detection rate of the disease in the last 10 years. More specifically in Piauí, a Northeastern Brazilian state, the aids detection rate had a mean increase of 45.6%, and the mortality coefficient rose 31.0% in the period from 2006 and 2016. Thus, faced with the official statistics, the need for studies with a population nature that identify the factors that may be influencing the increase of the disease incidence in the state stands out.<sup>3</sup>

The heterogeneity of the epidemic in the various socioeconomic and demographic contexts highlights the importance of an approach on the population that lives in specific places.<sup>4</sup> In view of this, studies that use geoprocessing tools and spatial analysis techniques in mapping aids in different territories have succeeded in outlining priority areas for planning and programming prevention strategies and tackling the disease, as well as in the evaluation of the impacts of the actions performed.<sup>5-6</sup>

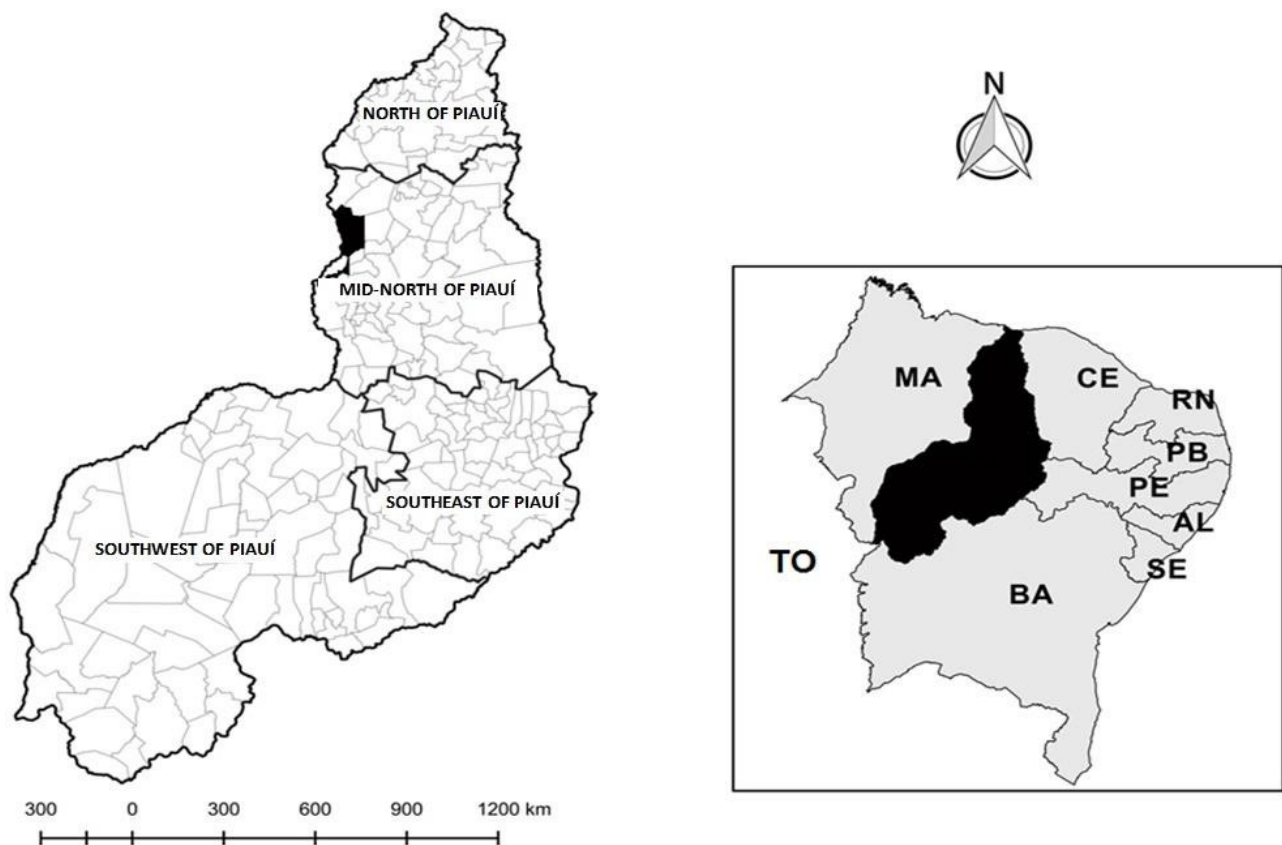
Every year, the expressive number of individuals that get infected with HIV and, at the same time the life expectancy of the infected people, increased considerably after the antiretroviral therapy was made available, thus increasing the number of PLWHA.<sup>2</sup> Given this, it is fundamental to know the social factors that are contributing to people falling ill due to causes related to aids among those living with HIV.

The knowledge of these social characteristics that lead the progression of the infection by aids is based on the Social Determination of Health (SDH), which refers to the social conditions in which people live and work and that directly interfere with the health-disease process. Health improvement only really occurs when the focus is on populations by means of inter-sectoral public policies that benefit society as a whole by encouraging it to be healthier.<sup>7</sup>

Therefore, health is inserted in a wider notion of living conditions, to the extent that both health and disease are socially built processes and that aspects such as environment, income distribution, and access to the health services can interfere with these processes with different intensities.<sup>7</sup> Given the above, this study aims to identify the social factors that determine the incidence of aids in the Piauí territory.

## METHOD

This is an epidemiological research study of the ecological type conducted in the state of Piauí, located in Northeast Brazil. The state limits to the North with the ocean, to the South with the states of Bahia (BA) and Tocantins (TO), to the East with Ceará (CE) and Pernambuco (PE), and to the West with Maranhão (MA). Piauí has 224 municipalities divided into four development mesoregions: North of Piauí, Mid-North of Piauí, Southeast of Piauí, and Southwest of Piauí. The capital Teresina is located in the Mid-North region, on the limit with the state of Maranhão, as shown in Figure 1.



**Figure 1** – Division of the state of Piauí into municipalities and development mesoregions and its location in the Northeast Region of Brazil. Parnaíba, PI, Brazil, 2007-2015.

The data from this study are of the secondary type and were made available by the State Secretariat of Health of Piauí (*Secretaria de Estado da Saúde do Piauí*, SES-PI). All aids cases that occurred from 2007 to 2015 were investigated, in individuals living in the state, whose notification occurred through the Notifiable Diseases Notification System (SINAN). Thus, in the study period, 2,908 cases of aids were recorded in Piauí.

Socioeconomic indicators of the Piauían population from the Demographic Census conducted in 2010 were obtained from the Internet page of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE). For each of the 224 municipalities in the state, 43 socioeconomic indicators were collected, including those presented in this study: unemployment rate; income ratios; proportion of households with a water supply network; percentage of individuals in households with inadequate walls; mean number of residents per household; proportion of households without electric power; percentage of individuals in households vulnerable to poverty and where no one has completed elementary school; and percentage of individuals in households vulnerable to poverty and dependent on older adults.

The aids incidence rate of each municipality was calculated with the TabWin v.4.14<sup>®</sup> software. Aiming to minimize the instability of the gross rates, they were smoothed by the Local Empirical Bayesian method to correct causal random fluctuations, which occur especially in municipalities with a small number of inhabitants.<sup>7</sup> Such estimate became necessary, since 37.05% of municipalities of Piauí have up to 5,000 inhabitants.<sup>8</sup> It is emphasized that the gross incidence rates were calculated by using the population of the central year (2011), multiplied by 100,000 inhabitants. Also, to calculate the Bayesian estimate, the neighborhood matrix according to contiguity criterion was used, in which

the value of 1 was assigned when the municipalities had common limits, and of 0 when they did not share limits.<sup>7</sup>

Later, the transformation of the Neperian logarithm (Ln) type was applied to the Bayesian incidence rate to get the values close to a normal distribution, which consists of a pre-requirement for adjusting the spatial regression model.<sup>9</sup>

The presence of correlation (collinearity) between the independent variables (socioeconomic) was verified by the *Variance Inflation Factor* (VIF), using the backward method and epidemiologic criterion. The non-collinear variables, that is, with a correlation < 0.7 were inserted in the multivariate linear regression model (*Ordinary Least Squares Estimation* - OLS).

Thus, the aim was to find the socioeconomic variables that better explained the incidence of the disease in the Piauí territory with a statistical significance of 5%. However, since the OLS classic model does not take into account in its adjustment the spatial location of the studied phenomenon, the *Geographically Weighted Regression* (GWR) spatial regression model was adjusted to the explanatory variables statistically significant in the OLS model, as the disease and their determinants suffer variations according to the area in which they are investigated.<sup>10</sup>

The comparison between the OLS and GWR models, so as to identify which one has the best adjustment, occurred by means of the Akaike (AIC) information criterion parameters and of the determination coefficient ( $R^2$ ), where the lower the AIC value and the higher the value of  $R^2$ , the better the adjustment of the model.

The statistical significance of the GWR model was verified by the Wald test by means of two choropleth maps. The first map, in shades of blue, shows the distribution of the parameter estimates. Cities in shades of lighter blue have a negative association, the highlighted variable being a protection factor for the disease. As for the municipalities in darker blue, they have a positive association with the variable represented consisting of a risk factor for the incidence of aids. The second map, in shades of grey, represents the statistical significance of the Wald test performed for each parameter, being classified as 99%, 95%, and 90% of reliability and not significant.

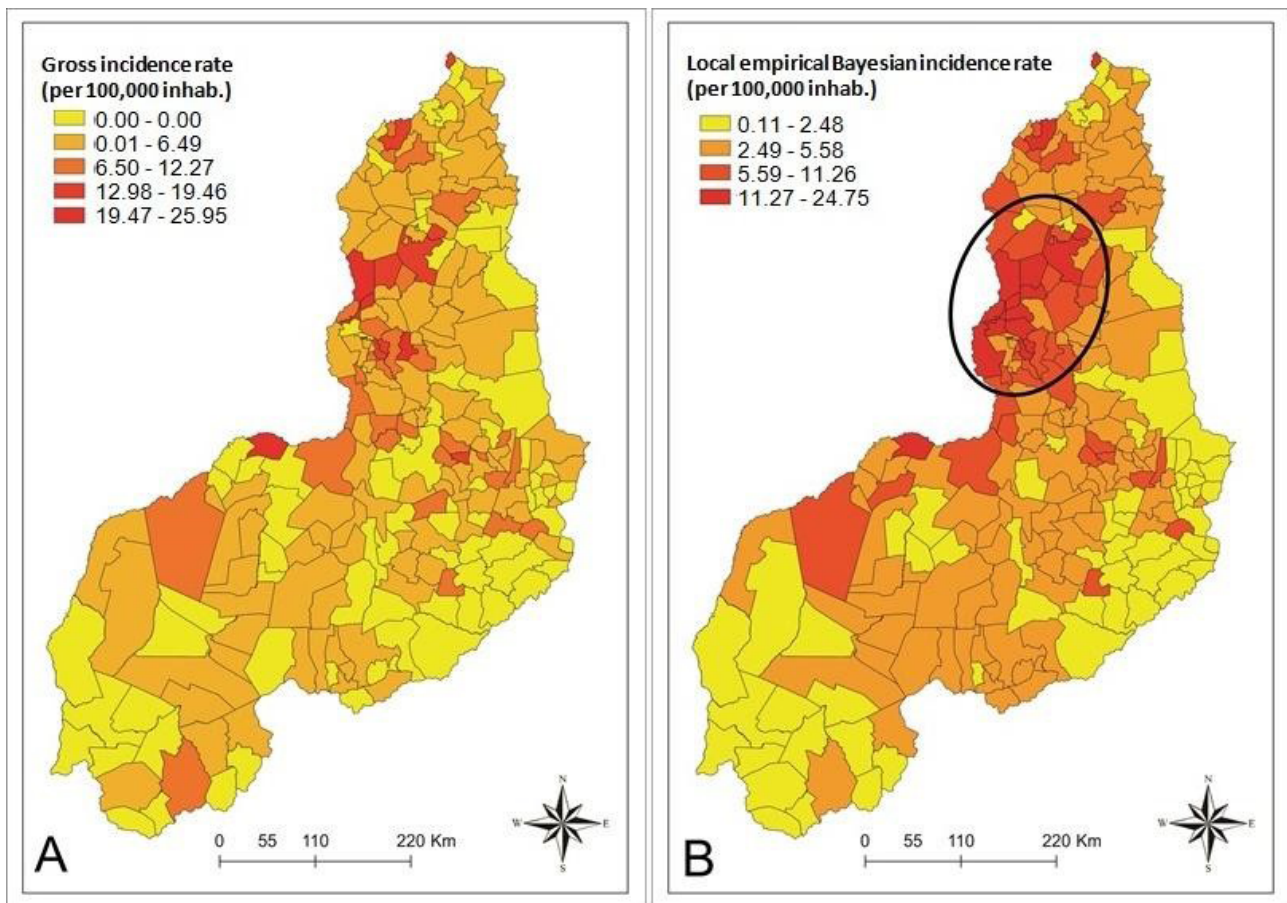
The GeoDa v.1.12<sup>®</sup> software was used to calculate the Bayesian statistics. The Neperian logarithm type transformation of the Bayesian incidence rate and the adjustment of the GWR and OLS models were done on the R software, version 3.3.3<sup>®</sup>, and the constructions of the maps from these statistics was made in the ArcGis 10.2.2<sup>®</sup> software.

All the ethical and legal aspects set forth in Resolution 466/12 were respected. After authorization by the SES-PI, the information was collected in a confidential manner, omitting the identification of the individuals.

## RESULTS

A total of 2,908 cases of aids, distributed in 66.1% of the Piauí municipalities, were notified. The majority were male (1,969; 67.7%), brown-skinned (2,092; 72.9%), aged 20 to 39 years old (1,773; 61.0%), and with more than eight years of schooling (1,452; 54.5%) (Data not shown).

Figure 2 shows the spatial distribution of the gross aids incidence rates (map A) and smoothed by the local empirical Bayesian method (map B). The gross rate map shows the spread of the epidemic to a significant portion of the state's municipalities, characterized by their small size and distance from large urban centers. The Bayesian map, in turn, shows that the highest rates are concentrated in municipalities close to the state capital with an incidence of over 11.27 cases/100,000 inhabitants (highlighted).



**Figure 2** – Spatial distribution of the gross aids incidence rate (A) and smoothed by the local empirical Bayesian method (B). Parnaíba, PI, Brazil, 2007-2015.

Table 1 presents the adjustment of the OLS model to the logarithm of the aids incidence rate after Bayesian smoothing. The following variables were considered predictors of the aids incidence rate in Piauí: percentage of individuals in households with inadequate walls ( $p=0.0139$ ), mean number of residents per household ( $p=0.0309$ ), and percentage of individuals in households vulnerable to poverty and in which no one has completed elementary school ( $p=0.0051$ ). In this model, the determination coefficient ( $R^2$ ) was 0.2401 and the Akaike information criterion (AIC) was 608,4473 (data not shown).

Subsequently, the spatial regression model (GWR) of the logarithm of the aids Bayesian incidence rate was adjusted to the variables that shown to be significant in the OLS Model (Figure 3). A regression model was adjusted to each point observed, that is, each of the 224 municipalities in the state has its own adjustment coefficients. When comparing the two regression models by means of AIC and  $R^2$ , it was verified that the GWR model had better adjustment than the OLS model, as it obtained an AIC of 379.5420 (lower than OLS), and an  $R^2$  of 0.7788 (higher than that obtained by the OLS) (Data not shown).

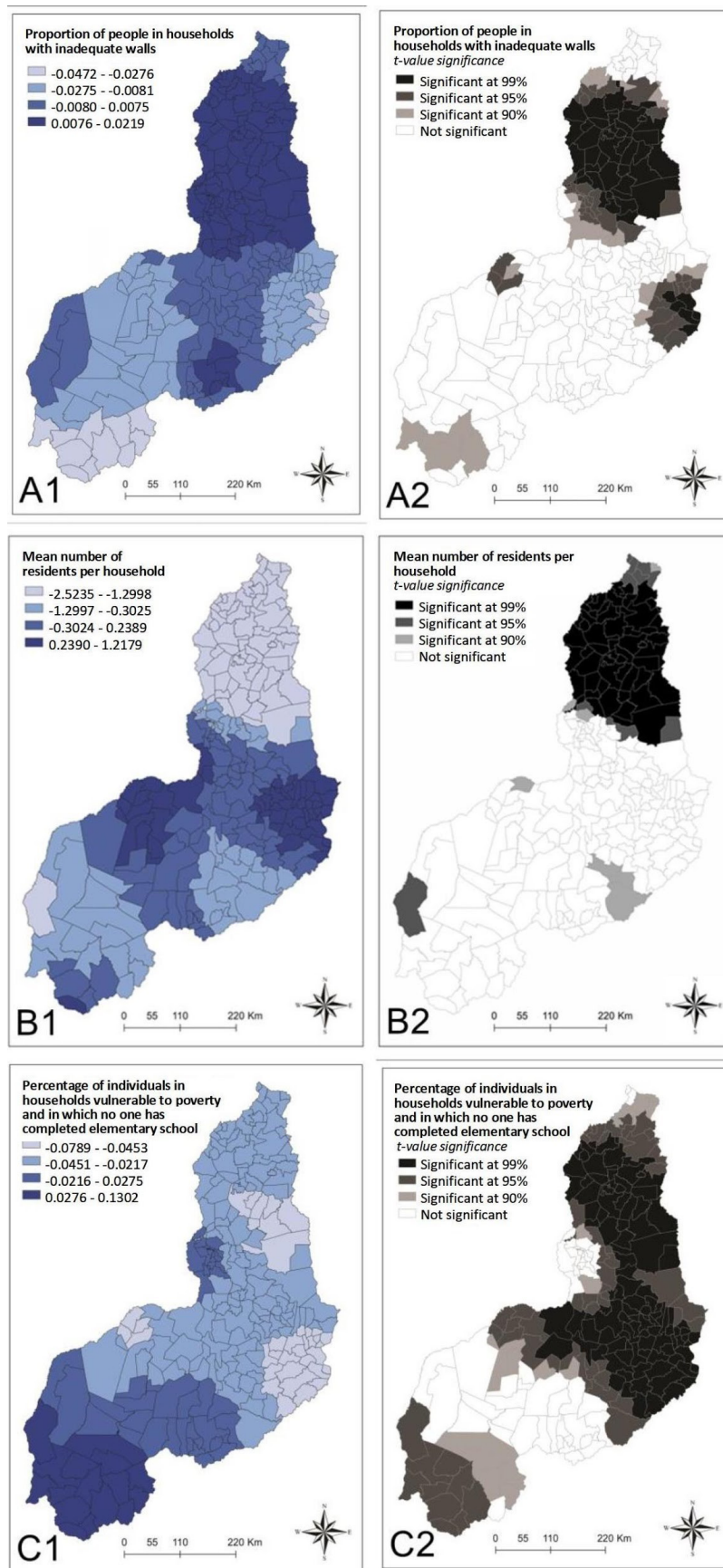
**Table 1** – OLS model for the logarithm of the aids incidence rate after Bayesian smoothing. Parnaíba, PI, Brazil, 2007-2015. (n = 2,908)

Variables	Estimate	Standard Deviation	t-value	Pr(> t )
Intercept	3.8831	1.0671	3.6390	0.0003
Unemployment rate	-0.0207	0.0141	-1.4720	0.1424
Income ratio	-0.0064	0.0045	-1.4320	0.1537
Proportion of households with a water supply network	0.0068	0.0035	1.9200	0.0562
Percentage of people in households with inadequate walls	0.0117	0.0047	2.4800	0.0139
Mean number of residents per household	-0.5971	0.2749	-2.1720	0.0309
Proportion of households without electric power	-0.0112	0.0062	-1.8120	0.0714
Percentage of individuals in households vulnerable to poverty and where no one has completed elementary education	-0.0266	0.0094	-2.8290	0.0051
Percentage of individuals vulnerable to poverty and dependent on older adults	0.0552	0.0389	1.4180	0.1576

Figure 3 shows the thematic maps of the results generated by the GWR model, which show the contribution of socioeconomic variables on the incidence of aids in the municipalities of Piauí. Maps A1 and A2 show that, in a significant part of the Mid-North and North mesoregions of Piauí there was a positive significant association, demonstrating that the higher the percentage of individuals residing in households with inadequate walls, the greater the logarithm of the aids Bayesian incidence rate (highlighted). However, in some municipalities located in the southernmost end of the state and in the limits with Pernambuco and Maranhão, the same variable has a negative association with the logarithm of the aids Bayesian rate and, therefore, acts as a protection factor in these territories.

Maps B1 and B2 points out that in a significant part of the Mid-North mesoregion, in all Piauían North and in four municipalities from South of the state (Santa Filomena, Dom Inocêncio, Capitão Gervásio de Oliveira, and São João do Piauí) there was a negative association between the independent variable and the logarithm of the aids Bayesian incidence rate. In these territories, the higher the mean number of residents per household, the lower the aids rate. Only in the polygon that corresponds to the municipality of Guadalupe, near Maranhão, did the independent variable present itself as a factor associated with the risk of the disease, with a 90% significance level.

The percentage of individuals in households vulnerable to poverty and where no one had completed elementary school, an independent variable, constitutes a protection factor for the disease in a significant part of the state, covering part of Southwest and Mid-North of Piauí and its Southeast and North mesoregions. In contrast, the same variable showed itself to be a factor associated with risk in municipalities in the southernmost end of Piauí, located near the limits with Bahia, Maranhão and Tocantins (Maps C1 and C2).



**Figure 3** – Spatial distribution of the estimated coefficients and significance of the t value associated with statistically significant independent variables in the OLS and GWR models. Parnaíba, PI, Brazil, 2007-2015.



## DISCUSSION

The local empirical Bayesian analysis maps indicate that the capital, Teresina, and some other surrounding cities such as Altos, Nazária, Dermeval Lobão, and Lagoa do Piauí, presented the highest smoothed rates of aids incidence. The epidemiological situation of the state capital deserves attention, considering that, in 2015, its incidence (24.77 cases/100,000 inhabitants) was higher than the Piauian (10.25 cases/100,000 inhabitants), Northeastern (15.3 cases/100,000 inhabitants), and Brazilian (20.7 cases/100,000 inhabitants) means.<sup>11</sup>

The increased incidence rates observed in the metropolitan region of the Piauí capital corroborate the aids distribution patterns in the Brazilian territory since the highest concentration of the epidemic in the country occurs mainly in the large urban centers and metropolitan regions.<sup>12</sup>

Although Brazil has specialized follow-up programs for PLWHA implemented in the capital and in several cities from the inland areas of the states,<sup>3</sup> in Piauí, the social networks and more complex health care networks are mostly concentrated in Teresina. Unlike the other capitals in the Northeast, located in the coastline and which receives tourists seeking leisure, most of the people that visit Piauí's capital is motivated by business tourism and by those who seek health treatment, as the city is an important outpatient and hospital complex since the 1990s.<sup>8</sup> In view of this, notification of the disease may be occurring with a higher frequency in the municipalities and metropolitan region as they offer a greater technological apparatus in the active search for cases. On the contrary, it is possible that HIV positive individuals who live in municipalities far from large urban centers do not even have access to diagnosis and, therefore, are not notified.

DSS affect socioeconomic status and interfere decisively in the health situation of individuals and populations. The greatest portion of the problems and inequalities in health that exist in all regions of the world reflects the conditions in which people are born, live, work, and age.<sup>4</sup> Accordingly, two indicators related to housing conditions as determinants of aids incidence in Piauí municipalities were observed, namely: the mean number of residents per household and the percentage of people in households with inadequate walls. The study on the households aims to comprehend more profoundly the life conditions of the population, since housing and environment have an important impact on human health and predict its socioeconomic *status*.<sup>13</sup>

In a significant part of the Mid-North and North mesoregions of Piauí, the higher the percentage of individuals who live in households with inadequate walls, the higher were aids incidence rates. This inadequacy occurs when the outer walls of the household are built mostly with non-lasting material, which makes the household too precarious.<sup>14</sup> On this, a number of research studies evidenced the household quality as significant predictors of HIV/aids,<sup>15-16</sup> considering that one third of PLWHA in the world live in structurally inadequate and/or overcrowded houses.<sup>17</sup>

Similarly, in the municipality of Guadalupe, the higher the mean number of residents per household, the higher the aids incidence rate. Overcrowding refers to housing with more than two residents per room. In Guadalupe, 32.01% of the population lived in overcrowded households, a percentage higher than the Brazilian (27.83%) and Piauian (31.44%) means. Household overcrowding affects 11.7 million of Brazilians and can be related to the lack of financial conditions to funding the construction of houses with adequate internal divisions or it may be a reflex of the high birth rate in poor families.<sup>14</sup>

The study of the mean number of residents per household is relevant not only because it predicts the socioeconomic level of the population but because it is also a significant risk factor for the transmission of opportunistic diseases, such tuberculosis (TB), especially among HIV positive individuals.<sup>17</sup> Thus, investments on governmental housing programs that reduce overcrowding in houses may be important to reducing social and opportunistic infection problems that can result in death to PLWHA.

With safe, adequate, and affordable housing, HIV-positive individuals are better able to access medical and support services and undergo treatment. In contrast, homeless people or those living in unstable housing are more likely to delay the beginning of the treatment, have less access to regular care, and adhere less to ART, increasing the chances of progressing to aids.<sup>15-16</sup>

Research points out that having good housing conditions can improve the health of infected individuals, as the housing *status* is a stronger predictor of the health results of HIV positive individuals than characteristics such as gender, race, age, use of drugs and alcohol, and mental health.<sup>16</sup>

In some cities from the southernmost end of the state, as the percentage of people living in households vulnerable to poverty and in which no one has completed elementary school increases, so do the aids incidence rates. Low schooling associated with poverty has a high explanatory power of HIV infection in several studies.<sup>15,18-21</sup>

It is important to highlight that HIV positive individuals with low schooling also tend to adhere less to the antiretroviral treatment, and do not seek for a better quality of life, which predisposes them to developing aids and to death due to causes related to it.<sup>19-21</sup>

To this problem, the fact is added that low schooling relates to low socioeconomic level, which makes adherence even more difficult by limiting access to health information, as well as the understanding of the patients on the importance of continuous therapy.<sup>19</sup>

In this research study, some paradoxical results were verified, in which social problems described by the indicators constitute a protection factor to the incidence rates of mortality due to aids, contradicting the findings of a significant part of the literature on this theme.

In a large part of the state, the higher the percentage of individuals in houses vulnerable to poverty and in which no one has completed elementary school, the lower the aids incidence rate. This result corroborates research studies carried out in several underdeveloped and developing countries that pointed out the more educated individuals as the ones most probable to be HIV positive compared to those who never attended formal education. According to these studies, those with a higher schooling level had more sexual partners or, if married, had more extra-conjugal partners than lesser educated individuals.<sup>18,22-23</sup>

However, this result can also be a reflex of the sociodemographic characteristic observed in the HIV population, as more than half of the PLWHA in this research have at least eight years of study. It is observed that the number of cases in Piauians with one to three years of study has been decreasing, while the number of HIV positive people with eight to 11 years and with 12 or more years of study has increased throughout the years. Such finding corroborates a research study carried out in Fortaleza-CE, in which most of the individuals with aids had a higher education degree.<sup>24</sup>

Controversial results in housing indicators were also observed. In the first place, it was verified that, as the mean number of residents per household in the Mid-North and North mesoregions of Piauí increased, the incidence rates decreased. A research study conducted in Recife-PE also found out a similar result since, for every one-unit increase of the mean of residents, there was a reduction of 49.72 times in the HIV/Tuberculosis (TB) co-infection rate. This finding was attributed to the fact that aids has reduced the association strength between indicators that denote worse living conditions and HIV/TB co-infection, since tuberculosis has a direct relationship with unfavorable living conditions and, with aids alone, this association is not always verified.<sup>25</sup>

It was observed that the aids incidence rate decreased as the proportion of households with inadequate walls increased in some municipalities in the southernmost end of the state and in the limits with Pernambuco and Maranhão. In a study conducted in the rural area of Malawi, HIV infection was significantly and positively associated with the wealth of the families, measured by several variables that denoted the living conditions of the population, the material used to build houses being one of them. It was verified that men who lived in brick wall houses had twice as more chances to be

infected by the virus compared to those who lived in houses built with earth and mud, materials still very common in African buildings.<sup>26</sup>

Although these results contradict most of the national studies, they strongly agree with several research studies published with data from Sub-Saharan Africa that signal the epidemic of HIV/aids as associated with a better socioeconomic status.<sup>18,22–23,26</sup>

A study that reviewed population studies published from 2006 to 2014 in relevant journals showed that, of the 19 surveys analyzed, 13 concluded that wealth is associated with a greater risk of HIV infection.<sup>27</sup> Another study carried out in 24 countries of Sub-Saharan Africa showed that, in most of the investigated countries, in general, HIV/aids concentrated among those who belonged to richer families, except for Guinea, Senegal, Swaziland, and Zimbabwe.<sup>18</sup> In Ethiopia, multivariate analyses showed that individuals belonging to the richer quintiles were more likely to have HIV than those belonging to the poorer quintiles.<sup>23</sup>

The researchers argue that it is necessary to take into account other aspects, such as behavioral and cultural factors, in the determination of the HIV/aids epidemic, instead of reducing them strictly to the socioeconomic aspect, since the individual factors can have decisive relevance. A meta-analysis with data from 26 countries went deeper in the investigation of the reasons why an individual with greater purchasing power, more educated, and residing in urban regions is more likely to HIV infection. The results showed that sexual risk behaviors, such as not using a condom in the last intercourse, are more prevalent in this group.<sup>22</sup>

The comparison of the paradoxical results from this study with data from research studies carried in Africa shows to be relevant, considering that some socioeconomic data from the African continent and from the state of Piauí are similar, although they are areas which are geographically far from each other in the globe and have different social and cultural characteristics. Of the 53 African countries from which there are data, 35 (66.03%) have a low or very low HDI,<sup>27</sup> while of the 224 Piauí municipalities, 182 (81.25%) have a low or very low HDI.<sup>28</sup> Also, the Gini Index (a measure of inequality in income distribution) of Piauí in 2007 was 0.599,<sup>8</sup> while in 2014, most of the countries in Sub-Saharan Africa presented a Gini Index that varied from 0.450 to 0.660.<sup>29</sup> Such similarities suggest that peculiarities of the social dynamics of the infection observed in specific Regions of Piauí can be similar to those recorded in the African continent.

Thus, it is important to emphasize that, to identify differences in the health levels of population groups and countries, attention should be directed to the degree of equality in income distribution. The main focus should be on articulated and coordinated interventions in sectors that influence the structural determinants, these being most relevant as they lead to social stratification. These structural determinants translate the distribution of wealth, power, income, and social class division, among other aspects, and they are the most significant cause of inequalities in health, as they alter the individuals' social placement.<sup>30</sup>

Given the above, investments in Brazil and in African countries are indispensable, especially with regard to the establishment of economic and social policies that improve the results of important indicators, such as life expectancy at birth, schooling, and GDP *per capita*.

Besides the similarity with African countries, another possible justification for the controversial results found in this research is the adoption of municipalities as unit of analysis. These, therefore, have in them pretty heterogeneous areas, as they are divided into several neighborhoods and census sectors that have different peculiarities, being characterized by better or worse living conditions. Thus, the municipality's social indicators are reduced to the mean of its heterogeneous areas. When the spatial analysis is performed using smaller and homogenous units of analysis such as the neighborhoods and census sectors, it may be possible to find specific associations and which translate more faithfully the social reality of a given territory.

This study has limitations which, however, do not make it unfeasible. The main one is the fact that secondary data have been used, which may present inconsistencies as regards the quantity and quality of the information. In addition, this research refers only to the notifications of aids, since the Ministry of Health considered, until 2014, only advanced cases of the disease for the purposes of notification, which may undersize the risk of infection by HIV/aids in Piauí. In this way, in future studies it will be possible to make more precise assessments of the infection scene in the territories.

## CONCLUSION

Three social determinants of aids incidence in Piauí have been identified through spatial and non-spatial regression models, namely: Proportion of individuals in households with inadequate walls; Mean number of residents per household, and Proportion of individuals in households vulnerable to poverty and in which no one has completed elementary school. The GWR spatial regression model showed that these determinants act, at the same time, as a risk or protection factor, depending on the municipality investigated.

Interventions on the social determinants of health with a structural nature should be established as effective methods for the prevention of HIV infection and of illnesses due to aids-related causes, in addition to the consolidated strategies typical of the health sector, since controlling the epidemic part of the broad spectrum of a territory's development agenda that involves several sectors of society, such as education, job creation, and income and housing. Therefore, it is necessary for Nursing professionals to be attentive to the influences that the territory characteristics have on the health-disease process and on the vulnerabilities of the individuals that live in it and that their care, in addition to be excellent, understands that the social context of each individual is a fundamental key to their health.

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## NOTES

### ORIGIN OF THE ARTICLE

Extracted from the thesis - Spatial and temporal distribution of the cases and deaths due to aids in Piauí and their relationship with social determinants of health, presented to the Nursing and Health Clinical Care Graduation Program of the *Universidade Estadual do Ceará*, in 2018.

### CONTRIBUTION OF AUTHORITY

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Data analysis and interpretation: Maranhão TA, Alencar CH, Magalhães MAFM.

Discussion of the results: Maranhão TA, Pereira MLD.

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### CONFLICT OF INTEREST

There is no conflict of interest.

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