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EPIDEMIOLOGY OF AIDS IN A NORTHEASTERN BRAZILIAN STATE

EPIDEMIOLOGIA DA AIDS EM UM ESTADO DO NORDESTE BRASILEIRO

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ABSTRACT

Objective: to identify high-risk clusters to AIDS and describe the epidemiologic profile of the disease in the municipalities of the State of Piauí, Brazil, from 2007 to 2015. **Methods**: This ecological study included 2.908 cases notified by the Brazilian System of Notifiable Diseases. Univariate and bivariate analyses were performed and the spatial scan statistic was used to evaluate the formation of purely AIDS clusters, with a significance of 5%. **Results**: Significant associations were observed between sexual orientation and sex and age (p<0.0001). The most probable cluster, with a relative risk (RR) of 5.05 (p <0.0001), covered six cities, including the capital of the state, Teresina. The BR-343 highway cuts through five cities in the Center-north mesoregion of state, with RRs to AIDS above the state average. **Conclusions**: Preventive intervention strategies are needed for young people, homosexual/bisexual men as well as in cities with high RR to AIDS that are transected by highways.

Keywords: HIV. Acquired Immunodeficiency Syndrome. Epidemiology. Spatial analysis. Ecological Studies.

RESUMO

Objetivo: Identificar aglomerados de alto risco para aids e descrever o perfil epidemiológico da doença nos municípios do Estado do Piauí, Brasil, de 2007 a 2015. **Métodos**: Estudo ecológico com inclusão de 2.908 casos notificados pelo Sistema Nacional de Agravos de Notificação. Foram realizadas análises univariadas e bivariadas e utilizada a estatística de varredura espacial para avaliar a formação de aglomerados de aids, com significância de 5%. **Resultados**: Foram observadas associações significativas entre orientação sexual e sexo e idade (p <0.0001). O cluster mais provável, com risco relativo (RR) de 5,05 (p

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<0.0001) cobriu seis cidades, incluindo a capital Teresina. A rodovia BR 343 corta cinco cidades da região Centro-Norte do estado, com RRs para aids acima da média estadual. **Conclusão**: São necessárias estratégias de intervenção preventiva para jovens, homens homossexuais/bissexuais, bem como em cidades com RR elevado para aids que são transectadas por rodovias.

Palavras-chave: HIV. Síndrome de Imunodeficiência Adquirida. Epidemiologia. Análise Espacial. Estudos Ecológicos.

INTRODUCTION

More than 30 years after its identification, acquired immunodeficiency syndrome (AIDS) is a chronic disease that remains a public health issue that worries and challenges the world. Along with the disease, there have also been devastating consequences on expenditures in the health sector (VIEIRA, 2009). In 2017, there were approximately 1.8 million new infections and 36.9 million people living with human immunodeficiency virus HIV/AIDS (PLWHA) worldwide (UNAIDS, 2017a).

According to an epidemiologic report on HIV/AIDS, from 1980 to June 2017, there were 882.689 notified cases of AIDS in Brazil, 15.4% of which occurred in the Northeast region and 4.8% of these cases in Piauí state. The mean detection rate in Brazil in the past decade was 18.5 cases/100,000 inhabitants. However, there are important differences between Brazilian regions, with a significant decrease in detection rates in the South and Southeast regions and a linear increase in the North and Northeast regions in the last ten years (BRASIL, 2017).

In the most diverse socioeconomic and demographic contexts, the heterogeneity of AIDS epidemiology highlights the importance of approaches specific to populations that live in certain areas (UNAIDS, 2017a). Thus, studies that use geoprocessing tools and spatial analysis techniques to map AIDS in different territories have identified priority areas for planning and program strategies to address the disease and to evaluate the impact of actions previously executed (HOLANDA *et al*., 2015; RODRIGUES-JUNIOR; RUFFINO-NETTO; CASTILHO, 2014; ZHANG *et al*., 2017).

According to a study that evaluated the epidemiological profile of AIDS, the state of Piauí registered a constant increase in the number of notifications from 2008 to 2013 (ALMEIDA *et al*., 2015). Thus, it is necessary to describe the epidemiology as well as the distribution pattern of AIDS rate in the state of Piauí in order to inform decision-making among health managers and policymakers from other social areas. This information will be helpful in the development of public policies in municipalities with high risks of HIV transmission and AIDS-related sickness. Therefore, this study aimed to identify high-risk clusters to AIDS and describe the epidemiologic profile of the disease in the Piauí's cities from 2007 to 2015.

METHODS

This ecological study used geoprocessing tools to analyze the spatial distributions of AIDS coefficients in the 224 municipalities of Piauí. This state is located in the Northeastern region of Brazil and according to the 2010 Demographic Census, Piauí had 3,118,360 inhabitants (IBGE, 2010).

A total of 2,908 new cases of HIV/AIDS were notified from 2007 to 2015 by the Brazilian System of Notifiable Diseases (in Portuguese: *Sistema Nacional de Agravos de Notificação* – SINAN).

The notified cases databases were available from the Coordination of Transmitted Diseases from the Piauí Health Secretary (in Portuguese: SES-PI). TabWin v.4.14® software was used for tabulation. All confirmed cases that developed AIDS were included in the present study, while discarded cases and HIV+ cases that did not develop AIDS were excluded.

The variables analyzed in this study included the year of notification, sex, years of schooling, age, race/color, and exposure categories. Information regarding the municipalities of residence was also collected to allow spatial analysis and classification as capital or interior.

In the exploratory analysis, categorical variables were described as absolute and relative frequencies. Bivariate analysis by non-parametric Pearson's chi-square tests (x^2) and odds ratios considered years of schooling and sexual orientation as dependent variables (PAGANO; GAUVREAU, 2010).

To perform the analyses, we used R version 3.3.3®. In the x^2 test and odds ratios, $p < 0.05$ was defined as the threshold to reject the null hypothesis (PAGANO; GAUVREAU, 2010).

We also used SaTScan version 9.6 (Harvard Medical School, Boston, USA) to identify high-risk clusters. This statistical technique uses a flexible geographic scanning circular window and includes different sets of neighboring areas. The clusters were identified using pure spatial analysis, using a window corresponding to 50% of the population at risk. A Poisson model was applied as the probabilistic method, which assumed the incidence to be proportional to the population size (BRASIL, 2006; KULLDORFF, 1997).

The scan method also enabled relative risk (RR) spatial maps. This indicator represents the intensity of AIDS case occurrences in the analyzed area. An RR smaller than 1 indicates that the risk of an area is lower than the risk of the region as a whole. In contrast, an RR above than 1 indicates that the risk in a specific area is higher than the total the risk of the region as a whole. Finally, an RR equal to 1 indicates that the risk is also equal to that of the whole area (PAGANO; GAUVREAU, 2010).

The maps were generated using QuantumGis® v.2.14.17® software. Digital cartographic bases in shapefiles with the municipalities and highways within Piauí state were obtained from the Brazilian Institute of Geography and Statistics website (in Portuguese: IBGE – Instituto Brasileiro de Geografia e Estatística).

The ethical and legal aspects from the Resolution 466/12 were respected. Anonymized data were obtained from the SES-PI by omitting individual identification. This study was submitted and approved by the Ethics in Research Committee of Piauí State University (number 1.665.775).

RESULTS

A total of 2,908 AIDS cases were notified from 2007 to 2015. Of those. More than half of those cases were male (1,969; 67.7%), adults ranging in age from 30 to 49 years (1,599; 55.0%) and having eight years or more of schooling (1,452; 54.4%) (data not shown). Table 1 highlights the significant statistical association between years in school and year of notification, sex, and place of residence ($p < 0.0001$).

The number of cases with only 1 to 3 years of schooling has been decreasing, while those who studied 8 to 11 years and 12 or more years have been increasing during the time period. Moreover, Teresina contained most of the cases with higher levels of schooling, while most of the PLWHA with no schooling or with 1 to 3 studied years lived in the countryside (Table 1).

Table 1 – Distribution of AIDS cases by number of years of study, Piauí, Brazil, 2007-2015. (N=2,665)*

Variables	Studied years											x^2†
	None		1 to 3		4 to 7		8 to 11		≥12		Total	
	n	%	n	%	n	%	n	%	n	%	N	p-value
Years												
2007	11	5.1	58	26.7	60	27.7	71	32.7	17	7.8	217	
2008	12	5.0	48	19.9	62	25.7	93	38.6	26	10.8	241	
2009	9	3.4	44	16.6	89	33.6	105	39.6	18	6.8	265	**<0.0001**
2010	14	4.5	38	12.3	110	35.5	120	38.7	28	9.0	310	
2011	7	2.5	34	12.0	108	38.2	103	36.4	31	10.9	283	
2012	13	3.5	31	8.4	113	30.6	162	43.9	50	13.6	369	

2013	21	5.5	29	7.6	115	30.3	163	42.9	52	13.7	380	
2014	12	3.3	21	5.7	81	22.1	198	53.9	55	15.0	367	
2015	11	4.7	17	7.3	45	19.3	114	48.9	46	19.8	233	
Sex												
Male	81	73.6	197	61.6	516	65.9	743	65.8	277	85.8	1,814	**<0.0001**
Female	29	26.4	123	38.4	267	34.1	386	34.2	46	14.2	851	
Residence												
Capital	47	42.7	151	47.2	449	57.3	782	69.3	271	83.9	1,700	**<0.0001**
Interior	63	57.3	169	52.8	334	42.7	347	30.7	52	16.1	965	

Source: Coordination of Transmitted Diseases from the Piauí Health Secretary
*There were excluded 243 cases, from that, 216 were "ignored" in years of study and 27 were children.
†x^2: Pearson's chi-squared test.

Table 2 presents the odds ratios of the AIDS case distributions by sex and place of residence according to the years of study. AIDS cases with more than 12 years of study were 2.16, 3.76, 3.12, and 3.13 times more likely to be being male than those with no schooling and 1 to 3, 4 to 7, and 8 to 11 years of study, respectively. Therefore, PLWHA with higher schooling levels were more likely to be male.

Individuals with 12 or more years of study were 6.99, 5.83, 3.88 and 2.31 more likely to live in the capital Teresina than those with no schooling and with 1 to 3, 4 to 7, and 8 to 11 years of study, respectively (Table 2).

Table 2 – Odds Ratio of the AIDS cases distribution by sex and place of residency and schooling crosses. Piauí, Brazil, 2007-2015

Schooling (studied years)	**Sex**				
	None*	**1 - 3 years***	**4 - 7 years***	**8 - 11 years***	**12 years or more***
None	1	1.74 (1.08-2.82)	1.45 (0.92-2.26)	1.45 (0.93-2.26)	0.46 (0.27-0.79)
1-3 years	0.57 (0.35-0.93)	1	0.83 (0.63-1.08)	0.83 (0.64-1.08)	0.27 (0.18-0.39)
4-7 years	0.69 (0.44-1.08)	1.21 (0.92-1.58)	1	1 (0.83-1.22)	0.32 (0.23-0.45)
8-11 years	0.69 (0.44-1.07)	1.2 (0.93-1.55)	1 (0.82-1.21)	1	0.32 (0.23-0.45)
12 years or more	2,16 (1.27-3.65)	3.76 (2.56-5.52)	3.12 (2.21-4.4)	3.13 (2.24-4.38)	1
Schooling (studied years)	**Place of residence**				
	None*	**1 – 3 years***	**4 - 7 years***	**8 - 11 years***	**12 years or more***
None	1	0.83 (0.54-1.29)	0.55 (0.37-0.83)	0.33 (0.22-0.49)	0.14 (0.09-0.23)
1 - 3 years	1.2 (0.77-1.85)	1	0.66 (0.51-0.86)	0.4 (0.31-0.51)	0.17 (0.12-0.25)
4 - 7 years	1.8 (1.2-2.7)	1.5 (1.16-1.95)	1	0.6 (0.49-0.72)	0.26 (0.19-0.36)

8 - 11 years	3.02 (2.03-4.5)	2.52 (1.96-3.25)	1.68 (1.39-2.03)	1	0.43 (0.31-0.6)
12 years or more	6.99 (4.32-11.29)	5.83 (4.03-8.44)	3.88 (2.79-5.39)	2.31 (1.67-3.19)	1

Source: Coordination of Transmitted Diseases from the Piauí Health Secretary
*Based on the odds ratio test. Each column corresponds to the comparison with all schooling levels with the schooling of the base column.

Table 3 shows that almost three in five individuals were heterosexual (1,745; 73.1%). There was a significant association between sexual orientation and notification year (p <0.001). Since 2012, the number of cases among heterosexual individuals has been decreasing, while the number of cases among homosexual individuals has progressively increased.

A significant association was also observed between sexual orientation and age range (p <0.001). Cases among homosexual and bisexual people occurred nearly exclusively in men (620; 96.6%). In contrast, 97.3% of women with AIDS declared themselves as heterosexuals. Furthermore, the age increased with the heterosexual percentage and decreased with the homosexual percentage (Table 3).

Table 3 – AIDS cases distribution by sexual orientation and notification years, sex and age range. Piauí, Brazil, 2007-2015. (N = 2.387)*

Variables	Sexual Orientation							x^2†
	Homosexual		Bisexual		Heterosexual		Total	
	n	%	n	%	n	%	N	p-value
Year								
2007	31	16.5	29	15.4	128	68.1	188	
2008	31	13.7	23	10.2	172	76.1	226	
2009	34	15.3	17	7.6	172	77.1	223	
2010	38	13.8	26	9.5	211	76.7	275	**<0.0001**
2011	32	12.7	24	9.5	196	77.8	252	
2012	42	12.9	33	10.1	251	77.0	326	
2013	71	20.7	34	9.9	238	69.4	343	
2014	76	23.5	23	7.1	224	69.4	323	
2015	58	25.1	20	8.7	153	66.2	231	
Sex								**<0.0001**
Male	397	25.2	223	14.2	953	60.6	1,572	
Female	16	2.0	6	0.7	792	97.3	815	
Age range								
10-19 years	13	20.3	6	9.4	45	70.3	64	
20-29 years	170	24.8	66	9.6	449	65.6	685	**<0.0001**
30-39 years	133	16.6	84	10.5	585	72.9	802	
40-49 years	62	12.5	49	9.8	387	77.7	498	

50-59 years	26	10.8	21	8.7	194	80.5	241
60 years or more	9	9.3	3	3.1	85	87.6	97

Source: Coordination of Transmitted Diseases from the Piauí Health Secretary
*There were excluded 521 cases. From that, 439 were with the exposition category as "ignored" or "not informed", 55 belonged to other exposition categories and 27 cases were children with less than 13 years old.
†x^2: Pearson's chi-squared test

Figure 1A shows Piauí's development mesoregion divisions and its location within the Brazilian Northeast region. Figure 1B shows that most of the cities in Piauí have RR of AIDS incidence below the state mean. However, municipalities highlighted in grayscale have a higher RR. The capital city had the highest RR of AIDS (4.90). Addition of a highway layer shows that the BR-343 passes through cities in the Center-north mesoregion with higher risks of AIDS, including Teresina, Altos, Campo Maior, Cocal de Telha, and Piripiri (highlighted); additionally, Piripiri also contains a highway junction that divides Ceará state and Piauí's coast.

The purely spatial scan statistics identified five high-risk AIDS spatial clusters, but only one was statistically significant ($p < 0.001$). The most probable cluster had an RR of 5.05 and a 29.99-km radius. The cluster covered six municipalities, including the capital city, three municipalities from the metropolitan region (Demerval Lobão, Nazária, and Altos), and other two municipalities (Lagoa do Sítio and Patos do Piauí) located in the Southeast mesoregion of the state (highlighted). The other clusters, located in the municipalities of Oeiras, Guadalupe, Campo Maior, and Luzilândia, did not reach statistical significance (Figure 1C).

Table 4 presents detailed information on the identified clusters of AIDS cases.

Figure 1 **–** Development mesoregion divisions in Piauí. Highlighted are the capital city Teresina within the Brazilian Northeast Region (A), relative risk (B), and AIDS clusters (C) in Piauí, Brazil, 2007-2015

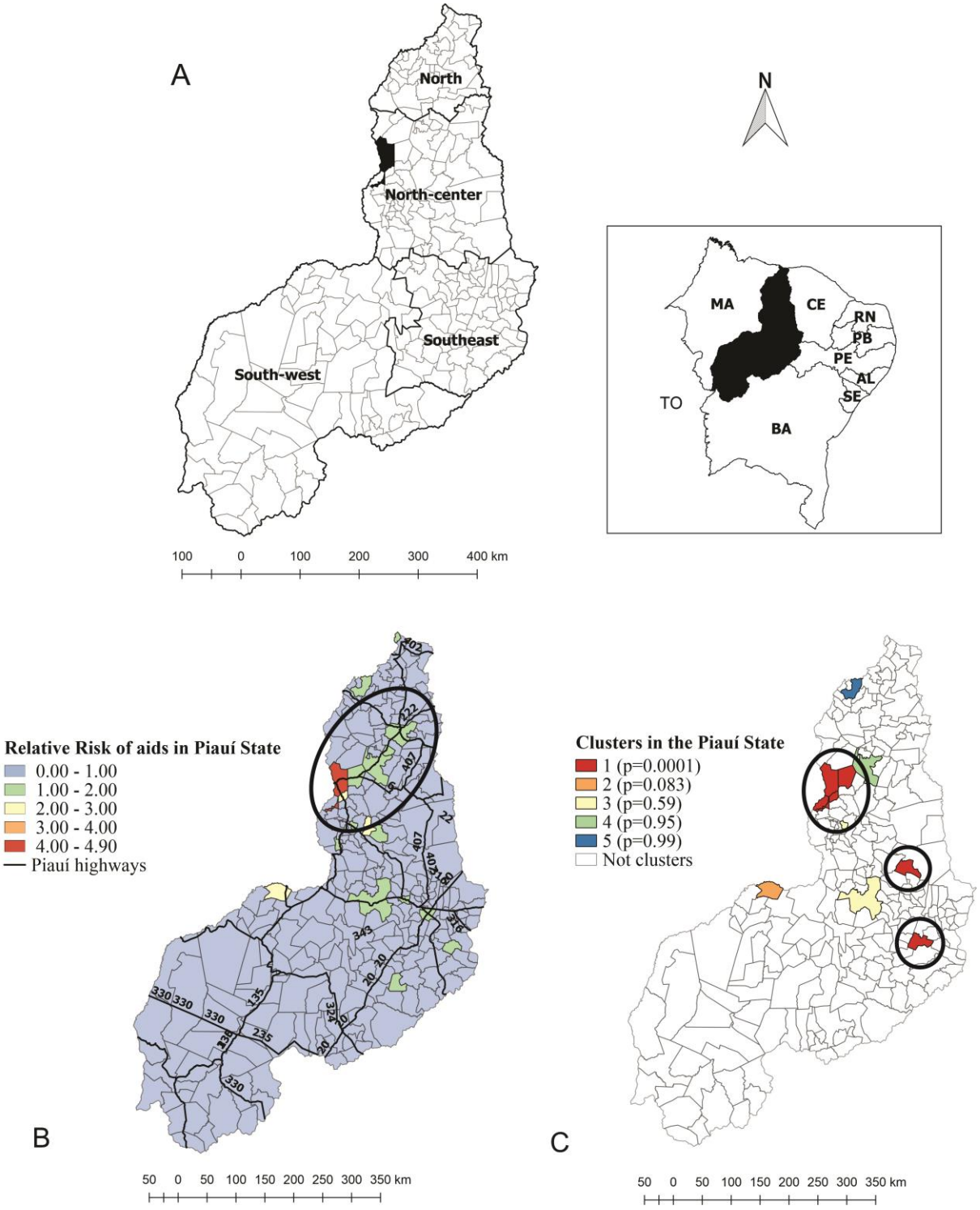

Table 4 – Spatial aggregation of AIDS cases, defined by purely spatial statistics, according to the city of residence in Piauí, Brazil, 2007-2015

Cluster	Number of cities	Radius (Km)	Number of cases	Number of expected cases	RR*	LLR†	p-value
1	6	29.99	1,934	819.61	5.05	917.45	**<0.001**
2	1	0.00	24	9.82	2.45	7.29	0.083
3	2	7.09	59	39.03	1.52	4.47	0.59
4	1	0.00	58	41.12	1.41	3.11	0.95
5	1	0.00	34	22.40	1.52	2.61	0.99

Source: the author.
*RR: Relative risk to the cluster compared to the state.
†LLR: Logarithmic likelihood ratio test.

DISCUSSION

In Piauí, the number of AIDS cases in men was more than twice that in women in 2007-2015. Traditionally, the male population is more likely to engage in risky sexual behaviors than women, predisposing them to sexually transmitted diseases (STDs) including AIDS (ALLEN JR; MYERS; RAY, 2015). Men are more vulnerable to HIV infection and are also more likely to develop AIDS-related sickness. Men less often seek HIV testing, leading to postponed diagnosis during advanced stages of the disease. Even after diagnosis, men tend to adhere to antiretroviral treatment less often than women. Less than half of seropositive men are under treatment, compared to 60.0% of the female seropositive population (UNAIDS, 2018). However, Brazilian studies have not identified significant statistical differences in the treatment of antiretroviral therapy between genders (FORESTO et al., 2017; SOUZA et al., 2019).

During the study period, there was a decreasing trend in the percentage of AIDS cases in Piauí among those with 1 to 3 years of study (uncompleted elementary school) and an increase in cases among those with 8 to 11 (completed elementary and high school) and 12 or more (uncompleted or completed degree) years. Brazil follows the same trend of a gradual decrease in the number of PLWHA with no education to completed elementary school and a progressive increase in the number of seropositive individuals who had not completed high school (BRASIL, 2016).

The advance of the disease among individuals with more years of schooling reflects the profile of those infected at the beginning of the epidemic, in which individuals with higher economic and educational levels were initially infected (FONSECA *et al*., 2000). The increase in schooling among PLWHA in Piauí may be associated with improvement in the general educational indicators in the state. Piauí showed a decreasing illiteracy rate and increased number of years of study, from 6.68 years in 2000 to 9.23 in 2010 (PNUD, 2020). Another reason for this finding may be that seropositive individuals live in the capital city, with greater numbers of offers and access to schools and universities.

The results of this study verified the relation between male sex and high levels of study among PLWHA. Gender inequalities, including low educational level and lack of economic power, make women more vulnerable to HIV and AIDS-related diseases. Thus, the Joint United Nations Programme on HIV/AIDS (UNAIDS) emphasizes the importance of educating women to combat the epidemic as the level of education is related to late sexual initiation, more knowledge about HIV, fewer sexual partners, and increased condom use (UNAIDS, 2017b). Additionally, the level of education of PLWHA is an important predictor of antiretroviral adherence (SILVA *et al*., 2015; FORESTO *et al*., 2017).

There was a significant association between the notification year and sexual orientation of PLWHA. Since 2012 there was a decrease in the number of cases among heterosexual individuals and an increase in homosexual cases. This result is similar to the Brazilian reality, which has observed a 32.9% increase in the proportion of homosexual and bisexual cases, from 35.6% in 2006 to 47.3% in 2016 (BRASIL, 2017). While the HIV incidence is decreasing in many parts of the world, the rates in homosexual and other men that have sex with men (MSM) are increasing in many regions. The fact that such group have a mean of 19 more prone to acquire the virus in comparison to the rest of the population (UNAIDS, 2014).

The percentage of heterosexual individuals increased with age, while a higher percentage of homosexuals was observed among younger individuals. Heterosexual intercourse is a major route of infection in the elderly population (AFFELDT; SILVEIRA; BARCELOS, 2015). This may be attributed to pharmaceutical innovations that have enabled the treatment of sexual dysfunctions, which has resulted in active sexual lives among the elderly. However, sexual practice in the elderly population is generally healthy and does not increase their vulnerability to HIV, but the unprotected sex (CERQUEIRA; RODRIGUES, 2016). Moreover, it is important to emphasize the physiological features of vaginal anatomy due to the aging process, which reduces the mucous lubrication, predisposing elderly women to lesions during sexual intercourse and HIV infection (AFFELDT; SILVEIRA; BARCELOS, 2015).

Almost all seropositive women declared themselves as heterosexuals while almost all homosexuals in this study were male. This difference is due to the increased risk of HIV/AIDS transmission in anal receptive sex (ranging from 0.8 to 3.2%) compared to that for vaginal sex without a condom (0.05 to 0.15%) (CHAN *et al*., 2014).

The scan spatial statistics showed that Teresina had the highest RR in the state and was also one of the cities comprising the single statistically significant AIDS cluster. This result corroborates with other investigations that have used the same statistical method to report an increased risk of this disease in larger cities (MEYERS; HOOD; STOPKA, 2014; ZHANG *et al*., 2017).

Timon city, the fourth most populous city in Maranhão state (the neighboring state) and which borders Teresina (separated only by the Parnaíba River), is part of the Great Teresina Development Integrated Region (in Portuguese: Região Integrada de Desenvolvimento da Grande Teresina) (IBGE, 2010). Maranhão has the highest AIDS rates among all states in the Northeast Brazilian region (21.4 cases per 100,000 inhabitants) (BRASIL, 2016). Thus, after confirming an intense daily transit of people between these cities, it is essential to evaluate the epidemiological situation of the neighbor state, as factors affecting the health-sickness process do not respect political-administrative borders (BRASIL, 2006).

The RR maps included state highway layers to highlight the role of these networks in spreading diseases, including HIV (TEIXEIRA *et al*., 2014). The map of cases showed that the BR-343 exactly divides cities with RRs above 1.0, closest to the capital city to the north, to Piripiri, where there is a road junction.

According to the mapping performed by the Brazilian Federal Police, during 2013-2014, the number of places conducive to prostitution in Piauí's Federal Highways grew 102.0% compared to the number in 2011-2012, while the Brazilian mean decreased 40.0%. A total of 110 prostitution vulnerability points were identified in 31 cities; among them, Teresina had seven risk points for prostitution on its highways (CHILDHOOD BRASIL, 2014). Many cities in Piauí border other states and have highway junctions (CEPRO, 2013). Thus, they are places where the wealth from goods circulation encounters places of poverty.

Studies of Brazilian truck drivers have reported occasional sexual partners or contact with sex professionals (ARAÚJO *et al*., 2015; MAGNO; CASTELLANOS, 2016). A study in Teresina on sexual behaviors in long-distance truckers showed that even though almost 80.0% of them were married, 64.5% reported multiple casual partners during their trips. Moreover, 45.8% reported having never used a condom during sexual intercourse and only 19.8% reported sporadic condom use, which increases the risk of HIV/AIDS and other STD transmission along their routes (ARAÚJO *et al*., 2015).

This study has some limitations that do not distract from its findings. First, this study used secondary data, which can result in inconsistencies regarding data quantity and quality. Another limitation is related to the fact that it only considered notified AIDS cases; the Brazilian Health Ministry considered cases notifiable only if they were advanced disease, which can underestimate the risk of HIV/AIDS infection in Piauí.

CONCLUSION

The results point to high relevance and need to plan intervention strategies focusing on young homosexual and bisexual male population as well as heterosexual women with low levels of education. Furthermore, special attention should be given to cities with high RR for AIDS, especially those transected by important highways, by implementing preventive action in strategic places with junctions or truck stops, as those highways enable the transit of people and wealth, so they can also disseminate diseases and favor sexual exploration.

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