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The AIDS epidemic in the Amazon region: a spatial case-control study in Rondonia, Brazil

Epidemia da Aids na região amazônica: estudo caso controle espacial em Rondônia, Brasil

ABSTRACT

OBJECTIVE: To analyze spatial changes in the risk of AIDS and the relationship between AIDS incidence and socioeconomic variables in the state of Rondonia, Amazon region.

METHODS: A spatial, population case-control study in Rondonia, Brazil, based on 1,780 cases reported to the Epidemiological Surveillance System and controls based on demographic data from 1987 to 2006. The cases were grouped into five consecutive four-year periods. A generalized additive model was adjusted to the data; the dependent variable was the status of the individuals (case or control), and the independent variables were a bi-dimensional spline of the geographic coordinates and some municipality-level socioeconomic variables. The observed values of the Moran's I test were compared to a reference distribution of values generated under conditions of spatial randomness.

RESULTS: AIDS risk shows a marked spatial and temporal pattern. The disease incidence is related to socioeconomic variables at the municipal level in Rondônia, such as urbanization and human capital. The highest incidence rates of AIDS are in municipalities along the BR-364 highway and calculations of the Moran's I test show positive spatial correlation associated with proximity of the municipality to the highway in the third and fourth periods ($p = 0.05$).

CONCLUSIONS: Incidence of the disease is higher in municipalities of greater economic wealth and urbanization, and in those municipalities bisected by Rondônia's main roads. The rapid development associated with the opening up of once remote regions may be accompanied by an increase in these risks to health.

DESCRIPTORS: Acquired Immunodeficiency Syndrome, epidemiology. Socioeconomic Factors. Spatial Analysis. Urbanization. Case-Control Studies.

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RESUMO

OBJETIVO: Analisar mudanças espaciais no risco de Aids e a relação entre incidência da doença e variáveis socioeconômicas.

MÉTODOS: Estudo caso-controle espacial, de base populacional, realizado em Rondônia, Brasil, com 1.780 casos notificados pelo Sistema de Vigilância Epidemiológica e os controles a partir de dados demográficos de 1987 a 2006. Os casos foram agrupados em cinco períodos de cinco anos consecutivos. Um modelo aditivo generalizado foi ajustado aos dados. O status dos indivíduos (caso ou controle) foi considerado como a variável dependente e independente: um alisamento (*spline*) bidimensional das coordenadas geográficas e variáveis socioeconômicas municipais. Os valores observados para o teste Moran I foram comparados com a distribuição de referência dos valores obtidos em condições de aleatoriedade espacial.

RESULTADOS: O risco de Aids apresentou padrão espacial e temporal marcado. A incidência associou-se a indicadores socioeconômicos municipais, como urbanização e capital humano. As maiores taxas de incidência de Aids ocorreram em municípios ao longo da rodovia BR-364; os resultados do teste Moran I mostram correlação espacial positiva associada à contiguidade dos municípios com a rodovia, no terceiro e quarto períodos (p = 0,05).

CONCLUSÕES: A incidência da doença foi maior em municípios de maior riqueza econômica e urbanização e naqueles cortados pelas estradas principais de Rondônia. O rápido desenvolvimento associado à ocupação de regiões remotas pode ser acompanhado por aumento de riscos à saúde.

DESCRITORES: Síndrome de Imunodeficiência Adquirida, epidemiologia. Fatores Socioeconômicos. Análise Espacial. Urbanização. Estudos de Casos e Controles.

INTRODUCTION

The spread of HIV/AIDS in Brazil has presented a variety of diffusion mechanisms, potentially related to social, economic and demographic factors.[1,2] HIV/AIDS infection has been described as a "mosaic of sub-epidemics"; each one has particular dissemination dynamics and characteristics, and each exposes particular vulnerabilities of the population in regions of Brazil.[3,4,8] With 600,000 people living with HIV/AIDS and 400,000 reported cases, since the beginning of the epidemics in Brazil, a number of regional differences in diffusion stand out: intravenous drug-use-related infection in the South; rising infection rates in lower socioeconomic brackets throughout the country and in municipalities along Brazil's frontier regions in the North and Midwest in formal and placer mining areas; and deceleration of the epidemic in the urban Southeast, where prevention efforts are most prevalent.[8,10,20,a]

According to the 2010 World Report on the AIDS epidemic,[11] the incidence of disease is diminishing in southeastern Brazil, and it is stable in the rest of the country, except in the North, where it continues to increase: The incidence rate of AIDS (per 100,000 inhabitants) went from 13.6 in 2006 to 20.1 in 2009.[b]

Studies have recorded the geographic spread of the epidemic in the Midwestern and Northern states, but little is known about the path of transmission in these regions, which are far from areas where transmission has a longer history. Infection has expanded in the Midwestern and Northern areas, mainly affecting heterosexuals, individuals with lower levels of education and few intravenous drug users.[18,a]

HIV/AIDS arrived in the state of Rondonia, Northern Brazil, seven years after the first cases were registered

[a] Barcellos C, Peiter P, Rojas LI. Matida A. A geografia da AIDS nas fronteiras do Brasil. Campinas; 2001 [cited 2013 Sept 11]. Available from: http://www.igeo.ufrj.br/fronteiras/pesquisa/fronteira/p02pub03.htm#1.2

[b] Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de DST, AIDS e Hepatites Virais. Bol Epidemiol AIDS-DST. 2010;7(1):4-10.

in the Southeast, and the initial pattern of infection in Rondonia differed from that found in the first decade of the epidemic. AIDS has affected mainly urban, well-educated homosexual/bisexual males in Southeastern Brazil.[3,18,20] The then-territory of Rondonia was relatively isolated from the rest of the country until the 1960s. It was covered mostly by tropical forest and inhabited mainly by rubber tappers and indigenous people. That is when the first overland connection to the state was made via construction of the federal highway BR-364 (Figure). The road was only dirt, made along the very trail, and eventual telegraph line, that Coronel Cândido Rondon first blazed in the early 1900s. The state's 1970 population was estimated at 70,000 and by 1991 it had risen to 1,132,692.[5,c] The paving of the BR-364 highway in 1983, and subsequent agricultural colonization projects led by the Brazilian government, allowed thousands of families to begin moving into the region, largely from Brazil's South and Southeast. The territory became a state in 1982 and the state had 52 municipalities and a total population of 1.4 million in 2007.[d]

Much understanding of the pattern of AIDS diffusion in places like Rondonia may come from close consideration of the settlement geography of this relatively remote region. The occupation of the state was strongly patterned by the federal highway BR-364, which bisected the state from Vilhena in the southeast to the capital city, Porto Velho, in the northwest on the Madeira River.[c] Along that road, the state's most populous municipalities formed as centers of agricultural settlement. Urban centers arose along the road, and families were settled on either side, extending some 80 to 100 km into what were mostly heavily forested areas. Two other major axes of settlement and spatial interaction that developed in the state ran along the state highway 429 from Presidente Médici (located on the BR-364) southwest to Costa Marques along the Guaporé River, and state highway 425 from the BR-364 west of Porto Velho South to the city of Guajará-Mirim, along the Mamoré River (Figure). Both rivers help form the Rondonia border with Bolivia. Costa Marques and Guajará-Mirim have significant spatial interactions with Bolivia across the rivers, related to everyday trade and likely illicit activities such as logging and drug trafficking. These patterns of spatial interaction along main transportation axes are important to consider in a developing area like Rondonia where many adjacent municipalities have little interaction between them because there is no road connecting them.

This study aimed to analyze spatial changes in the risk of AIDS and the relationship between AIDS incidence and municipal-level socioeconomic variables. This study can contribute to understanding the diffusion dynamics of the epidemic in the North of the country, where transmission began late in relation to other regions of Brazil.

Figure. Map of the state of Rondonia, Brazil, including federal highways and state roads.

METHODS

The study involved all cases of AIDS in Rondonia (n = 1,780), reported by Brazil's Epidemiological Surveillance System and provided by the Health Statistics System (DATASUS), from 1987 to 2006. The reported cases were grouped into five consecutive four-year periods: 1987 to 1990, 1991 to 1994, 1995 to 1998, 1999 to 2002, and 2003 to 2006. This was done because changes in AIDS incidence are too small in Rondonia to be tracked on an annual time-scale. AIDS incidence was reported according to the municipal residence of the individual, not the municipal location of the reporting.

Incidence rates of AIDS per 100,000 inhabitants for each four-year period were calculated for the municipalities of the state. For the denominator, the mean population for each four-year period was used, and it was calculated from demographic census data (1991, 1996, 2000, and 2007) obtained from the Brazilian Institute of Geography and Statistics (IBGE). The municipal population between census years was estimated by interpolating known values, with a geometric function.

The geographic distribution of risk of AIDS in the state was estimated by performing a spatial case-control study based on secondary population data for each period. The reports of AIDS among residents of Rondonia comprised the individuals in the case group. The controls were selected through a stratified random sample of municipalities in Rondonia. In each stratum, individuals were sampled in proportion to the estimated

[c] Mahar DJ. Government policies and deforestation in Brazil's Amazon Region. Washington (DC): World Bank; 1989.
[d] State of Rondonia Government [Internet]. Porto Velho; 2007 [cited 2013 Oct 31]. Available from: http://www.rondonia.ro.gov.br/

Table 1. Sex and categories of transmission of AIDS in five four-year periods. Rondonia, Northern Brazil, 1987 to 2006.

Four-year period	Sex ratio Male/Fem	Homo/Bi. sexual		Het. sexual		IDU		Not reported[a]		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1987 to 1990	7	7	29.2	6	25.0	4	16.6	7	29.2	24	1.4
1991 to 1994	2.5	18	16.1	52	46.4	19	17.0	23	20.5	112	6.4
1995 to 1998	1.5	47	16.7	172	61.0	24	8.5	39	13.8	282	15.9
1999 to 2002	1.3	70	13.2	332	62.8	29	5.5	98	18.5	529	30.0
2003 to 2006	1.3	56	6.9	536	64.2	16	4.1	210	25.6	818	46.3
Total	2.0	198	11.2	1,098	62.2	92	5.2	377	21.4	1,765	100.0

IDU: Intravenous drug user
[a] Not reported and others, such as blood transfusion and occupational

population of the city in the middle of the four-year period analyzed. The geographic coordinates (latitude and longitude) of the cases and controls were set at the centroids of each municipality. These data were obtained from IBGE, using the Universal Transverse Mercator Projection and Datum SAD69.

A generalized additive model (GAM) was adjusted to the data. The dependent variable was the status of the individuals (case or control), and the independent variable was a bi-dimensional spline of the geographic coordinates.

The municipal-level socioeconomic variables were obtained from the Institute for Applied Economic Research (IPEA): percent of population living in the urban zone, number of doctors per thousand inhabitants, human capital (the difference between expected income obtained by the work force of the municipality in the labor market and the estimate of that obtained by workers without education and experience), gross national product (a form of municipal-level gross domestic product), and a human development index (a composite of education, income, and life expectancy). These variables are used frequently in economic and demographic studies.[e]

A logistic regression model was adjusted with the dependent variable being the status of the individual (case = 1, control = 0) for each four-year period studied, with municipal-level socioeconomic indicators as independent variables analyzed in the middle of the four-year period.

The significance level of the estimates obtained for the spatial distribution of AIDS risk was verified using a Monte Carlo algorithm proposed by Kelsall & Diggle[12] (1998). The adjustment was performed using the software R, version 2.11.1, library mgcv. The Moran's I statistic was calculated to estimate spatial autocorrelation of AIDS incidence for each four-year period.[8,a] This was done using two different matrices that defined the spatial contiguity among the municipalities. The first defined two municipalities as neighbors when their borders shared any point of contact with each other (queen weights). The second defined municipalities as neighbors only if the above condition was complemented by the municipalities being connected by a federal or state highway (road weights), based on the 1993 edition of the Rondonia State Road Map produced by the Department of Highways and Roads (DER-RO). The statistical significance level of the observed Moran's I was established by comparing it to a reference distribution of Moran's I values generated under conditions of spatial randomness. The calculations were performed using GEODA, version OpenGeoDa beta release 0.9.9.14.

RESULTS

There were 1,765 cases of AIDS reported among residents of Rondonia from 1987 to 2006, with a progressive increase throughout the four-year periods studied (Table 1). An increase in the proportion of cases among women was observed: the male/female ratio reached 1.5 after the third four-year period. There was a decrease in individuals in the homosexual/bisexual and intravenous drug use categories and an increase in the percentage and absolute number of heterosexuals affected in the second four-year period. Considering the 10 municipalities with the highest incidence rates of the 52, 8 were bisected by the federal highway BR-364 (Table 2).

Urbanization and human capital were positively associated with AIDS risk in Rondonia, and the number of doctors per thousand inhabitants was negatively associated (Table 3).

AIDS risk was first detected in the northwest of the state near Rondonia's capital. A center of risk then emerges in the southeast along the border with the state of Mato Grosso, eventually affecting eastern Rondonia. Risk was present in areas along the federal highway BR-364 in the 1991 to 1994 period, distant from western Rondonia. Risk appeared on the border with Bolivia toward the end of the 1990s. AIDS risk

[e] Institute for Applied Economic Research - IPEA [Internet]. Brasília (DF); s.d. [cited 2013 Oct 31]. Available from: http://www.ipea.gov.br/portal/

Table 2. Cases and incidence rates (per 100,000 inhabitants) in Rondônia's municipalities (ten-highest of 52 municipalities). Rondonia, Northern Brazil, 1987 to 2006.

Municipality	1987 to 1990 Cases/Incid.[b]	1991 to 1994 Cases/Incid.[a]	1995 to 1998 Cases/Incid.[b]	1999 to 2002 Cases/Incid.[b]	2003 to 2006 Cases/Incid.[b]
Porto Velho	21/7.3	81/28.2	180/61.6	364/108.8	448/124.4
Vilhena[a]	4/10.2	3/7.6	31/69.8	31/57.8	75/124.4
Ji-Paraná[a]	0/0	10/10.2	12/12.7	30/28.1	56/52.1
Cacoal[a]	0/0	3/3.8	14/19.2	14/19.0	42/55.2
Ariquemes[a]	0/0	4/4.8	5/7.3	17/22.8	41/49.7
Jaru[a]	0/0	2/3.2	7/14.6	4/7.5	14/26.7
Guajará-Mirim	1/3.1	2/6.1	4/11.1	5/13.1	11/27.9
Presid. Medici[a]	0/0	7/23.3	3/10.9	6/22.7	6/27.0
Pimenta Bueno[a]	0/0	0/0	4/8.4	8/25.2	10/30.4
Candéias Jamari[a]	0/0	0/0	0/0	6/45.8	13/77.7

[a] Municipalities bisected by federal highway BR-364
[b] Cases/Incidence of Aids per 100,000 inhabitants

spreads throughout the state into areas that were previously safe from the epidemic in the final four-year period. The risk of AIDS was particularly high (OR = 5) at the border with the state of Acre along the BR-425 highway and at the border with the state of Mato Grosso (Annex 1).

The Annex 2 shows the semi-parametric spatial distribution of AIDS risk, i.e., controlling for the non-spatial covariates selected in the multinomial adjustment and significant areas (in gray), for each four-year period. The first period (1987 to 1990) was not presented because the entire distribution was not significant (all gray). The spatial models adjusted by socioeconomic variables show that the borders with Bolivia, the state of Mato Grosso and Acre were important areas of risk. Socioeconomic variables like urbanization and human capital explained the risk in the region of the capital city, Porto Velho, and along the highway BR-425 to the state of Acre, but there was still an excess of risk in Porto Velho (north) and the Vilhena region in the south. White areas corresponded to low-risk unpopulated and isolated regions.

The values obtained for the third and fourth four-year period, using the road-based contiguity, were significant ($p = 0.05$), with the others not significant (Table 4).

DISCUSSION

The data show a steady growth of AIDS risk throughout the years of the study, starting along the main roads and in the most developed regions and spreading through all municipalities of Rondonia. The spatial and temporal distribution of AIDS risk in the state is associated with socioeconomic and contextual determinants. The diffusion pattern in the state differs from regions in Brazil where HIV transmission has a longer history. The beginning of AIDS transmission in Rondonia came late, with the first reported case in 1987, a few years after the main highway through the state, the BR-364, was first paved. In the mid-1990s, the highest incidence was already among heterosexuals, in individuals with lower levels of education, and a small proportion of cases were found among intravenous drug-users. The sex ratio of affected people (males/females) was nearly equal at the time, suggesting a heterosexual transmission pattern. The dissemination of AIDS and the factors that maintain the epidemic in the region were different than in other regions of the country in the first decade of the epidemic. These same characteristics were identified in the Midwest, North and other frontier areas of Brazil, most intensely after the 1990s.[17-19,a]

The epidemic first began in the northwest of Rondonia, the site of the state's capital, Porto Velho, which is the political and economic hub of the region. The multiple logistic regression showed greater disease risk being maintained in municipalities with higher urbanization and income over the five periods. Higher levels of human capital were also associated with the disease. Municipalities with higher urbanization and population density, accompanied by economic relationships with other regions, tend to attract migratory populations and seasonal workers.[2,9] Regions with greater movement of people, goods, and associated changes in the sociodemographic structure have been shown to have increased infection risk, in Brazil and worldwide.[2,9,17] The disease is associated with a reduced number of doctors (doctors per 1,000 inhabitants) in the fourth period. This indicates the importance of health services and related educational and prevention programs in preventing AIDS. More study would be needed to determine whether the number of doctors per 1,000 inhabitants is indeed a good indicator of overall health services. HIV/AIDS control programs have positive impact on controlling AIDS morbidity and mortality in the Southeast region of Brazil.[16]

Table 3. Results of a logistic regression model of AIDS risk in five four-year periods. Rondonia, Northern Brazil, 1987 to 2006.

Socioeconomic variable	1987 to 1990		1991 to 1994		1995 to 1998		1999 to 2002		2003 to 2006	
	OR_{aj}[a]	p	OR_{aj}[a]	p	OR_{aj}[a]	p	OR_{aj}[a]	p	OR_{aj}[a]	p
Urbanization %	1.75	0.0021	–	–	–	–	3.93	< 0.0001	2.73	< 0.0001
Physician/1,000 inh	–	–	–	–	–	–	1.11	0.0130	–	–
Hum Capital/year	$5.04*10^{-7}$	0.0007	$1.54*10^{7}$	0,0199	$1.40*10^{-7}$	0.0001	$1.83*10^{-7}$	< 0.0001	$7.60*10^{-8}$	< 0.0001
HDI	–	–	19.75	0.0009	26.57	< 0.0001	–	–	–	–
GDP *per capita*	–	–	–	–	0.17	0.0191	–	–	–	–

HDI: Human Develop Index; GDP *per capita:* Gross domestic product *per capita*
[a] OR_{aj}: Adjusted Odds Ratio

With the general relationship established between disease incidence and urbanization, one can also explore mechanisms of spatial interaction that allow diffusion of the disease among urban centers. A visual comparison of Figure and Annex 1 suggests a spatial-temporal resemblance between the path of the main highways in the state and the spread of AIDS risk in the second, third, and fourth periods. The Moran's I statistics for disease incidence provide a more rigorous test of the importance of Rondonia's road network in the spread of the disease. The Moran's I that considered the road network (road weights) was significant, which is consistent with the hypothesis that the road network played a major role in the diffusion of the disease. A significant Moran's I is an indication of spatial autocorrelation in the data. Moran's I was significant for the third and fourth periods, but only when municipalities were designated as neighbors in the spatial contiguity matrix by sharing a border and a connection via state or federal highways. The highest incidence rates of AIDS in municipalities along the BR-364 highway and the Moran's I analysis are consistent with the explanation that AIDS followed the road network in Rondonia along with the development and occupation of urban spaces.

The data cannot be used to confirm exactly what mechanisms of spatial interaction initially allowed AIDS to arrive in the state and to then diffuse within it, but the spatial-temporal results do suggest some plausible scenarios. Disease risk first appears in the extreme northern and then int the extreme southern parts of the state. The northern region is under the influence of Porto Velho, the state capital, which has a major airport. It could be that middle-to upper-class air travelers from other regions of the country initially brought it to Porto Velho, spreading the disease first among homosexual/bisexual males in the urban area of the capital. The next emerging area of risk then appears in the extreme south of Rondonia, in the region of Vilhena, suggesting some potential influence from neighboring Mato Grosso state via ground transportation, since Vilhena has no major airport. Disease risk spreads to other parts of the state, likely via ground transportation (buses and commercial trucking) along state and federal highways in the subsequent periods of the study. The spread of the disease during these periods could be due to transmission of HIV within the heterosexual and less educated population, as suggested by socioeconomic and epidemiologic data. An especially vulnerable group is comprised of people who have occupations involving trucking and prostitution, as pointed out by studies in developed and developing countries.[13,15,22]

Table 4. Moran's I statistics and P values for five four-year periods, according to queen weights-based contiguity[1] and road weights-based contiguity.[1] Rondonia, Northern Brazil, 1987 to 2006.

Four-year period	Queen weights		Road weights	
	Moran's I	p	Moran's I	p
1987 to 1990	-0.01	0.68	-0.09	0.17
1991 to 1994	-0.08	0.08	-0.05	0.33
1995 to 1998	-0.09	0.21	0.18	0.02
1999 to 2002	-0.06	0.31	0.16	0.06
2003 to 2006	0.05	0.17	0.04	0.32

The relationship between highways, frontier expansion and health threats (particularly violence, malaria and AIDS) in the central Brazilian Amazon was suggested by Barcellos et al[2] (2010). Such development increased economic expansion. However, it attracted migrants searching for work and a better life, eventually leading to growth in a marginalized population concentrated along the region's main highway, allowing for daily interaction with people from various parts of the country.[2] Frontier regions are often areas at high risk of disease and death. This is due to the flow of workers, typically with lower skill and education levels, who comprise a large group of individuals vulnerable to infection via un-safe sex practices and prostitution.[14,15,19,22,a] An increased HIV vulnerability may be due to a poor sense of community and inadequate social support systems in areas dominated by migrant populations and seasonal workers.[2,14,18]

The results of the present study are consistent with the general picture that the rapid development associated with the opening of once remote regions may be accompanied by an increase in these health threats. Annex 1 and 2 show highest risk of AIDS on the

borders of the state, and the Moran's I test indicates highways as associated with the disease incidence. Many regions of Rondonia have suffered from malaria and violence since the state was first opened to settlement in the 1960.[2,c] The highway BR-364 was paved in 1983, followed by intensified economic development, rapid urbanization, in-migration, and movement of people and goods across and within the state. The first reports of AIDS in the state quickly followed these events. Given that Rondonia was but one center of development in the Amazon, albeit a major one, these disease patterns likely manifested themselves in similar areas in Brazil's North. The North region's population grew 4.0% during the 1990s, double the growth of the nation's population as a whole during the same period.[5,a] Vulnerability to HIV/AIDS infection in Rondonia and elsewhere is possibly associated with the process of human occupation and regional development, through which isolated regions became more tightly integrated into the country's economy. Socio-anthropological studies could show precise interactions and behaviors in the population living in the region, particularly along major roads, to better understand the disease risk in individual particular situations.

Studies show high risk sexual behavior among truck drivers with a poor perception of HIV infection risk, indicating the importance of movement of people and goods in putting people at risk of AIDS in Brazil.[6,7,23] The existence of municipal, state, and federal programs for AIDS control and prevention aimed at truckers at checkpoints, weigh stations, and service centers located at border crossings between states appears justified.[3] Studies from other developing regions of the world are also consistent with the possible scenarios of disease diffusion presented here. In studies in India, Tanzania, Uganda and other countries in Africa, long-haul truckers are considered crucial agents in the dissemination of AIDS. Their impact is strengthened by the presence of impoverished populations settled along trucking routes, where prostitution is often the only way for women to survive from an early age.[21,22,24] The role of road networks in the dissemination of AIDS in South Africa, Uganda, and Brazil is suggested by authors who have identified a strong relationship between infection and proximity to roads and commercial centers.[2,6,21,22]

In studies like this, bias can occur when the geographic distribution of cases merely reflects the distribution of locations where the disease can be reported. This is not an issue in the instance of this study. AIDS in Brazil is reported by the country's Surveillance System, which records, among other variables, the place of residence of the individual, and that variable was used in this study. Under-notification is also a common issue in studies, especially when individuals contract diseases in remote areas, dying or recuperating without subsequent report of the disease. No doubt there is under-notification, but in the case of AIDS, it is less of a concern than with studies of other diseases. AIDS is a severe and progressive disease in which people tend to eventually seek hospitalization and treatment in some urban center, leading to an official report of the disease, even in remote areas.

Another limitation is that notification of cases in chronic diseases of long duration and long latency periods refers to infection that occurred in the past, making it difficult to understand the dynamics of viral transmission in the present.

There is a marked spatial and temporal pattern to the distribution of AIDS risk that is concentrated in Rondonia, during its expansion, in municipalities along major roads in the north and south. The epidemic is also related to socioeconomic variables at the municipal level in Rondonia, such as urbanization and human capital in municipalities that are also bisected by Rondonia's main roads. The increase of preventive measures by the Ministry of Health directed at long-haul truckers crossing the region could have an impact on the dissemination of the disease. Spatial analysis may aid in identification of disease transmission patterns in different regions, suggesting specific populations and locations where interventions can have the greatest impact.

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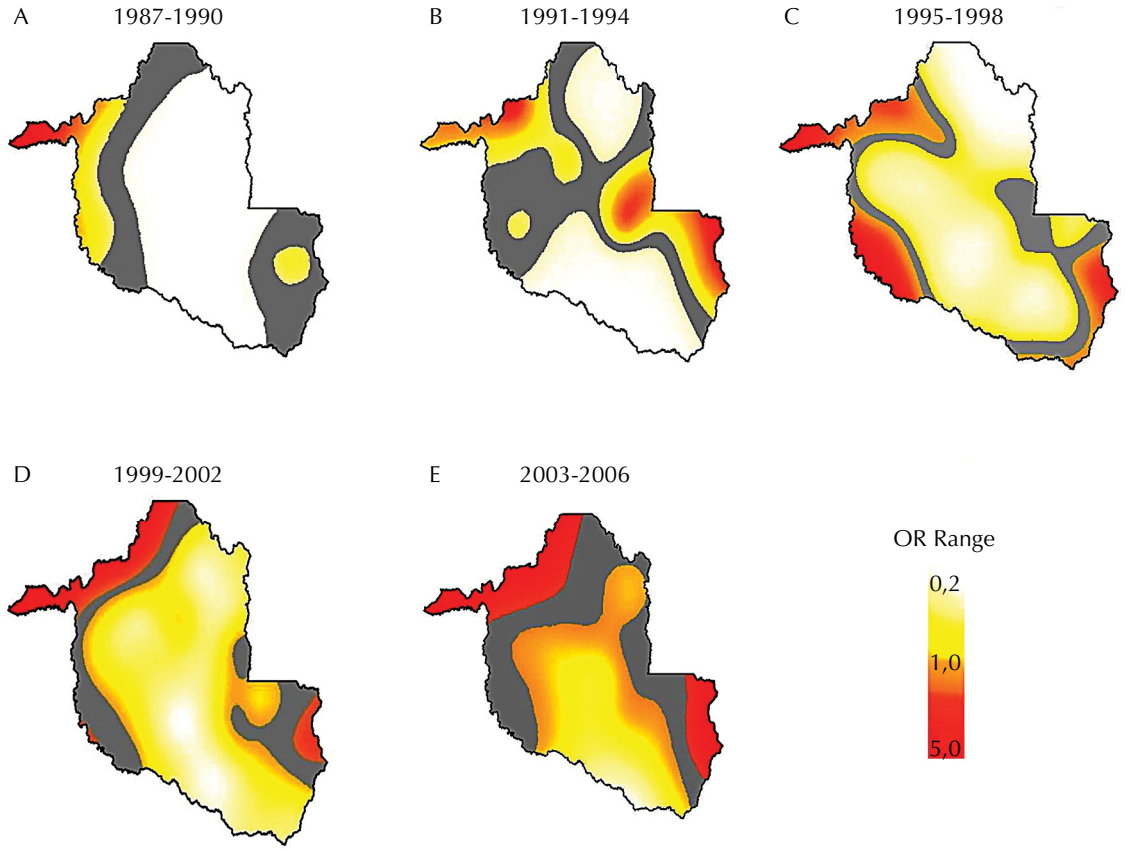
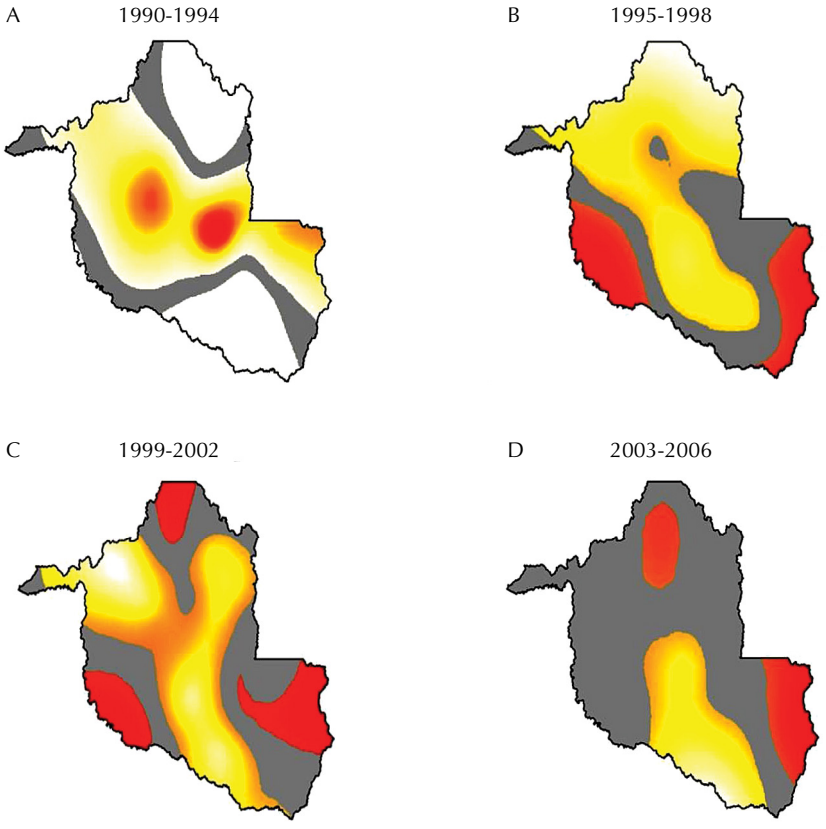
Annex 1. Spatial distribution of AIDS risk in Rondonia, Northern Brazil in four, five-year periods, 1987-2006.



Red to yellow areas show significantly higher AIDS risk than the region's average (odds ratio = 1.7 to 5.0); white areas present lower risk than the region's average. Gray areas are insignificant for AIDS risk.

Annex 2. Adjusted spatial distribution of AIDS risk in Rondonia, Northern Brazil, with socioeconomic variables in four five-year periods, 1987-2006.



Red to yellow areas show significantly higher AIDS risk than the region's average (odds ratio = 1.7 to 5.0); white areas present lower risk than the region's average. Gray areas are insignificant for AIDS risk.