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# Geographic expression of AIDS epidemic in Campinas, Southeastern Brazil, between 1980 and 2005

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## ABSTRACT

**OBJECTIVE:** To analyze the spatial distribution of reported AIDS cases in adults and its association with living conditions in the city of Campinas, Southeastern Brazil.

**METHODS:** Data on AIDS cases in men (n=2,945) and women (n=1,230) aged more than 13 years and living in Campinas, recorded in the SINAN (Brazilian Information System for Notifiable Diseases), were used to map the spatial distribution of this disease and the male:female ratio. Maps were constructed for the following periods: from 1980 to 1995, from 1996 to 2000, and from 2001 to 2005. The variables included in the analysis were address, sex and age. A weighted composite index was used to study living and health conditions in the area. Patients' home addresses were geocoded on a cartographic base, after correction and standardization according to a reference database of streets. A generalized additive model was adjusted to analyze the spatial distribution of the ratio of male:female cases in space, in the three study periods.

**RESULTS:** The ratio of male:female cases was higher in areas with better living conditions (central) and around the prison (northwestern), where families of prisoners and former prisoners live temporarily, while this ratio was lower in the city suburbs (southwestern).

**CONCLUSIONS:** The trends towards the AIDS epidemic affecting more women and poorer individuals were confirmed by the decrease in the ratio of male:female cases in the period, particularly in vulnerable and impoverished populations. Geographic information systems and spatial data analysis can be useful for AIDS control and surveillance actions.

**DESCRIPTORS:** Acquired Immunodeficiency Syndrome epidemiology. Information Systems. Disease Notification. Geographic Information Systems. Socioeconomic Factors.

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## INTRODUCTION

The first cases of AIDS in Brazil were diagnosed in the cities of São Paulo and Rio de Janeiro, in the Southeastern region, in the early 1980s.<sup>4</sup> Considering the natural history of this disease, it is believed that the HIV was introduced in Brazil in the 1970s, spreading throughout the country in an insidious and progressive way, in the following decades, with different dissemination patterns.<sup>5,7</sup> In 1985, the city of Campinas was among the six cities with five or more cases of AIDS in the state of São Paulo.

In the onset of the HIV/AIDS epidemic, this disease was predominant in men who had sexual intercourse with other men, bisexual males, white, with a high level of education and who lived in large cities of the Southeastern region of Brazil.<sup>11,12</sup>

After the first decades, the epidemiological profile of the disease changed, with a trend of HIV/AIDS dissemination in heterosexual men, women and children of all social classes, particularly affecting marginalized and vulnerable populations.<sup>6,9,10,13</sup> In a few years, it became one of the main causes of mortality in adults.<sup>7,13</sup> The male:female ratio of AIDS cases was 26.7:1 in 1985, decreasing to 1.5:1 in 2008.<sup>4,11</sup>

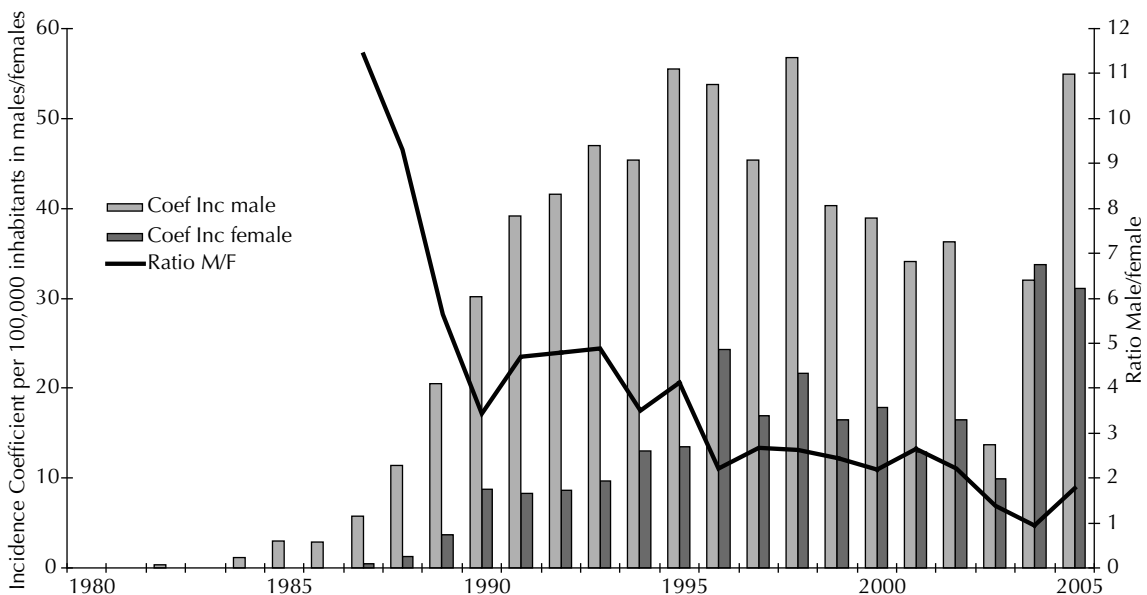
The spatial dissemination of AIDS has been investigated, using geoprocessing and spatial data analysis, increasing the understanding of the dynamics of this epidemic in Brazil and enabling public health to have tools traditionally used in geography and cartography.<sup>2,5,14</sup> Health services have also incorporated statistical analyses, computer programs and geographic information systems (GIS), particularly in programs of epidemiological surveillance of diseases. In this way, space began to be thoroughly analyzed, bringing important contribution to epidemiological studies and the performance of health services.<sup>2,3</sup>

The present study aimed to analyze the spatial distribution of reported AIDS cases in adults and its association with living conditions in the city of Campinas, Southeastern Brazil.

## METHODS

An ecological study on the spatial distribution of the total number of AIDS cases in individuals aged more than 13 years was performed, excluding vertical transmission cases, in residents of the city of Campinas, State of São Paulo, Brazil, recorded in the Epidemiological Surveillance System, between 1980 and 2005. The variables identified in the epidemiological report file of the Information System for Notifiable Diseases (Sinan) and included in the spatial analysis of cases were address and sex. Maps of the three epidemic periods (from 1980 to 1995, from 1996 to 2000 and from 2001 to 2005) were constructed, with the distribution of male:female ratios (number of cases in men divided by that of women). The time trend of AIDS incidence rates per 100,000 cases, according to sex, and that of the male:female ratio was analyzed between 1980 and 2005.

The *Índice de Condições de Vida* (ICV – Life Conditions Index), comprised of eight socioeconomic indicators, weighted and selected from data available in the City of Campinas Department of Health,<sup>a</sup> was used to differentiate areas of the city in terms of quality of life and population health. The ICV enables the classification of areas of coverage of health centers distributed into three homogenous areas. These areas were grouped with approximately the same number of health centers, with an improvement from ICV 1 (the worst one), ICV 2 to ICV 3 (the best one). The indicators used were as follows: annual growth rate, proportion of residents in



Source: Information System for Notifiable Diseases (Sinan), Campinas

**Figure 1.** AIDS incidence rate per 100,000 inhabitants, according to sex. City of Campinas, Southeastern Brazil, 1980-2005.

<sup>a</sup> Secretaria Municipal de Saúde. Coordenadoria de Vigilância e Saúde Ambiental. Índice de Condição de Vida. Campinas; 2001 [cited 2009 Jan 10]. Available from: <http://tabnet.saude.campinas.sp.gov.br/mapas/ICV.pdf>

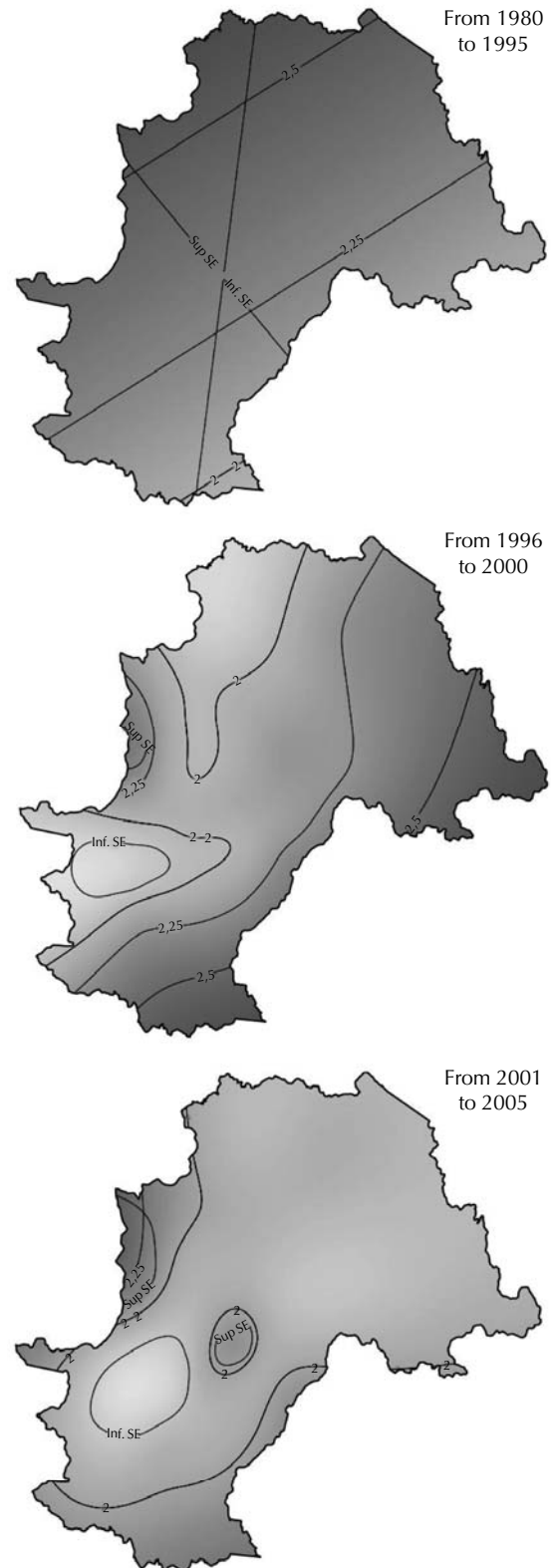
low-income dwellings (slums, tenement houses and improvised dwellings), level of education of head of family, proportion of mothers younger than 20 years, coefficient of child mortality and mortality from homicide, incidence of tuberculosis and incidence of malnourishment in children younger than five years. Mean values of each area of health centers are used to analyze the ICV, which could limit the identification of intra-area differences.

The digitalized cartographic base of the city of Campinas was designed by the Sociedade de Abastecimento de Água e Saneamento de Campinas (City of Campinas Sanitation and Water Supply Society) in 2000 with the AutoCAD software, and it is periodically updated by the Municipal Department of Planning and the Municipal Department of Health (last updated in 2006). Using the MAPINFO software, new districts, illegal settlements, urban constructions and housing complexes were included, in addition to the updating of data of interest in the area of health. The following parameters were used to construct this cartographic base: Hayford International Ellipsoid and Universal Transverse Mercator Projection, Córrego Alegre, State of Minas Gerais, Brazil.

The location of cases on the cartographic base was performed using home addresses, through the ArcMap 9.2. software method of geocoding, after correction and standardization of data, according to the city street layout base. Addresses that did not enable the exact location of the point in the map, due to a lack of information or inaccuracy of street name, were excluded. Once geocoded, the cases located on the base had their geographic coordinates projected on the UTM SAD69.

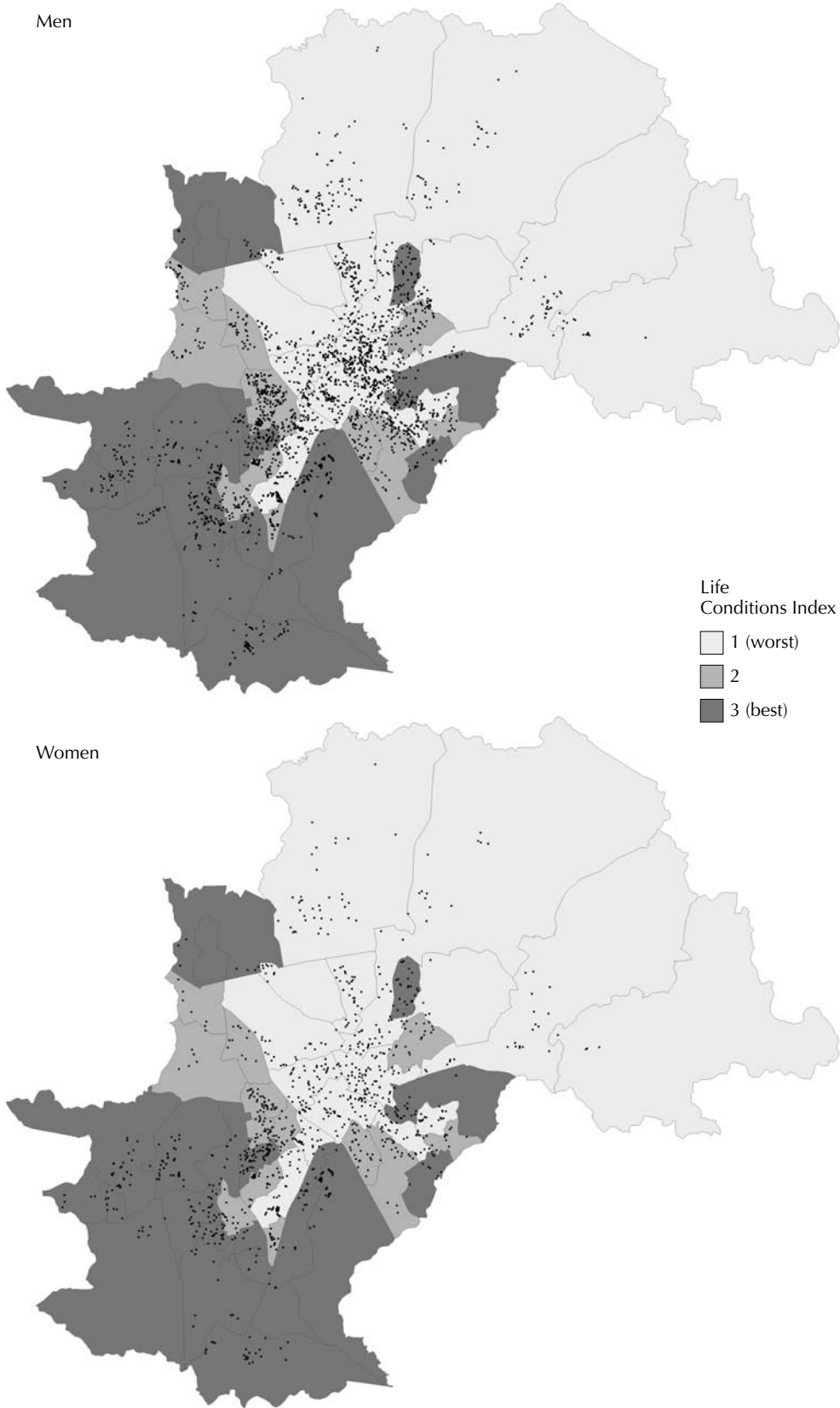
Kelsall & Diggle<sup>8</sup> developed a method to obtain the spatial risk, with the adjustment of generalized additive models (GAM), including the analysis of statistically significant areas. A model was adjusted for each period, where the sex variable was used as response (coded as 1 for men and 0 for women) and the pair of geographic coordinates of cases, included as a non-parametric variable in a smoothing function, as predictive variable.<sup>1</sup> In this way, the values predicted by the model represent the relative proportion between men and women suffering from this disease.

The models were calculated in the R software, version 8.2.0, using the GAM function of the mgcv package. The values predicted by the models were obtained for the coordinates of a grid of color, due to the predictive variable of the model, with the respective 95% confidence intervals, in which the 2.5% upper (SUP-SE lines) and lower limits (INF-SE lines) of standard error are shown. The numbers of lines in the map indicate how many times the male:female ratio is higher in that particular area, compared to the reference value of 1.



Note: the SUP-SE and INF-SE lines refer to the upper and lower limits of significance of the values found

**Figure 2.** Spatial distribution of the male:female ratio of cases, after adjustment of the generalized additive model in the three periods of study. City of Campinas, Southeastern Brazil, 1980–2005.



**Figure 3.** Maps of AIDS cases in men and women and Life Conditions Index (ICV) in areas covered by health services. City of Campinas, Southeastern Brazil, 1980-2005.

## RESULTS

A total of 7,381 AIDS cases, reported between 1980 a 2005, were recorded, of which 5,195 were in men (70.4%) and 2,186 in women (29.6%). Of these, 4,175 (56.6%) records were located in the cartographic base.

Figure 1 shows the temporal distribution of AIDS incidence rates by sex and the male:female ratio, in the period of study. A relative increase in incidence in women from 1990 on is observed.

The maps shown in Figure 2 reveal generalized linear models of spatial distribution of the male:female ratio in the three periods of study and the limits of significance of estimators (SUP-SE and INF-SE). The differences throughout time indicate city locations where the male:female ratio of cases was significantly higher, among which are the districts in the central and north areas of Campinas, the area surrounding the *Complexo Presidiário de Hortolândia* (Hortolândia Prison Complex), in the city of Hortolândia, a neighboring city of the Metropolitan Area of Campinas. The lower male:female ratio of cases was significantly concentrated in the suburbs situated in the southwestern area of the city, where living and health conditions are worse.

The spatial distribution of AIDS cases per sex and according to the ICV showed a significant concentration of cases in areas with worse life conditions, groups 1 and 2, particularly with a greater proportion of women, when compared to areas with better quality of life and health belonging to the ICV 3 group (Figure 3).

Figure 4 shows the temporal distribution of the male-female relationship in areas of the city classified by the ICV, revealing different profiles of the epidemic in Campinas. This index was higher in areas with better living conditions (ICV 3) during the entire period, reaching a value almost three times higher than those found in areas with ICV 1, in the onset of the epidemic.

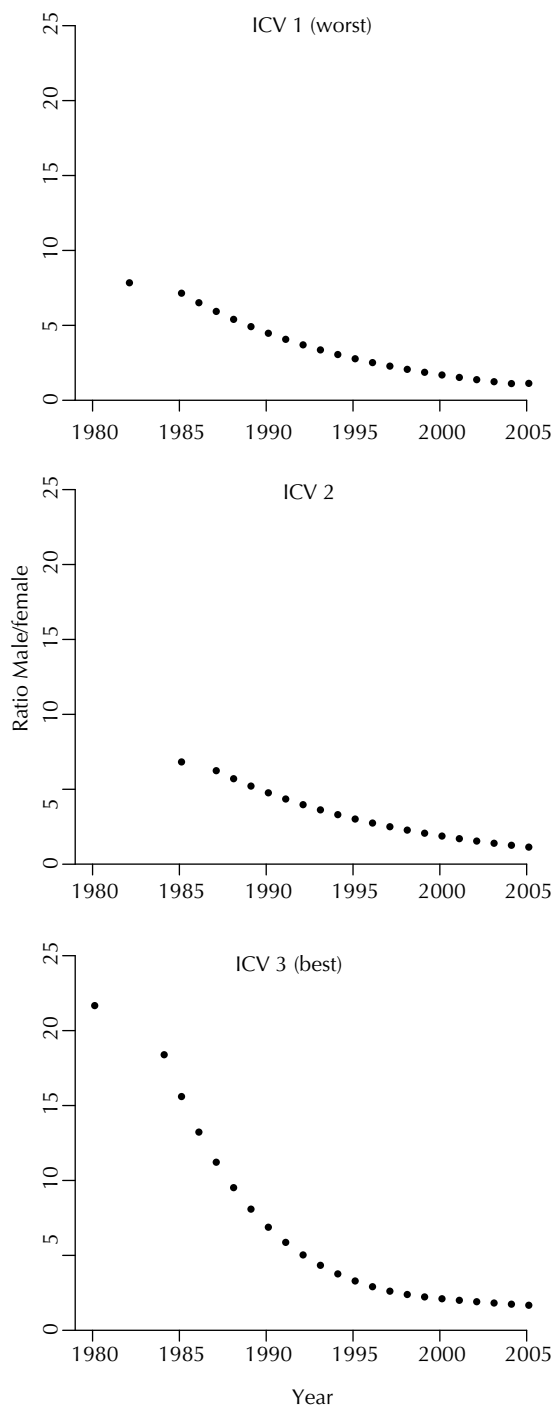
## DISCUSSION

The maps of AIDS in Campinas show a trend towards this epidemic affecting more women and poorer individuals, with a decrease in the male:female ratio throughout time, in a heterogeneous way and in urban areas. This is a trend that has already been recorded in other regions of Brazil in the last decades.<sup>6,7,10</sup>

Certain areas of Campinas have a higher male:female ratio than others, particularly districts situated in the central and northern areas of this city, close to the prison in Hortolândia, where former prisoners and their families have settled temporarily. The population of men infected with HIV/AIDS has a lower proportion in districts situated in the southwestern area of the city,

suburbs with low values of ICV and high criminality rate. The greater spread of HIV in women in poorer areas has been reported in several studies.<sup>9,10,12,13,15</sup>

In addition to greater biological vulnerability to HIV infection, due to the higher prevalence of asymptomatic sexually transmitted diseases and the higher risk



**Figure 4.** Temporal distribution of the male:female ratio of reported AIDS cases, according to the Life Conditions Index (ICV). City of Campinas, Southeastern Brazil, 1980–2005.

of infection in sexual intercourse, there are subjective situations associated with gender inequalities that women are exposed to, especially those from lower social classes. HIV transmission in women increases in populations with lower level of education and income, with limited access to health services and policies to prevent HIV infection, apart from the variables related to the previously mentioned gender inequality.<sup>9,14</sup>

Given the need to increase the understanding of the dynamics of production and transmission of HIV/AIDS infection, instruments traditionally used in GIS can be useful to identify areas with a greater concentration of cases, in addition to enabling the identification of places with higher risk of infection, using statistical models with greater explanatory potential.<sup>1,2,3</sup> The use of georeferenced points in maps allows greater accuracy of analysis, because it is assumed that possible inner differences and inequalities in an area, divided into polygons, will not disappear. Thus, the onset of a disease is the focus, as a result of the demographic and social structure of the city and its differentiation in the country. In the present study, addresses that were not georeferenced result in loss of information, probably concentrated in the city suburbs. This could become bias of selection of cases, underestimating the occurrences in poorer areas.

Efforts to improve the quality of information about the HIV/AIDS epidemic can be increased, leading to the development of the Epidemiological Surveillance System. The more accurate collection of addresses in the Sinan, in addition to the implementation of computer programs that enable the standardization of these addresses, correcting them and eliminating

duplicities, would facilitate data analysis and allow geoprocessing and the spatial analysis of the epidemic in the local/city dimension. Moreover, the return of such information to primary health units can result in greater involvement of local teams with prevention and care actions for populations included in the areas of their respective health centers.

Although the ecological approach enables the visualization of epidemic trends in the urban space and the identification of places with a greater concentration of cases and risks, studies with a qualitative approach are required to enable the social and behavioral dynamics of susceptible groups to be better understood. The identification of the main types of behavior towards and perceptions of the risk of AIDS and the barriers against changes in the routine interactions can certainly facilitate the performance of municipal control programs.

In conclusion, different epidemics were visualized in the city maps. A pattern of transmission could be perceived in districts with better living and health conditions, where cases are concentrated in men, while another pattern of transmission is present in the suburbs, where the male:female ratio of cases is lower, revealing greater female susceptibility to infection. Spatial visualization of the male:female ratio enabled the trend towards more women being infected with HIV/AIDS to be confirmed in the city of Campinas, particularly in the city suburbs.

The identification of "regional epidemics" can facilitate the approach of vulnerable populations and the implementation of specific measures of health care and disease prevention and control by local health teams.

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