

Definition of persistent areas with increased dengue risk by detecting clusters in populations with differing mobility and immunity in Rio de Janeiro, Brazil

Definição de áreas persistentes com risco aumentado de dengue através da detecção de clusters em populações com diferentes padrões de mobilidade e imunidade no Rio de Janeiro, Brasil

Definición de áreas persistentes con riesgo elevado de dengue, mediante la detección de clústeres en poblaciones con diferente movilidad e inmunidad, en Río de Janeiro, Brasil

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Abstract

Dengue is a re-emerging arbovirus infection of major epidemiological importance. The detection of dengue clusters is an important epidemiological surveillance strategy, contributing to better allocation of control measures and prioritizing areas that are subject to increased risk of transmission. Studies involving human populations with low mobility are scarce, and the current study thus aims to investigate the presence of persistent dengue clusters in the city of Rio de Janeiro, Brazil, in populations with different mobility and immunity. Epidemiological data on dengue were obtained from the Brazilian Ministry of Health. Areas of increased risk were defined by the space-time scan statistical method and analysis of persistence with use of map algebra. For both study populations, the clusters that were identified did not show spatial concordance, except in years when both presented the same immunological profile. Their persistent clusters were located mostly in the West Zone of city. The clusters of the two study populations only displayed spatial concordance in years with similar immune profiles, which confirms the confounding role of immunity and supports the use of populations with high percentages of susceptible individuals when designing territory-based dengue studies. The space-time similarity between the areas of persistent risk in both populations suggests that the West Zone, a region with disorderly urban growth and low mean income, shows the highest risk of dengue transmission. The definition of persistent dengue clusters contributes to the improvement of dengue control strategies and territorial planning.

Dengue; Space-time Clustering; Risk

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Introduction

Arbovirus infections including dengue, chikungunya, and Zika are important emerging and re-emerging diseases. They are considered serious global public health problems due to their heavy morbidity and mortality ^{1,2,3}. Dengue is endemic in more than 100 countries in the world's tropical and subtropical regions. The disease totals approximately 100 million reported cases per year ⁴. Estimates using statistical modeling have suggested that dengue infects approximately 390 million persons per year in the world, of whom 96 million present detectable symptoms with different levels of severity ⁵.

Dengue arbovirus infection has four antigenically distinct subtypes (DENV-1, DENV-2, DENV-3, and DENV-4), transmitted by infected female mosquitoes of the genus *Aedes* ^{6,7}. The culicid mosquitoes *Aedes aegypti* and *Aedes albopictus* are widely dispersed around the world and are still undergoing geographic expansion ⁸. Both species are adapted to the peridomicile, where they feed and perform oviposition in different artificial and natural breeding places ^{7,9}.

Since Brazil's re-infestation by *Ae. aegypti* in the 1970s and later the appearance of its first dengue epidemics in 1986 (which have lasted to date), the country has experienced successive epidemic outbreaks. Total reported dengue cases in Brazil by 2017 have been estimated at 12 million ¹⁰. In 2017, according to Brazilian Ministry of Health data, 252,054 suspected dengue cases were reported, distributed across all 27 states of the country ¹⁰. The state of Rio de Janeiro has been historically presented as being among the highest dengue incidence rates in Brazil. The state has suffered epidemics since 1986, when DENV-1 was isolated in the city of Nova Iguaçu ^{11,12,13}. The city of Rio de Janeiro and its metropolitan region have historically recorded frequent dengue epidemics over the years ¹⁴. Rio de Janeiro is considered the "dengue metropolis", since it is one of the most receptive areas in the country for the maintenance and spread of DENV serotypes ^{14,15}. In addition, the state and city of Rio de Janeiro display high *Ae. aegypti* density in the urban areas, which are highly susceptible to the dengue virus ^{7,16}.

DENV transmission patterns are determined by a combination of social and environmental factors that include the human host, the virus, and the vector ¹⁷. The city of Rio de Janeiro is characterized by great spatial heterogeneity and complexity. The city has a high population density, disorderly urban growth, lack of infrastructure, environmental degradation, and major socio-spatial inequality ^{18,19}. These territorial characteristics together with the local climate conditions contribute to establishing and maintaining the epidemics, hindering dengue control and prevention measures ^{20,21,22}.

A major portion of ecological studies in epidemiology view the territory homogeneously for the detection of transmission patterns, failing to represent the heterogeneity involved in the epidemiological dynamics of given diseases. Thus, territorial stratification in areas with increased risk through cluster analysis seeks spatial patterns of events and characterization of homogeneous areas ²³.

As described in Block ²⁴, SaTScan (<http://www.satscan.org>) is free software that allows the identification of temporal, spatial, or space-time clusters through the spatial scan statistic (Scan) developed by Kulldorff & Nagarwalla ²⁵. Pioneering studies demonstrating the feasibility of the use of SaTScan for space-time analyses in health can be found in Hjalmars et al. ²⁶, Kulldorff et al. ²⁷ and Park et al. ²⁸. SaTScan is currently a well-established methodology employed in space-time analyses of various diseases and health conditions, as illustrated in the studies on leishmaniasis by Schweiger & de Freitas ²⁹, tuberculosis by Santos Neto et al. ³⁰, schistosomiasis by Cardim et al. ³¹, transportation accidents by Morais Neto et al. ³², and leprosy by Penna et al. ³³.

Space-time scan analysis has also been used to study dengue. Schmidt et al. ³⁴ studied the interaction between population density and lack of running water as a cause of dengue outbreaks in Vietnam. In northern Argentina, Rotela et al. ³⁵ studied the spread of a dengue outbreak based on space-time grouping of cases. Space-time analyses of dengue cases have been performed in Thailand ³⁶, Vietnam ³⁷, and Colombia ³⁸. In Brazil, three publications were identified that discuss dengue using SaTScan: one analyzes dengue cases in the city of Lavras, Minas Gerais State, between 2007 and 2010 ³⁹; the second detects clusters based on dengue seasonality in Brazilian municipalities from 2007 to 2011 ⁴⁰; and the third, by Vicente et al. ⁴¹, analyzes the determination of clusters and factors associated with the spread of dengue during the first epidemic involving DENV-4 in the city of Vitória, Espírito Santo State.

No study on the detection of clusters using SaTScan was found for the city of Rio de Janeiro. In this context, the city is an important scenario for understanding the factors affecting dengue trans-

mission dynamics and the exacerbation of the disease, since Rio de Janeiro has considerable socio-economic and demographic differences between its administrative regions, in addition to displaying high incidence rates over the years.

The way geographic space is shaped significantly affects human mobility patterns, generally giving rise to highly local clusters of mobility⁴². The use of population groups that differ in their mobility can be a major tool for the choice of population groups to address specific objectives and diseases⁴³. Both human mobility and immunity to the different DENV serotypes are considered confounding factors in the definition of priority areas for dengue interventions⁴⁴.

The current dengue control strategies, especially those targeted to the primary vector, *Ae. aegypti*, are known to produce limited results⁴⁵, since health systems have used across-the-board methodologies in the entire territory, failing to take different local realities into account. Defining areas with increased risk is thus a way of rationalizing resources and optimizing the interventions' results.

This study thus sought to investigate the presence of persistent space-time dengue clusters in the city of Rio de Janeiro in populations with distinct mobility and immunity profiles, based on dengue incidence between 2008 and 2014. We used incidence data for the population 5 years and older (with greater mobility and more exposed to the DENV over time) and the population of children under 5 years (with less mobility and lower probability of having been exposed to different DENV serotypes), in addition to defining the regions with persistent clusters, that is, those that repeat themselves over the years in both population groups.

Materials and methods

Study area

The city of Rio de Janeiro, capital of the state of Rio de Janeiro, is located in the Southeast Region of Brazil and has an area of approximately 1,197km² and a population of 6,320,446 as of 2010⁴⁶. The city is divided into 10 Planning Areas, 33 Administrative Regions, and 160 neighborhoods (Figure 1). The climate is hot humid tropical, with local variations due to the city's geomorphology. Mean annual temperature is 22°C, and annual rainfall varies from 1,200 to 1,800mm⁴⁷.

The city of Rio de Janeiro displays great geographic complexity: its topographic characteristics, peculiar coastline, and spatial heterogeneity generated by the process of urban land use and occupation make the city a mosaic of landscapes and social contrasts (Figure 1).

Epidemiological data

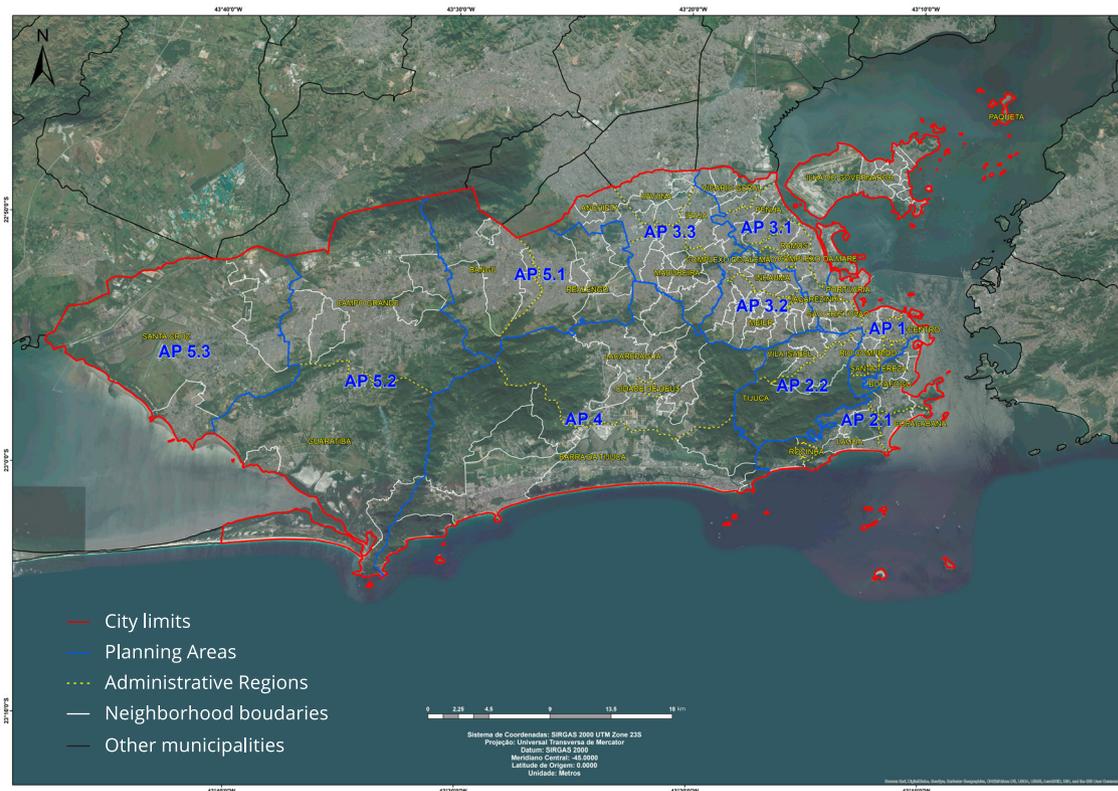
The current study used reported dengue cases from 2008 to 2014 from the city of Rio de Janeiro, Brazil. Data were obtained from the Information System for Notifiable Diseases (SINAN) through the National Dengue Control Program of the Ministry of Health. The data were tabulated by month and year for each neighborhood both for the population 5 years and older and the preschool population. Crude population data were obtained from the Population Censuses of 2000 and 2010 conducted by the Brazilian Institute of Geography and Statistics (IBGE)^{46,48}. For the inter-census years, population estimates were calculated for the city of Rio de Janeiro and its neighborhoods with use of the geometric method, using the populations of 2000 and 2010 as the basis.

Space-time analysis

Space-time analysis requires that the spatial unit, in this case each neighborhood, be transformed into a single point, the centroid. Oftentimes during the process of allocating centroids with the geometric method, the centroids end up being defined in areas outside their own demographic references. The territory's representation thus loses precision, failing to accurately portray how the space is occupied (Figure 2a). Seeking to mitigate this issue, the centroids' location was adjusted to the areas with the highest population density in each neighborhood. First, supervised classification of the Landsat 8 satellite image of 2014⁴⁹ was performed in order to demarcate areas occupied by the human popula-

Figure 1

Map of the city of Rio de Janeiro with the location in Brazil and population density.



AP: Planning Areas.

tion (Figure 2b). Next, using the population data for each census tract, kernel analysis of the density was performed, thus allowing allocation of the centroids into the areas with the greatest population density within the occupied area in each neighborhood (Figures 2c and 2d). Comparison of the two methods clearly evidenced a superior fit to the territorial reality with use of the method that uses the occupied area and population density rather than the method that merely uses formal political-administrative boundaries (Figures 2e and 2f).

We then performed retrospective space-time analysis with Poisson probability distribution to identify the most likely clusters with high risk for dengue in each year from 2008 to 2014, for each of the two population groups used in the study. The scan statistic proposed by Kulldorff⁵⁰ was used for the detection and identification of space-time clusters with increased relative risk, using neighborhoods as spatial units and months as temporal units.

Figure 2

Map of neighborhood centroids using the geometric method readjusted according to population density and occupied area. Rio de Janeiro, Brazil.

2a)



● Centroids by the geometric method

2b)

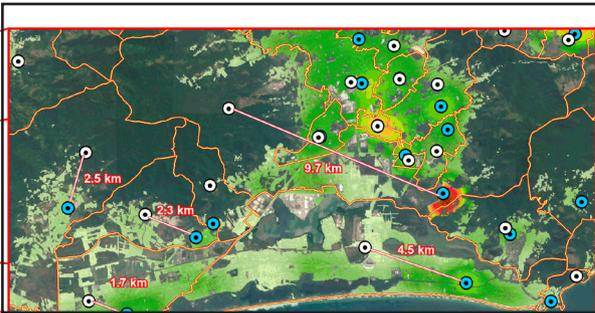


■ Areas occupied by human population

2c)



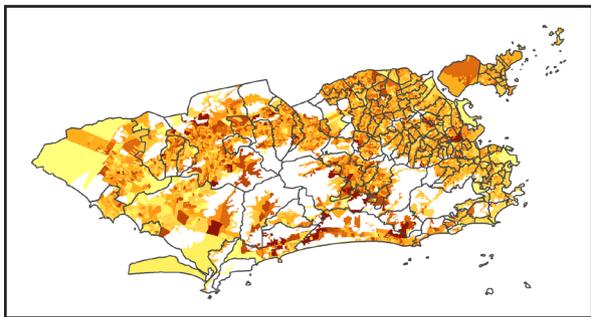
2d)



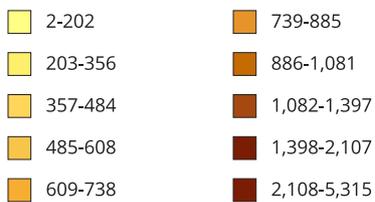
● Centroids by population density and the occupied area

— Distance between the centroids defined by the geometric method and the area occupied

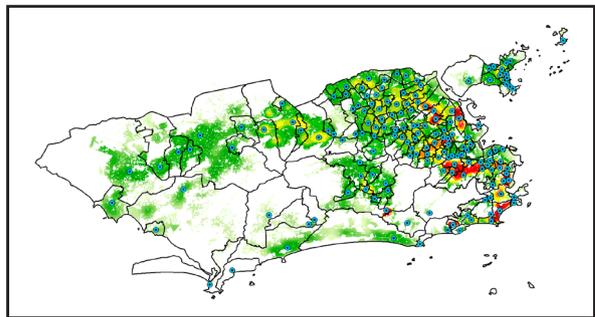
2e)



Population by census sector



2f)



● Centroids in the areas with the greatest population density with in the occupied area

Population density



In order to avoid unwanted effects associated with different sizes of scan windows⁵¹, we used 20% of the total population, which allowed the neighborhood with the largest population to form a cluster. As for the time factor, we used the clusters that occurred in up to 50% of the study period, which is standard value for the statistical package and proved valid for this study.

In order to test the null hypothesis that no difference exists in the relative risk (RR) of dengue between the neighborhoods over time, we used the Monte Carlo approach with 9,999 repetitions, with significance set at 0.05. Log-likelihood ratio (LLR) was used to test the formation of clusters. The most likely cluster is the one with the highest LLR.

To analyze spatial persistence in both population groups, the clusters defined for each year were mapped and later overlaid and added through the map algebra methodology. A summary map was constructed, indicating how many times in the study period each neighborhood belonged to a cluster.

The scan methodology was performed with use of the SaTScan software package v9.4.2 (<http://www.satscan.org>), and geoprocessing, mapping, and map algebra were performed with use of the ArcGis software package, version 10.2 (<http://www.esri.com/software/arcgis/index.html>).

Results

In the city of Rio de Janeiro as a whole, 464,500 dengue cases were reported, of which 32,749 were in the population group under 5 years of age and 431,751 in the population 5 years and older. Dengue rates showed the same profile over the years in both population groups, with four observed epidemic peaks, in 2008, 2011, 2012, and 2013. The predominant serotypes were DENV-2 in 2008, DENV-1 in 2011, and DENV-4 in 2012 and 2013 (Table 1).

According to the space-time analysis for 2008 to 2014, the most probable clusters in both the pre-school and five-and-over population groups were identified in the West and North Zones of the city in the years 2008, 2009, 2010, 2011, 2012, and 2014. However, only in 2013 were probable clusters for both populations located in the South and Central Zones of the city.

In the years 2011, 2012, and 2013, the defined clusters for the two study populations showed similar location and spatial conformation in the city. In the years 2008, 2009, 2010, and 2014, the defined clusters for the two populations did not coincide spatially. Both clusters over the years had the same defined timeframes in the first semester, except for the year 2010 (Tables 2 and 3; Figure 3).

Table 1

Historical series of dengue serology in the city of Rio de Janeiro, Brazil, from 2002 to 2014.

| Year | Tests | Positives | Positives (%) | DENV-1 (%) | DENV-2 (%) | DENV-3 (%) | DENV-4 (%) |
|------|-------|-----------|---------------|-------------|-------------|--------------|-------------|
| 2002 | 710 | 558 | 78.6 | 7.2 | 0.9 | 91.9 | 0.0 |
| 2003 | 1,471 | 88 | 6.0 | 2.3 | 1.1 | 96.6 | 0.0 |
| 2004 | 37 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2005 | 183 | 4 | 2.2 | 0.0 | 0.0 | 100.0 | 0.0 |
| 2006 | 3,449 | 42 | 1.2 | 0.0 | 0.0 | 100.0 | 0.0 |
| 2007 | 3,081 | 327 | 10.6 | 0.9 | 4.0 | 95.1 | 0.0 |
| 2008 | 1,704 | 214 | 12.6 | 0.0 | 82.7 | 17.3 | 0.0 |
| 2009 | 3,656 | 26 | 0.7 | 30.8 | 65.4 | 3.8 | 0.0 |
| 2010 | 1,971 | 216 | 11.0 | 28.7 | 68.1 | 3.2 | 0.0 |
| 2011 | 1,959 | 564 | 28.8 | 79.3 | 17.9 | 2.8 | 0.0 |
| 2012 | 2,471 | 948 | 38.4 | 20.0 | 0.1 | 0.3 | 79.6 |
| 2013 | 1,236 | 372 | 30.1 | 8.0 | 0.0 | 1.6 | 90.4 |
| 2014 | 1,089 | 81 | 9.0 | 65.4 | 0.0 | 0.0 | 34.6 |

Source: Rio de Janeiro Municipal Health Department¹⁶.

Table 2

Most likely clusters analysis of reported dengue cases in the preschool population (under 5 years of age) in the city of Rio de Janeiro, Brazil, from 2008 up to 2014.

| Year | Planning areas (Aps) | Radius (km) | Time window (Y/M/D) | RR | LLR | p-value |
|------|----------------------------|-------------|------------------------|------|---------|---------|
| 2008 | AP 4, AP 5.1, and AP 5.2 | 13.44 | 2008/3/1 to 2008/4/30 | 6.8 | 2146.75 | < 0.001 |
| 2009 | AP 3.1, AP 3.2, and AP 3.3 | 5.89 | 2009/1/1 to 2009/3/31 | 5.92 | 53.14 | < 0.001 |
| 2010 | AP 3.1 | 9.96 | 2010/7/1 to 2010/12/31 | 6.95 | 25.35 | < 0.001 |
| 2011 | AP 5.2 and AP 5.3 | 18.69 | 2011/3/1 to 2011/5/31 | 6.73 | 1732.45 | < 0.001 |
| 2012 | AP 5.1 and AP 5.2 | 10.64 | 2012/3/1 to 2012/5/31 | 8.42 | 3250.80 | < 0.001 |
| 2013 | AP 1, AP 2.1, and AP 2.2 | 7.89 | 2013/2/1 to 2013/5/31 | 5.98 | 467.40 | < 0.001 |
| 2014 | AP 1, AP 2.2, and AP 3.2 | 6.69 | 2014/1/1 to 2014/2/28 | 4.32 | 34.75 | < 0.001 |

LLR: log-likelihood ratio (maximum); RR: relative risk.

Table 3

Most likely clusters analysis of reported dengue cases in the population 5 years and older in the city of Rio de Janeiro, Brazil, 2008 to 2014.

| Year | Planning areas (Aps) | Radius (km) | Time window (Y/M/D) | RR | LLR | p-value |
|------|----------------------------------|-------------|-------------------------|------|----------|---------|
| 2008 | AP 4, AP 5.1, AP 3.2, and AP 3.3 | 6.96 | 2008/1/1 to 2008/4/30 | 4.35 | 15988.53 | < 0.001 |
| 2009 | AP 4 and AP 5.2 | 18.73 | 2009/1/1 to 2009/3/31 | 5.46 | 494.76 | < 0.001 |
| 2010 | AP 3.3 | 2.96 | 2010/12/1 to 2010/12/31 | 4.70 | 72.20 | < 0.001 |
| 2011 | AP 5.2, AP 5.3, and AP 4 | 19.80 | 2011/3/1 to 2011/5/31 | 6.43 | 15779.43 | < 0.001 |
| 2012 | AP 5.1 and AP 5.2 | 10.64 | 2012/3/1 to 2012/5/31 | 7.93 | 50635.28 | < 0.001 |
| 2013 | AP 1, AP 2.1, and AP 2.2 | 9.37 | 2013/3/1 to 2013/5/31 | 5.02 | 10130.68 | < 0.001 |
| 2014 | AP 5.1 | 4.92 | 2014/1/1 to 2014/4/30 | 2.69 | 96.01 | < 0.001 |

LLR: log-likelihood ratio (maximum); RR: relative risk.

In the under-five population group, the West Zone of the city showed the largest area of persistent risk, followed by the North Zone. The area of persistent risk located in the West Zone consists of 7 neighborhoods in the administrative regions of Bangu, Campo Grande and Guaratiba. Those in the North Zone consist of 11 neighborhoods located in the administrative regions of Tijuca, Ramos, Alemão, and Inhaúma (Figure 4).

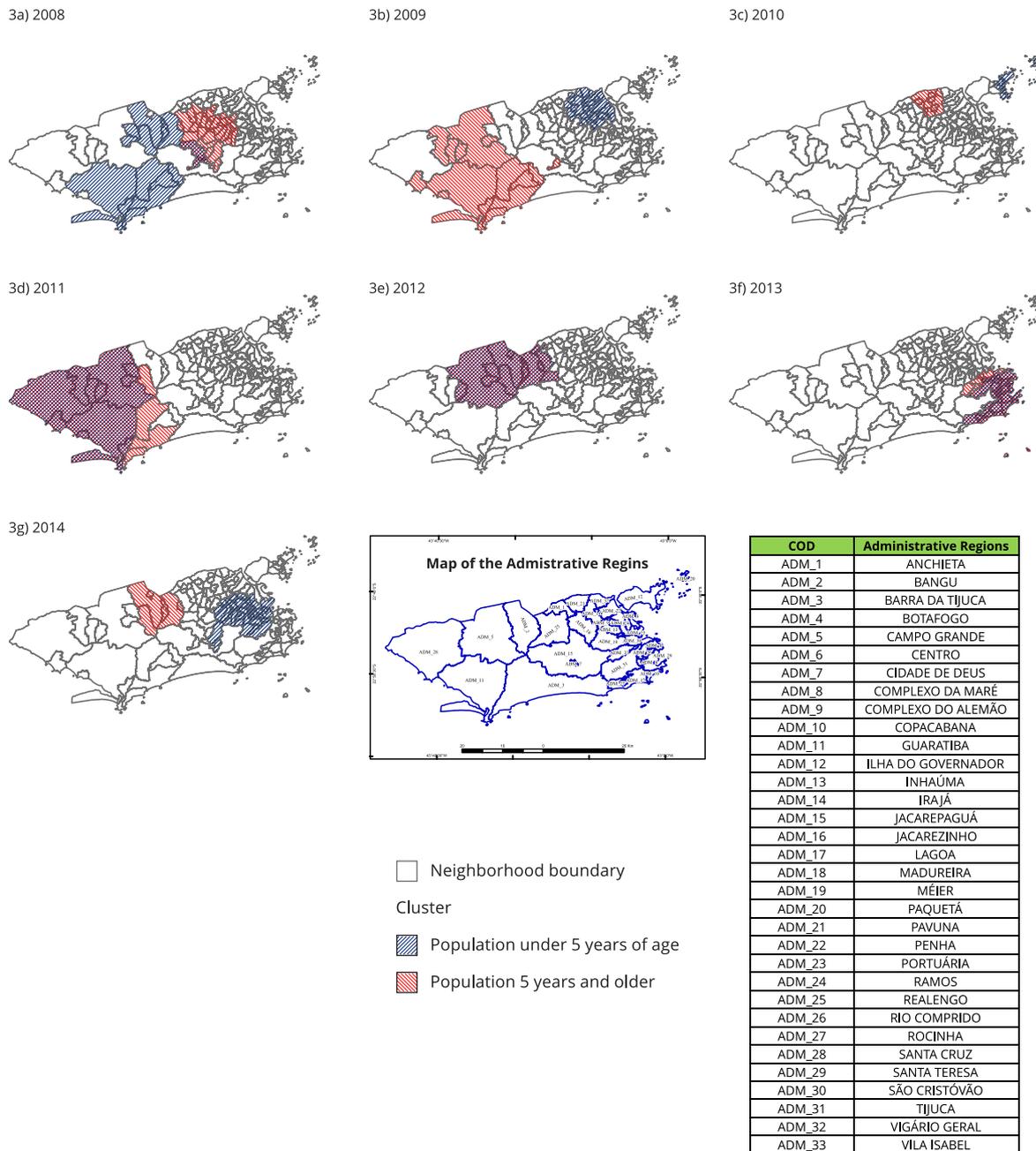
The five-and-over population group showed a similar pattern to that of the preschoolers, with the West Zone as the part of the city with the largest area of persistent risk, consisting of 22 neighborhoods from the administrative regions of Bangu, Campo Grande, and Guaratiba, followed by the North Zone with 3 neighborhoods located in the administrative region of Madureira (Figure 4).

Discussion

The results of this study showed that the Scan methodology was able to define the areas of greatest risk for dengue through the identification of incidence clusters, as well as the identification of persistent areas over the years analyzed by means of the map algebras methodology. The areas of persistently increased risk of dengue (clusters) in the city of Rio de Janeiro were shown to be concentrated in the West Zone of the city.

Figure 3

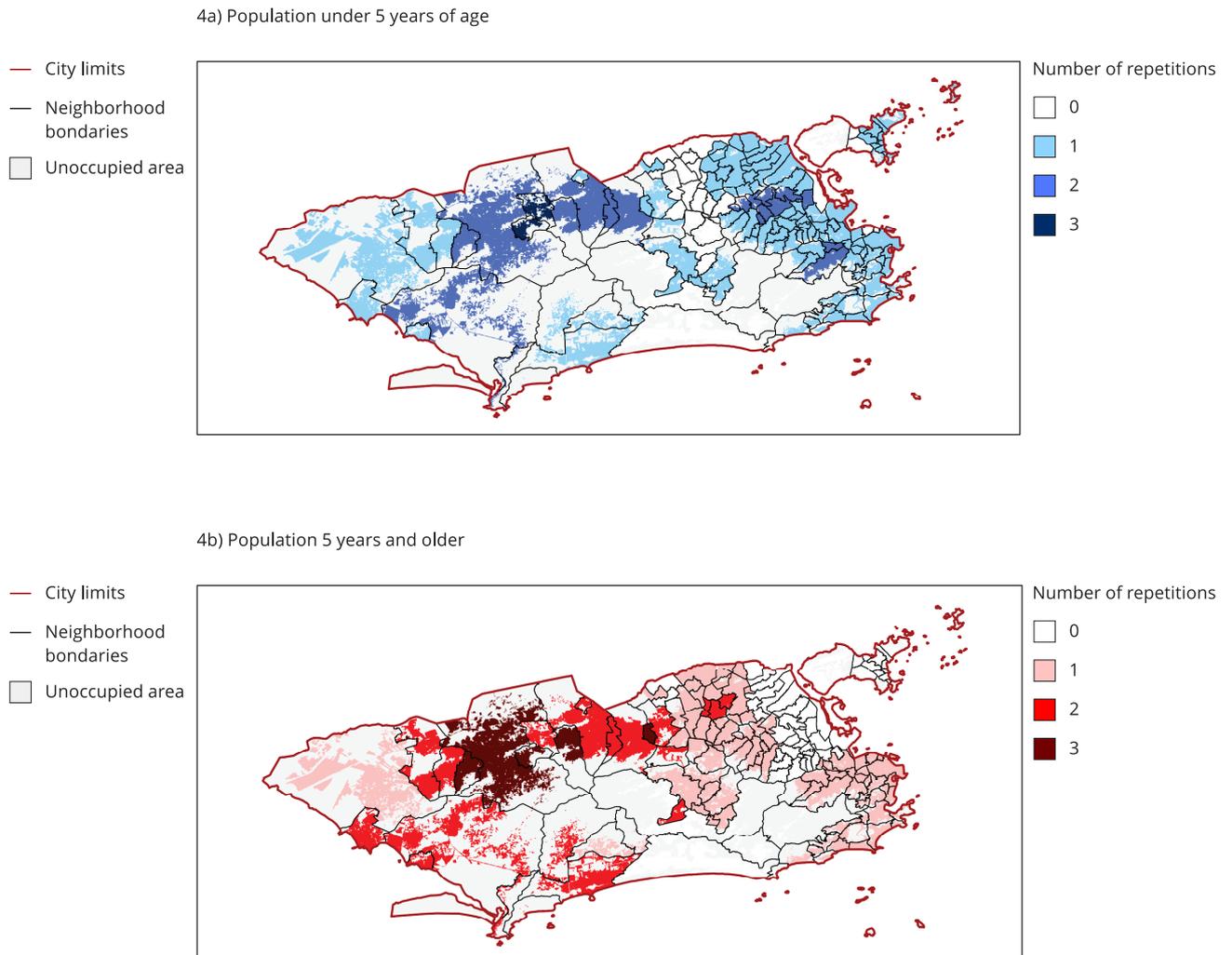
Map of dengue clusters in both study populations. Rio de Janeiro, Brazil, 2008 to 2014.



The results also showed the probable influence of the population's immunological status on the geographic distribution of the incidence and risk areas of dengue, only demonstrating spatial agreement between the two target populations when they presented the same immunological status with regard to the predominant circulating serology for the cases reported during the period in question.

Figure 4

Persistent risk map of dengue for both study populations. Rio de Janeiro, Brazil, 2008 to 2014.



Different social groups tend to occupy the territory in more or less grouped ways as a function of their similarities. In order to understand the dynamics of the territory to which these different groups belong, it is essential to understand the spatial distribution of health-disease processes¹³. The city of Rio de Janeiro is a heterogeneous mosaic of territorial realities, and analysis on a larger geographic scale such as a Zone allows for the analysis of common structural characteristics that can help explain the persistence of risk in some areas or zones.

The West Zone of Rio de Janeiro was the area with the most neighborhoods displaying clusters throughout the study and in both population groups analyzed. However, in the preschool population, the number of neighborhoods and the total area were lower than in the population 5 years and older, which could be explained by the difference in mobility between these populations⁴³. Thus, the West Zone of Rio was the one with the most areas of persistent dengue risk in the city.

The repetition of areas comprising clusters throughout the study period thus characterizes a level of persistent risk in certain areas or zones. Understanding the structuring processes in these persis-

tent areas through variables that allow grasping the changes in the geographic space can help identify the determinants of dengue in the territory ^{52,53}.

Historically, the West Zone of Rio de Janeiro was the last to be incorporated into the city's urban fabric. The transformation of farmlands into urban areas occurred largely due to the stagnation of agricultural properties, which were cut up into housing lots. This new mode of occupation reflected the diverse rationale of social agents shaping the urban space, leading to a constant process of spatial reorganization ^{53,54}. The West Zone is the area of the city with the greatest recent alteration in its landscape, and its territory has undergone an accelerated process of growth and increased population density, but lacking a corresponding increase in urban infrastructure ⁵⁴.

The areas of persistent risk of dengue (clusters) in the city of Rio de Janeiro are concentrated in the Planning Areas 5.1 and 5.2 located in the West Zone of the city (Figure 4), which mostly presents low socioeconomic development ^{52,54} and no fully consolidated urban occupation. Planning Areas 5.1 and 5.2, identified as areas of persistent dengue risk, displayed low Social Development Indices (SDI) in 2010 (0.57 and 0.56, respectively) ^{52,55}. The SDI is a composite indicator that measures the degree of social development of a given geographic area compared to other areas: the closer to 1, the higher the level of social development ⁵². These areas of the city also showed high vector density between 2009 and 2014, with building infestation indices nearly always between 1% and 4% according to the Rapid Index Survey for *Aedes aegypti* (LIRAA) conducted by the Rio de Janeiro Municipal Health Department ¹⁶.

The clusters identified for each year of the study period showed spatial variability at the neighborhood level over the years in both population groups. The majority of the neighborhoods defined as clusters in a given year were not repeated in the following year, and so on successively. This spatial variability might be related to uncontrolled local situational factors such as the population dynamics of the mosquito vector, the population's immunity, mobility, and changing priorities in vector for control measures ⁵⁶.

Following outbreaks and epidemics, dengue antibody seroprevalence can reach 80% of the population, and herd immunity is a determinant factor for new infections ⁵⁷. Dengue has four antigenically distinct serotypes (DENV-1, DENV-2, DENV-3 and DENV-4) that produce lasting immunity specifically for each serotype. However, this immunity is specific and does not protect against other serotypes. As such, the stock of individuals susceptible to a certain serotype ends up having a determining role in the epidemic process and in the spatial distribution of dengue cases in the territory ⁵⁸.

The persistence of dengue epidemics in the human populations of a given territory only occurs in urban spaces that maintain significant indexes of vector infestation and large population densities, which, together with birth rates, will restore the stock of individuals susceptible to infection. This is because the vector's main or perhaps only source of infection is human viremia, which persists for only seven days during the acute phase of infection, and recurrent viremia with the same serotype has never been demonstrated ⁵⁹.

As a result, the spatial distribution of dengue cases can vary according to the study population's immune status at any given moment. In this study, most areas defined as clusters did not coincide between both population groups when analyzed year by year. This result is explained by the differing immunological profile of the two study populations with regard to the different serotypes prevalent in the years 2008, 2009, 2010 and 2014 ¹⁶ (Table 1).

However, in 2011, 2012, and 2013, when the immune profile concerning the year's predominant serotype was similar between both groups, and the clusters defined by the modeling displayed major spatial coincidence that was even identical in 2012 and extremely similar in 2013 ¹⁶ (Table 1).

In 2011, the preschool population was practically entirely susceptible, since the predominant serotype that year was DENV-1, which had not predominated in the city for at least ten years, besides the introduction of DENV-4. The large time lapse since the last epidemic caused predominantly by DENV-1 also produced a large contingent of susceptible individuals in the population 5 years and older. In 2012 and 2013, the predominant serotype was DENV-4, which had been introduced into the city in 2011, so both populations had the same profile with regard to this serotype in those two years.

The fact that two populations with varying mobility showed the same location of clusters during years with similar immune profiles suggests that the spatial definition of clusters occurs more as a function of immunity or the reserve of susceptible individuals than as a function of mobility.

The extremely local profile of human movement networks ⁴² and the reduced individual mobility when a person becomes ill with dengue ⁴³ can help explain the similarity in the area of clusters identified between 2011 and 2013.

Use of the scan statistic to determine clusters (assigning statistical significance to them), the high georeferencing degree of reported cases at the neighborhood level, and the shifting of the neighborhoods' centroids to their demographic centers via remote sensing increased the analyses' robustness. In the specific case of shifting the neighborhoods' centroids, this process adds great value to studies that take space into account, since it seeks a more trustworthy picture of the territory's reality.

One limitation of this study was the exclusive use of incidence data in the statistical model. More robust statistical models that take explanatory variables into account could contribute to a better understanding of dengue determinants. However, the strategy of using only incidence data in the model can facilitate the model's implementation and use in health services, since incidence is one of the few forms of data available practically in real time for health service managers.

Another limitation is that the reported dengue cases used in this study probably do not include all infection cases. Many dengue infections are asymptomatic, and differential diagnosis is difficult for dengue, since its symptoms are similar to those of various other diseases ⁶⁰. In addition, data from SINAN include both suspected and confirmed cases. There was also a low percentage of serotyping tests performed, thus compromising the definition of the circulating serotypes.

We emphasize that the main objective of this study was to present the method for identifying areas of persistent risk through incidence data using the Scan statistic. These areas are always related to the period of the time series used. Thus, the results must be interpreted and possibly applied with caution because they have been defined with previous incidence data.

The use of maps in routine surveillance facilitates the identification of visible elements in the territory, thus aiding the understanding of local realities ⁶⁰. An important strength of spatial analysis is that it allows easy and rapid identification and visualization of areas with different realities, which as such are exposed to different risk levels ⁶¹.

The fight against dengue is not a simple task, since its occurrence in both classic and severe form involves social, economic, and environmental factors, the supply of health services, and the population's immune status ⁶². The use of spatial analysis techniques in the study, more specifically the scan statistic, allowed the identification of areas of increased risk that were repeated over time. Therefore, this method can be used to assist local dengue surveillance activities with customized strategies in the territory as a function of the risk and recurrence in each area.

We emphasize that the use of populations with a high percentage of susceptible individuals, such as young populations or total population in epidemic years with the entry of new serotypes, is theoretically more adequate for the territorial study of dengue. These populations are more likely to express the areas with increased risk of transmission, since the confounding factor of immunity is minimized in these cases.

Contributors

J. P. C. Santos, N. A. Honório and A. A. Nobre made substantial contributions to the study conception and design; data acquisition, analysis, and interpretation; writing and critical review of important intellectual content. All authors approved the final version to be published.

Additional informations

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Resumo

A dengue é uma arbovirose reemergente de grande importância epidemiológica. A detecção de clusters de dengue representa uma importante estratégia de vigilância epidemiológica, que contribui para melhor alocação de medidas de controle no território e priorização de áreas sujeitas a risco aumentado de transmissão. São raros os estudos que envolvem populações humanas com mobilidade baixa; portanto, este estudo tem como objetivo investigar a presença de clusters persistentes de dengue no Município do Rio de Janeiro, Brasil, entre populações com diferentes padrões de mobilidade e imunidade. Os dados epidemiológicos sobre dengue foram obtidos do Ministério da Saúde. As áreas de risco aumentado foram definidas pelo método estatístico de varredura espaço-tempo, e a análise de persistência usou a álgebra cartográfica. Para as duas populações do estudo, os clusters identificados não mostraram concordância espacial, exceto nos anos em que ambas apresentaram o mesmo perfil imunológico. Para ambas as populações, os clusters persistentes estavam localizados principalmente na Zona Oeste da cidade. Os clusters nas duas populações do estudo mostraram concordância espacial apenas nos anos em que ambas apresentavam perfis imunológicos semelhantes, o que confirma o papel de confounding da imunidade e sustenta o uso de populações com percentuais altos de indivíduos suscetíveis no desenho de estudos sobre dengue com base territorial. A semelhança espaço-temporal entre as áreas de risco persistente em ambas as populações sugere que a Zona Oeste, uma região com crescimento urbano desordenado e média de renda baixa, apresenta o maior risco de transmissão de dengue. A definição de clusters de dengue persistentes contribui para o aprimoramento das estratégias de controle da dengue e de planejamento territorial.

Dengue; Conglomerados Espaço-temporais; Risco

Resumen

El dengue es una infección por arbovirus reemergente de mucha importancia epidemiológica. La detección de clústeres de dengue es una importante estrategia de vigilancia epidemiológica, que contribuye a mejorar la asignación de medidas de control en el territorio, priorizando áreas que están sujetas a un riesgo de transmisión más elevado. Los estudios que implican poblaciones humanas con baja movilidad son escasos y, por tanto, el presente estudio tiene como fin investigar la presencia de clústeres persistentes de dengue en la ciudad de Río de Janeiro, Brasil, en poblaciones con diferente movilidad e inmunidad. Los datos epidemiológicos sobre dengue se obtuvieron del Ministerio de Salud brasileño. Las áreas de riesgo elevado se definieron mediante un método de análisis espacio-tiempo estadístico, además, el análisis de persistencia utilizó álgebra de mapas. Para las dos poblaciones en estudio, los clústeres que fueron identificados no mostraron concordancia espacial, excepto durante los años en que ambos presentaron el mismo perfil inmunológico. Para ambas poblaciones, los clústeres persistentes se localizaron en su mayoría en la zona oeste de la ciudad. Los clústeres de las dos poblaciones en estudio solo mostraron concordancia espacial durante los años en que ambas contaban con perfiles inmunes similares, lo que confirma el rol confusor de la inmunidad y respalda el uso de poblaciones con altos porcentajes de individuos susceptibles, cuando se diseñan estudios sobre el dengue basados en territorios. La similitud espacio-tiempo entre áreas de riesgo persistente en ambas poblaciones sugiere que la zona oeste, la región con un crecimiento urbano desordenado y una media de ingresos bajos, muestra el riesgo más alto de transmisión de dengue. La definición de los clústeres dengue persistente contribuye a la mejora de las estrategias para el control del dengue y su planificación territorial.

Dengue; Agrupamiento Espacio-temporal; Riesgo

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