

Spatial distribution of dengue disease in municipality of Mossoró, Rio Grande do Norte, using the Geographic Information System

Distribuição espacial da dengue no município de Mossoró, Rio Grande do Norte, utilizando o Sistema de Informação Geográfica

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Abstract

The dengue viral infection is one of the most relevant vector-borne diseases in the world. The disease can manifest in a variety of forms, from asymptomatic to a condition of dengue hemorrhagic fever (DHF). The last reported cases in Brazil correspond to 80% of the cases reported in the Americas, which emphasizes the magnitude of the problem. This study was conducted using Geographic Information System (GIS) techniques, in order to evaluate the spatial distribution of the disease in the urban area of Mossoró, Rio Grande do Norte. In the period between 2001 and 2007, 867 new cases were listed. About 85.7% of the addresses were georeferenced, with a larger number of cases, 14.8%, in the neighborhoods of Santo Antônio and Santa Delmira (north region), and 11.7% in the neighborhoods of Conjunto Vingt-Rosado and Alto de São Manoel (east region). There were 18 confirmed cases of dengue hemorrhagic fever associated with regions with the highest incidence of classic cases of the disease. The use of Geographic Information System (GIS) proved a great benefit for better visualization of the endemic, especially in elucidating the actual distribution of dengue cases in the county and providing an effective tool for planning the monitoring of the disease at a local level.

Keywords: Spatial Analysis. Epidemiology. Dengue. Dengue hemorrhagic fever.

A infecção viral pelo dengue compreende uma das doenças de transmissão vetorial mais importante do mundo. A doença pode apresentar uma manifestação variada, desde uma forma assintomática até quadros de Febre do Dengue Hemorrágico (FDH). Os últimos casos reportados no Brasil correspondem a 80% dos casos notificados nas Américas, o que enfatiza a magnitude do problema. Este estudo foi realizado utilizando técnicas de geoprocessamento, com o objetivo de avaliar a distribuição espacial da doença na zona urbana do município de Mossoró, Rio Grande do Norte. Foram arrolados 867 casos novos da doença no período de 2001 - 2007. Foram georreferenciados 85,7% dos endereços, apresentando um maior número de casos nos bairros do Santo Antônio e Santa Delmira (zona norte), com 14,8%, Conjunto Vingt-Rosado e Alto de São Manoel (zona leste), com 11,7%. Foram confirmados 18 casos de FHD associados às regiões com maior incidência de casos clássicos da doença. O uso do SIG revelou um grande benefício pela melhor visualização da epidemia, sobretudo elucidando a distribuição real dos casos de dengue no município e propiciando um instrumento eficaz para o planejamento da vigilância em nível local.

Palavras-chave: Análise espacial. Epidemiologia. Dengue. Febre hemorrágica da dengue.

Dengue is an acute infectious disease whose etiologic agent is a flavivirus, with *Aedes aegypti* as its only vector in Brazil. Considered the most important arboviral disease in the world, dengue has been in the Americas for centuries, but its current situation is dynamic and aggravating^{1,2}.

During the last two decades, the incidence of dengue increased significantly in this region. It is estimated that over three million new cases were reported in 30 Latin American countries. Dengue hemorrhagic fever (DHF) has occurred in over 20 countries, with 17,000 reported cases, including 225 deaths³.

In Brazil, the last epidemic peak occurred in 2002, due to the introduction of DEN-3, with 794,000 cases reported, which corresponds to an incidence rate of 398 cases per 100 thousand inhabitants. Northeastern Brazil was the second most affected region, with 25% of total cases^{4,5}.

In the last decade, the number of new cases of dengue diagnosed in the state of Rio Grande do Norte showed a sharp growth. In 2008, it was registered as the State's greatest epidemic, with an incidence rate of 1,123 cases per 100 thousand inhabitants, larger than the rate observed in Brazil and in the Northeast, representing an increase of 158.7% compared to the previous year. Over the past 10 years, new cases were identified in all the municipalities of Rio Grande do Norte, especially the municipalities of Mossoró and Natal, with 51% of cases⁶.

Control strategies, to date, have proved ineffective due to the intense urbanization of the disease and to a limitation in the monitoring process of the disease itself. Given the above, the instrumentalization of control measures and support to the actions prescribed by vector and epidemics control programs prove to be essential⁷.

The spatial distribution of diseases can be mapped and analyzed using the Geographic Information System (GIS), capable of storing geographic information, correlating them with tabular data; it can

be used for collection, storage, interrogation and display of spatial data, helping to determine the spatial location of diseases and the graphical analysis of epidemiological indicators. According to the World Health Organization (WHO), it is an effective tool in the management of the Brazilian Dengue Control Program (NPDC)^{8,9}.

Taking the above into account, and considering the epidemic nature of dengue in the city of Mossoró, Rio Grande do Norte, the second largest and most populous in the State, this study used GIS in order to determine the spatial location of new dengue cases diagnosed between 2001 and 2007 in the urban area of Mossoró. It is believed that the data obtained this way will allow a better understanding of the dynamics of dengue transmission in the city of Mossoró, Rio Grande do Norte.

Materials and Methods

The study object was the urban area, located in the city of Mossoró, situated at 37°20' west longitude and 05°11' south latitude, at an altitude of 18 meters (approximately 60 ft). The municipality is approximately 285 kilometers (177 miles) from Natal, the State capital. It occupies a geographical area of 2099.328 km² (approximately 810.428 square miles) and a population of 254,032 inhabitants. Its climate is dry, with rainfall concentrated in the beginning of the year. The mean annual temperature and humidity, respectively, are 27°C and 69%¹⁰.

This is a descriptive ecological study conducted in the municipality's urban area, using Mossoró city's cadastral map as cartographic bases, in addition to database from the Brazilian System of Diseases and Notification (SINAN) and from report files from the city's Health Management.

Subjects included in the study are living in households of Mossoró's urban area and represent all dengue cases diagnosed between 2001 and 2007.

Armed with the city's cadastral map and spreadsheets created for this study, the

researchers georeferenced the addresses of registered patients using a GPS unit (Garmin 76). Coordinates collected in the field were transcribed into an Excel spreadsheet and later transformed into dBase files (dbf) for direct use on the ArcView GIS 3.2a software. After formatting the data in spreadsheets, the ArcMap application was used, transforming the information available in a variety of thematic maps showing the distribution of georeferenced cases in the city. To explore the variability and spatial relationships data, we used the interpolation module (IDW) spatial analyst to obtain disease density maps that represent the number of cases within 100 m² (1076.39 ft²) with areas of different colors.

This study was approved by the Research and Ethics Committee of Hospital Universitário Onofre Lopes (CEP-HUOL 077-07).

Results

Mossoró is a fast-growing city, particularly in the economic and social aspects, due to its geographical location. This phenomenon has generated a process of uncontrolled urbanization, producing regions with large clusters, mainly characterized by poor housing, inadequate collection of organic waste and deficiencies in water supply¹¹. This scenario, coupled with a good adaptation to urban centers, offers a favorable environment for *Aedes aegypti* to breed, which makes vector control an arduous task.

In the State of Rio Grande do Norte, two epidemic peaks were observed, in 2002 and 2008, due to the introduction of serotypes DENV-3 and DENV-2, respectively, in most Brazilian States. The municipality of Mossoró followed the State's trend and presented an incidence rate of 47.01 cases per 10,000 inhabitants in 2008 (Graph 1).

Between 2001 and 2007, approximately 1,212 new cases of dengue were confirmed in city residents, with 867 (71.5%) located in the urban area, which was the object of this study. From the study population, the most

affected were the females with 60.2%, and the predominant age group was 21 – 40 years (Table 1). These results are similar to those found by Santos¹² and Vasconcelos¹³ which describe the prevalence of females due to greater permanence of women in or around their homes, where the transmission usually occurs.

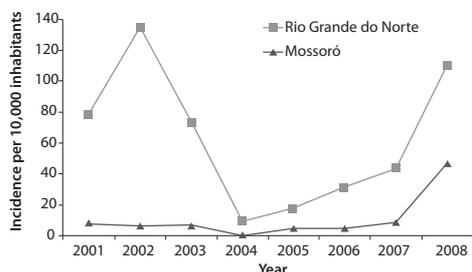
Of the total cases selected for the study, 745 addresses (85.7%) were located and georeferenced, which reflects some difficulties, such as lack of information in the notification forms, the city's size (over 200,000 inhabitants)¹⁰, the large number of cases and the fact that many of those affected are living in invaded areas, in which they have no defined address.

Building a density map of cases by city neighborhoods in the period 2001 – 2002, an initial prevalence of the disease in the neighborhoods Presidente Costa e Silva (east region) and Barrocas (north region) was observed. However, after

overlapping the cases during the period of 2001 – 2007, it was possible to observe a new reality in the distribution of new cases of dengue, especially in neighborhoods like Santo Antônio and Santa Delmira (north region), with 118 cases (14.8%), Conjunto Vingt-Rosado and Alto de São Manoel (east region), with 93 cases (11.7%) (Figure 1). More outlying neighborhoods, such as Lagoa do Mato and Aeroporto (west region), are also highlighted, with 99 cases (12.4%). The data revealed a change in the dynamics of the disease, possibly contributing to the recurrent cases of dengue.

Making an association of the epidemic peaks identified in the study with the rainfall indexes in the period of 2001 – 2007, there is a regular distribution regarding the disease's seasonality that occurs predominantly between the months of February and May, when the climatic conditions are favorable to the mosquito (Graph 2).

According to Keating¹⁴, among other factors, temperature and rainfall affect the vector's survival, reproduction, changes in distribution and density. In Mossoró, the mean temperature and annual humidity are, respectively, 27°C and 69%, and the highest rainfall indexes occur between February and May, after which high numbers of people affected by dengue (Graph 2) can be observed. These abiotic climatic factors have shown to be associated with dengue cases. The seasonal pattern of the disease coincides with the summer due to the increased occurrence of rain and the higher temperature in this season^{15,16}.



Graph 1 - Incidence rate of confirmed cases of dengue in Mossoró and the State of Rio Grande do Norte from 2001 to 2008.

Gráfico 1 - Taxa de incidência de casos confirmados de dengue no município de Mossoró e o Estado do Rio Grande do Norte de 2001 a 2008.

Table 1 - Dengue cases by gender and age, Mossoró, Rio Grande do Norte, 2001 to 2007.

Tabela 1 - Casos de dengue segundo o sexo e a faixa etária, Mossoró, Rio Grande do Norte, 2001 – 2007.

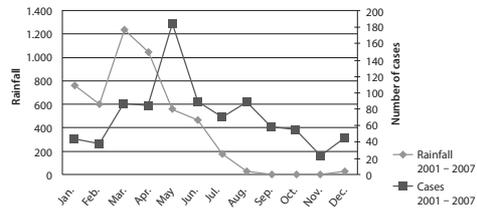
Age group (years)	Gender		Total (n)
	Male	Female	
0 – 20	114 (41.9%)	158 (58.1%)	272
21 – 40	141 (38.2%)	228 (61.8%)	369
41 – 60	79 (41.6%)	111 (58.4%)	190
> 60	11 (30.5%)	25 (69.5%)	36
Total	345 (39.8)	522 (60.2%)	867

Among the cases reported, about 178 of them (20.5%) are recurrences, i.e., individuals who had dengue more than once. This is worrying data for the municipality that increases the risks of developing the most severe form of the disease, DHF. However, regarding the 18 confirmed cases of DHF, we observed an association with classic dengue cases (Figure 2) only in the neighborhoods of Santa Delmira and Presidente Costa e Silva.

By assessing the geographic distribution of dengue in the municipality of São José do Rio Preto (SP) between 1990 and 2002, and using georeferencing through census sectors, Mondini¹⁷ found 29% of sectors had incidences lower than 100 cases per 100,000 inhabitants and 5% of them exceeded 5,000 cases.

Barcellos¹⁸ used GIS to do a point-to-point georeferencing when he studied dengue's transmission capabilities in the city of Porto Alegre associated with the presence of the vector and the environmental factors that characterized that location.

Most studies using GIS for dengue describe the georeferencing of cases per sanitary district or census sector, unlike the study conducted in Mossoró, which considered each separate case at the address provided. This type of data collection, point to point, enables a more realistic visualization of the distribution of the disease and allows the identification of sites where there are clusters of cases. According to Câmara¹⁹, this



Graph 2 - Association between rainfall and the number of dengue cases in Mossoró, Rio Grande do Norte.

Gráfico 2 - Associação entre o índice pluviométrico e o número de casos de dengue em Mossoró, Rio Grande do Norte.

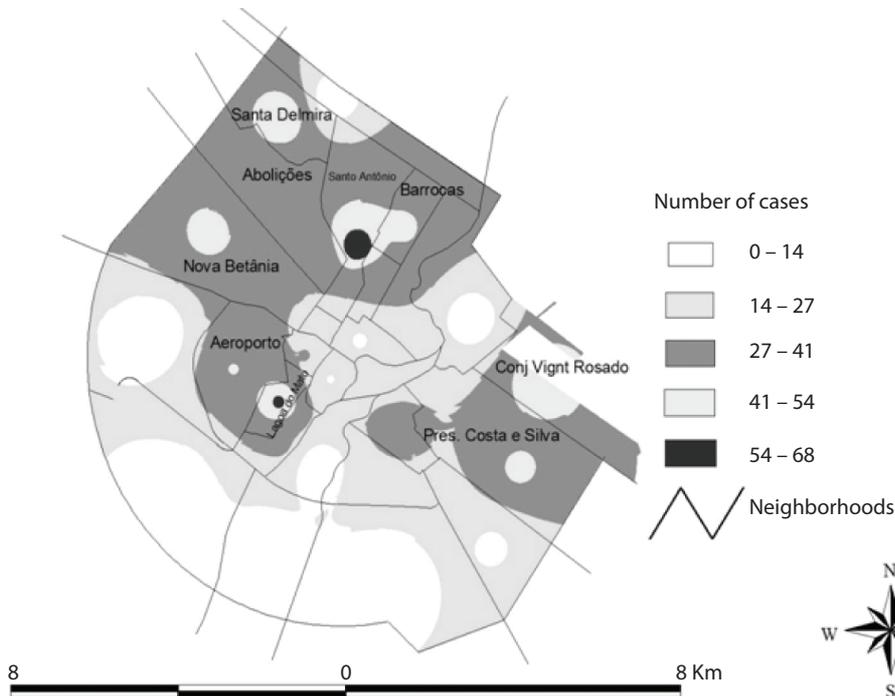


Figure 1 - Density of dengue cases in Mossoró, Rio Grande do Norte, in the period from 2001 to 2007.

Figura 1 - Densidade dos casos de dengue em Mossoró, Rio Grande do Norte, no período de 2001 - 2007.

type of georeferencing aims to study the spatial distribution of these points, testing hypotheses on the observed pattern — whether it is random or regularly distributed in clusters, etc. This type of mapping can also identify the existence of possible environmental factors^{20,21}.

The study of the spatial distribution of dengue in the city of Mossoró using GIS provided information that would not be visualized by working only with tabular data. The highest number of cases in the area comprising the north and east regions of the city was a widely known fact; however, as these regions occupy a large geographical area, there was no spatial visualization of the actual distribution of the disease. The georeferencing made possible to identify outbreaks, which showed the geographic “portrait” of the endemic, alerting researchers and the municipality’s Health Management to the fact that dengue is in need of more attention from organizations that develop actions aiming at its elimination.

Conclusion

Dengue is advancing geographically throughout the Brazilian territory, reaching larger populations and causing more severe manifestations of the disease, especially in areas with simultaneous or sequential circulation of different serotypes.

The study of the spatial distribution of dengue in the municipality of Mossoró using GIS proved to be a usable and useful tool in epidemiological monitoring. With the visualization of the endemic, many doubts were clarified regarding the actual location of the cases, revealing that the disease is concentrated in more outlying areas, where the population of low socio-economic standard resides, according to the findings in the field.

The results obtained point to the need for specific studies to clarify issues related to various factors involved in the transmission, such as the specific characteristics of the mosquito population, productivity of breeding sites and its role in the density

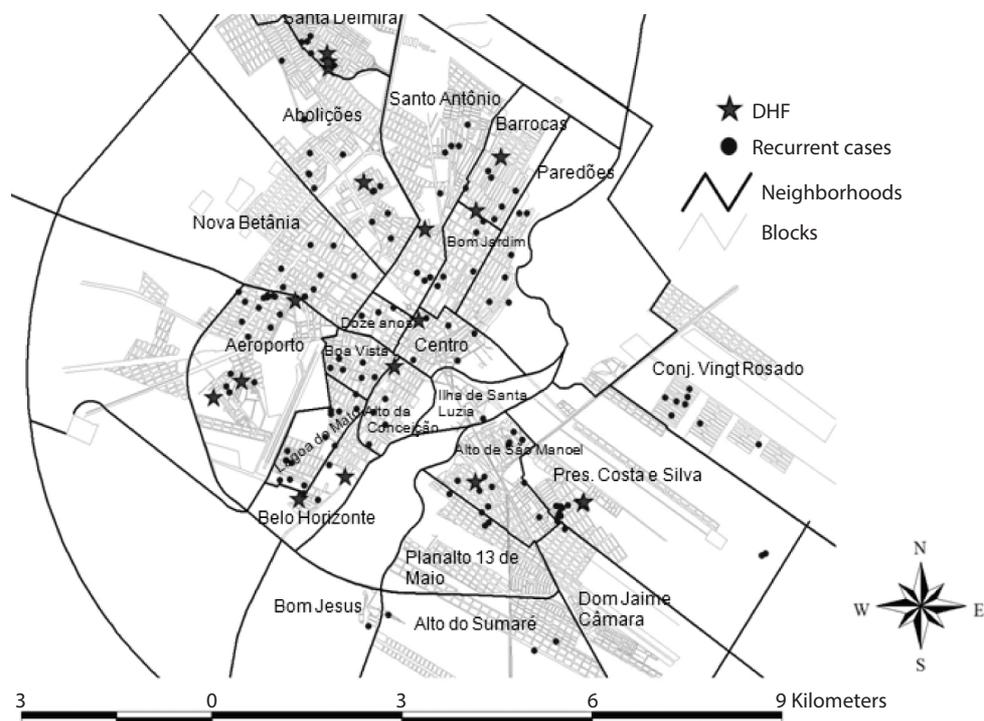


Figure 2 - Distribution of recurrent dengue cases and DHF in Mossoró city.

Figura 2 - Distribuição dos casos recorrentes de dengue e FHD no município de Mossoró.

of adult mosquitoes and their range of dispersal. Therefore, it is necessary to focus and facilitate actions of Mossoró's Public Health Surveillance, seeking strategies to fight this problem in priority areas.

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References

1. Costa CA, Façanha GP. Sorotipos virais de dengue identificados em crianças de Manaus, Estado do Amazonas, 2008. *Rev Soc Bras Med Trop* 2011; 44(2): 249-51.
2. Flauzino RF, Souza-Santos R, Oliveira RM. Indicadores socioambientais para vigilância da dengue em nível local. *Saúde Soc* 2011; 20(1): 225-40.
3. Guzm MG, Kouri G. Dengue and dengue hemorrhagic fever in the Americas: lessons and challenges. *J Clin Virol* 2003; 27(1): 1-13.
4. Santos SL, Augusto LGS. Modelo multidimensional para o controle da dengue: uma proposta com base na reprodução social e situações de riscos. *Physis* 2011; 21(1): 177-96.
5. Cardoso IM, Cabidelle ASA, Borges PCL, Lang CF, Calenti FG, Nogueira LO, et al. Dengue: clinical forms and risk groups in a high incidence city in the southeastern region of Brazil. *Rev Soc Bras Med Trop* 2011; 44(4): 430-35.
6. Rio Grande do Norte. Governo do Estado do Rio Grande do Norte. Secretaria do Estado de Saúde Pública - SESAP. Subcoordenação de Vigilância Epidemiológica. Boletim Epidemiológico Dengue 2010. Ano I - Edição 11/2010 - Semanas Epidemiológicas de 01 a 44 (3/1/2010 a 6/11/2010). Rio Grande do Norte: Secretaria do Estado de Saúde Pública; 2010.
7. Barbosa GL, Lourenço RW. Análise da distribuição espaço-temporal de dengue e da infestação larvária no município de Tupã, Estado de São Paulo. *Rev Soc Bras Med Trop* 2010; 43(2): 145-51.
8. ESRI. What is GIS?. Disponível em <http://www.gis.com/whatisgis/index.html> (Acessado 12 de novembro de 2007).
9. Vigilância Epidemiológica. Programa Nacional de Controle da Dengue (PNCD). Disponível em http://bvsm.sau.gov.br/bvs/publicacoes/pncd_2002.pdf. (Acessado em 25 de agosto de 2011).
10. Instituto Brasileiro de Geografia e Estatística. Resultados Preliminares do Universo do Censo Demográfico 2010. Censo Demográfico 2010. Disponível em <http://www.ibge.com.br/cidadesat/topwindow.htm?1>. (Acessado em agosto de 2011).
11. Santos CD. A cidade de Mossoró, Rio Grande do Norte: processo de formação e produção do espaço urbano. *Revista Mercator* 2009; 8(17): 97-108.
12. Santos RC. Updating of the distribution of *Aedes albopictus* in Brazil (1997-2002). *Rev Saúde Pública* 2003; 37(5): 1-4.
13. Vasconcelos PFC. Epidemia de febre clássica de dengue causada pelo sorotipo 2 em Araguaína, Tocantins, Brasil. *Rev Inst Med Trop* 1993; 35(2): 141-48.
14. Keating J. An investigation into the cyclical incidence of dengue fever. *Soc Sci Med* 2001; 53(12): 1587-97.
15. Teixeira MG, Costa MCN, Barreto LM, Barreto FR. Epidemiologia da dengue em Salvador - Bahia, 1995-1999. *Rev Soc Bras Med Trop* 2001; 34(3): 269-74.
16. Moore CG. Predicting *Aedes aegypti* abundance from climatological data. In Lounibos LP, Rey JR, Frank JH (eds.). *Ecology of mosquitoes*. Vero Beach: Florida Medical Entomology Laboratory; 1985. p. 223-33.
17. Mondini A, Neto FC, Saches MG, Lopes JCC. Análise espacial da transmissão da dengue em cidade de porte médio do interior paulista. *Rev Saúde Pública* 2005; 39(3): 444-51.
18. Barcellos C, Pustai AK, Weber MA, Brito MRV. Identificação de locais com potencial de transmissão de dengue em Porto Alegre através das técnicas de geoprocessamento. *Rev Soc Bras Med Trop* 2005; 38(3): 246-50.

19. Câmara G, Monteiro AM, Fucks DS, Carvalho MS. Análise espacial e geoprocessamento. Disponível em <http://www.dpi.inpe.br/Gilberto/livro/analise/cap1.pdf>. (Acessado em 23 de março de 2007).
20. Leite ME. Análise da correlação entre dengue e indicadores sociais a partir do SIG. *Hygeia, Rev Bras Geogr Méd Saúde* 2010; 6(11): 44-59.
21. Machado JP, Oliveira RM, Souza-Santos R. Análise espacial da ocorrência de dengue e condições de vida na cidade de Nova Iguaçu, Estado do Rio de Janeiro, Brasil. *Cad Saúde Pública* 2009; 25(5): 1025-34.

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