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Spatial analysis for identification of priority areas for surveillance and control in a visceral leishmaniasis endemic area in Brazil

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ABSTRACT

Spatial analysis of epidemiological data may be used to assist in the implementation of surveillance and control measures against visceral leishmaniasis (VL) in endemic areas. This ecological study aimed to identify priority areas for surveillance and control of VL in São Luís, the capital of the state of Maranhão in northeast Brazil, a highly endemic area for the disease. We evaluated the spatial structure of the incidence rates of human VL and of the mean number of human and canine cases occurring between 2005 and 2007 in 355 neighborhoods (aggregated into 203 geographical analytical units) within the municipality. The presence of spatial autocorrelation was explored using global and local Moran's I statistics. A local indicator of spatial autocorrelation was used to generate maps for the identification of VL clusters. The global Moran's I index revealed a weak, but statistically significant spatial autocorrelation for human VL incidence rates (I = 0.138). A total of 43 geographical analytical units, encompassing 121 neighborhoods, were identified as priority areas for implementing surveillance and control actions. For the purpose of defining an action plan for the delivery of these measures, those 16 geographical analytical units (encompassing 54 neighborhoods) identified as clusters with high incidence rates of human VL should receive the highest priority. An additional nine geographical analytical units (comprising 28 neighborhoods) showed non-significant clustering of high rates of human, and might be considered as the next priority for VL management. Finally, a further 18 geographical analytical units (covering 39 neighborhoods) had records of coexisting human and canine VL cases during the study period, and these should receive priority attention when resources become available. Spatial data analysis is a valuable tool for defining priority areas for VL surveillance in high transmission areas contributing to a more effective management of financial and technical resources, increasing the sustainability and efficiency of control efforts.

1. Introduction

Visceral leishmaniasis (VL) is a major public health problem in many parts of the world. Approximately 0.2–0.4 million VL cases occur every year (Alvar et al., 2012) in 12 countries in the Americas and in 65 in Europe, Asia and Africa (World Health Organization, 2010). In Brazil, VL is a zoonotic vector-borne disease widely distributed throughout Brazil with a high mean annual incidence rate of around two cases per 100,000 inhabitants (Ministério da Saúde do Brasil, 2006). VL constitutes an important public health issue owing to the increasing number of new cases notified and the continuous expansion of the disease in state capitals and adjacent metropolitan regions (Barreto et al., 2011; Costa, 2008; Oliveira et al., 2008; Werneck, 2008).

A program to monitor and control VL (*Programa de Vigilância e Controle da Leishmaniose Viscera* – PVCLV) has been created by the Brazilian Ministry of Health with the objective of reducing transmission rates and the mortality and morbidity burden associated with the disease. The strategies of this program are (i) early diagnosis and treatment of human VL cases, and (ii) control of the insect vector population (phlebotomines) and elimination of infected reservoirs (dogs, in urban areas) (Gontijo and Melo, 2004;

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Ministério da Saúde do Brasil, 2006; Savani et al., 2003; Silva et al., 2007). Although PVCLV guidelines emphasize the importance of risk reduction measures, the strategies employed have not been effective in reducing the incidence of VL (Romero and Boelaert, 2010). Indeed, in comparison with the many advances that have been made in the control of other infectious diseases in Brazil, the management of VL must be considered one of the most striking failures (Barreto et al., 2011). In order to augment the effectiveness of the strategies proposed by PVCLV, the Brazilian Ministry of Health recommends that all municipalities classified as intense transmission zones (mean annual incidence rate ≥4.4 notified cases during the previous three years) should identify priority areas for the implementation of the recommended surveillance and control measures (Ministério da Saúde do Brasil, 2006).

Geographic information systems (GIS) are important tools in understanding the epidemiology of infectious diseases, and can provide valuable contributions to the determination of resource allocation and implementation of control measures. The combination of GIS with reliable data generated by surveillance activities enables the routine construction of maps showing the distribution of vectors, reservoirs and cases of human VL, through which past and present situations can be compared and changes in the patterns of disease occurrence identified (World Health Organization, 2010).

Spatial data analyses have been employed in epidemiological research of VL in Brazil at the municipal (Camargo-Neves et al., 2001; Carneiro et al., 2004; Margonari et al., 2006; Oliveira et al., 2001; Vigilato, 2004; Werneck et al., 2002, 2007; Lopes et al., 2010) and state levels (Bavia et al., 2005; Correa-Antonialli et al., 2007; Dantas-Torres and Brandão-Filho, 2006; Mestre and Fontes, 2007; Nieto et al., 2006; Tavares and Tavares, 1999). Some of these studies were performed in Northeast Brazil, with different approaches, levels of analysis and geostatistical techniques used (Tavares and Tavares, 1999; Bavia et al., 2005; Nieto et al., 2006; Dantas-Torres and Brandão-Filho, 2006; Werneck et al., 2007; Carneiro et al., 2004). However, there is still a need to explore the potential of these techniques to generate more practical information to be used by the health services.

The state of Maranhão in the northeast region of Brazil is of particular epidemiological importance with respect to human VL because the reported incidence of the disease (7.2 cases per 100,000 inhabitants for 2009) is much higher than the average of the whole country. Moreover, in São Luís, the state capital, the incidence is 1.7 cases per 100,000 inhabitants, and the Brazilian Ministry of Health has classified the municipality as an intense VL transmission zone because of the elevated average annual number of cases (29.6) reported during the period 2007–2009 (Ministério da Saúde do Brasil, 2011).

While various epidemiological studies have been carried out in São Luís (Caldas et al., 2001, 2002; Costa et al., 1995; Mendes et al., 2002; Silva et al., 2008), new approaches are required in order to improve the effectiveness of VL surveillance and control measures. Within this context, the municipality of São Luís was selected as a model area for a detailed investigation aimed at determining the value and limitations of spatial data analysis in identifying priority areas and developing an action plan for surveillance and control of human VL.

2. Materials and methods

2.1. Ethical considerations

The research project was approved by the Research Ethics Committee of the National School of Public Health Sergio Arouca/Oswaldo Cruz Foundation (ENSP/FIOCRUZ) under protocol number 208/10. No human and animal populations were damaged or harmed by the collection, storage, and analysis of the data employed in the present study or by the publication of the findings derived there from.

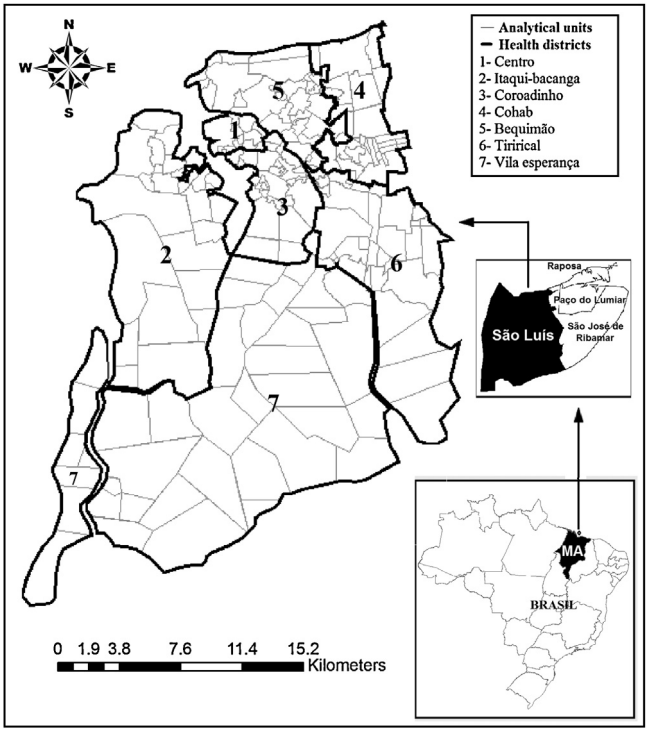

Fig. 1. Health districts (defined by numbers) and geographical analytical units (subdivisions) of the municipality of São Luís, state of Maranhão, Brazil.
Source: Adapted from Instituto da Cidade (INCID, Prefeitura de São Luís – Maranhão), Instituto Brasileiro de Geografia e Estatística (IBGE) and Secretaria Municipal de Saude (SEMUS)/Prefeitura Municipal de São Luís databases.

2.2. Study area

São Luís is located in northern Maranhão in the metropolitan region of the Ilha do Maranhão (S 2°31′47″; W 44°18′10″; altitude 24.391 m). The municipal territory comprises an area of approximately 835 km^2 with a population of 1,014,837 inhabitants (Instituto Brasileiro de Geografia e Estatística, 2011). According to the City Health Department (Secretaria Municipal de Saude – SEMUS) of São Luís, the city is divided into seven health districts, namely Centro, Itaqui-bacanga, Coroadinho, Cohab, Bequimão, Tirirical and Vila Esperança (Prefeitura Municipal de São Luís, 2012). The municipality of São Luís encompasses 355 urban and rural neighborhoods (villages, farms, homesteads, industrial areas, ports, etc.) which, for the purposes of this investigation, were assembled into 203 geographical analytical units (Fig. 1). The geographic analytical units were defined by the research team considering the need to make different databases from various sources compatible. The different sources of geographic information considered were: (a) the geographic units used by the Institute for Research and Urban and Rural Planning of São Luís (INCID) (urban neighborhoods); (b) the geographic data available from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE) (urban and rural census tracts) and (c) field maps used by health workers from SEMUS. The geographic analytical units were then defined considering the established limits in the INCID geographic database, plus new geographic units created based on census tracts (IBGE) and considering the locations defined in the field maps from SEMUS.