

## **The use of Geographical Information System (GIS) to improve active leprosy case finding campaigns in the Municipality of Mossoró, Rio Grande do Norte State, Brazil**

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*Summary* There is a high incidence of leprosy in the municipality of Mossoró, Rio Grande do Norte state, where the detection coefficient has risen from 2.78/10 000 population in 1998 to 5.14 in 2004. While cases have been registered throughout the urban area, the disease is concentrated in select neighbourhoods. This study was undertaken using Geographical Information System (GIS) with the objective of defining low-cost, effective strategies to control leprosy. The land registry map of the city, Ikonos satellite images and the SINAN (National Morbidity Notification Information System) database were used as the cartographical basis for the study. The sample for the leprosy mapping was drawn from the 358 new cases of the disease diagnosed in the municipality between 1998 and 2002. The houses of 281 patients were located (78.5% of the total) and their addresses geo-referenced using a GPS handheld device. Subsequently, geographical analysis was carried out using ArcView 9.0 software showing predominant concentration of cases in the neighbourhoods of Barrocas, Santo Antônio, Bom Jardim and Paredões. This mapping served as the basis for four active case finding campaigns conducted in the most highly concentrated areas between March and September of 2005. Campaigns guided by spatial analysis led to the diagnosis of 104 new cases of the disease (50% of the total number of new cases detected in the municipality in 2005). The use of GIS in leprosy diagnosis has shown to be extremely effective, providing a clear visual understanding of the distribution of the disease in the municipality, which results in targeted interventions and important cost reductions in leprosy control activities.

## Introduction

There is a high incidence of leprosy in the municipality of Mossoró, Rio Grande do Norte, Brazil. The municipality's annual detection coefficient has grown in a non-uniform fashion, under the direct influence of operational factors, such as the number of Primary Health Centres (UBS—*Unidades Básicas de Saúde*) and Family Health Programme (PSF—*Programa de Saúde da Família*) teams trained in diagnosis and treatment of leprosy, the number of dermatologists in the public health system and the occurrence of diagnostic campaigns. This coefficient increased by 85% between 1998 and 2004.

In 2004, the municipality of Mossoró, with a population estimated by the Brazilian Institute of Geography and Statistics (IBGE—*Instituto Brasileiro de Geografia e Estatística*)<sup>1</sup> at 222,587 inhabitants, registered 115 new leprosy cases, which corresponds to a detection coefficient of 5.16 cases per 10 000 population,<sup>2</sup> considered highly endemic by the Brazilian Ministry of Health (MoH).

The increase in the detection of new cases has taken place throughout the urban zone of the municipality; albeit with areas of greater concentration. The geographical distribution of leprosy has been associated with low living standards by several authors in Brazil, notably Bechelli.<sup>3</sup> In general this distribution is unequal both between and within countries,<sup>4</sup> and these inequalities extend to states and municipalities.

The spatial distribution of diseases can be mapped and analysed using a Geographical Information System (GIS),<sup>5</sup> a tool capable of storing geographical information and correlating it with tabular data from spreadsheets, tables and graphs. It can be used to collect, store, administrate, question and exhibit data, assisting in the spatial localisation of diseases and the graphical analysis of epidemiological indicators.<sup>4,6</sup> According to the World Health Organization (WHO), it is an efficient administrative tool in the leprosy elimination programme and its use is recommended in all endemic countries.<sup>7</sup>

The main objective of this work was to use geo-referencing data to define strategies to combat the disease in the municipality of Mossoró/RN and select the most appropriate areas for active case-finding campaigns to be carried out.

## Materials and Methods

This is a descriptive intervention study carried out in the urban area of the municipality of Mossoró/RN based on case detection data from 1998 to 2002. We chose to use the land registry plan for the city<sup>8</sup> and the Ikonos PSM satellite image of the municipality's urban area (Proj. 4310, provided by Engesat) as the principle cartographical tools. In addition, we made use of the SINAN (National Morbidity Notification Information System) database, online postal codes,<sup>9</sup> notification forms and registration books from the municipal health administration. The new cases of leprosy diagnosed among urban residents in Mossoró during the selected period were included (358 total) in the study and 281 had their addresses geo-referenced. The SINAN database showed some incompatibilities with our methodology and the format of data for insertion in the ArcView 9.0 software. Thus, a spreadsheet was produced on Microsoft Excel (2000) with the patient's name, sex, age, address (street, number, neighbourhood, reference point) and geographical coordinates.

Armed with these spreadsheets and the land registry plan for the city, the addresses of the registered patients using a GPS handheld device (Magellan 320) were geo-referenced.

The coordinates gathered in the field were transcribed to the Excel spreadsheet and subsequently transformed into dbf files (dBase files) to be used directly in the ArcView 9.0 software. After the data had been formatted in the spreadsheets, the ArcMap application was used to make the information available in several maps showing the distribution of the geo-referenced cases in the municipality according to different variables. The Spatial Analyst extension was used to create a density map for the disease, representing the concentration of cases in a 100m<sup>2</sup> radius. Using the maps generated, the areas with the greatest concentration of the disease were defined in order to carry out four campaigns to search for new cases in 2005.

The campaign strategies included identifying the UBS in the target areas, training all the community health agents (408 ACS - *agentes comunitários de saúde*), 37 doctors and 37 nurses in the PSF units, the production and distribution of educational leaflets, media coverage of the campaign - radio, TV and newspapers - and the creation of a timetable for training and for campaigns.

Campaigns were undertaken separately in four areas and each was conducted over a two-week period. In the first week ACS made house-to-house visits alerting the population to the signs and symptoms of the disease. In the second week PSF health professionals examined patients with symptoms suggestive of leprosy. Diagnosis was then confirmed by PSF doctors supervised by dermatologists during in-service training sessions carried out at the UBS.

## Results

### GEO-REFERENCING

Between 1998 and 2002, 368 new leprosy cases had been diagnosed in the municipality of Mossoró, of whom 358 resided in urban areas. The addresses of 281 of these patients were located and geo-referenced (78.5%). The neighbourhoods most affected were: Barrocas (69 cases - 25%), Santo Antônio (39 cases - 14%), Bom Jardim (39 cases - 14%) and Paredões (14 cases - 5%); however, other important areas were also observed, such as the neighbourhoods of Alto de São Manoel, Abolição and Alto da Conceição (Fig. 1).

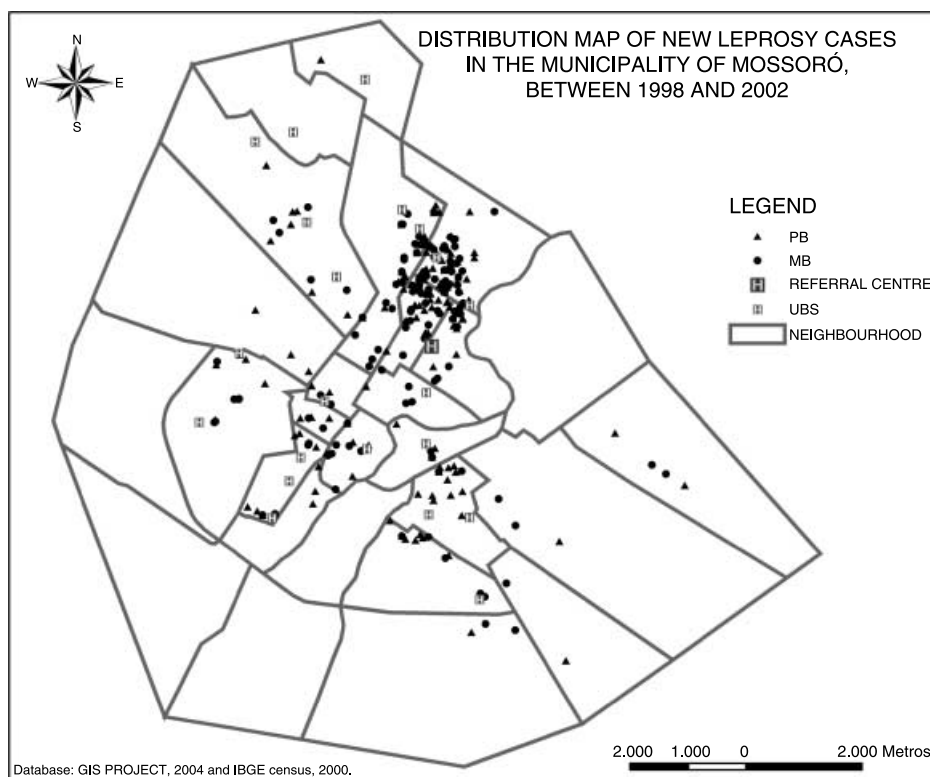
The density map (Fig. 2) shows that the greatest concentrations of the disease are in the neighbourhoods of Santo Antônio, Bom Jardim, Paredões and Barrocas. Consequently, one can assume that these are the areas where the risk of getting leprosy would be greatest.

Using the thematic maps it was possible to spatially identify four areas (Fig. 3) with the greatest concentration of leprosy cases. All had public health facilities and were thus appropriate for active case detection campaigns.

During the four map-based detection campaigns, the ACS referred 512 patients with possible leprosy symptoms to the UBS. The PSF teams carried out a triage of these patients and selected 225 to be evaluated with the visiting leprologists during in-service training at the units supporting the campaigns. Of these 225, 104 new cases of the disease were confirmed, corresponding to 50% of all the new cases diagnosed in 2005, and increasing the detection rate from 5.16/10,000 inhabitants in 2004 to 9.34/10,000 in 2005.

The majority of new patients (39.42%) lived in the neighbourhoods of Barrocas, Bom Jardim and Santo Antônio (Area 1). The area with the second largest number of cases (32.69%) included the neighbourhoods of Belo Horizonte, Lagoa do Mato, Alto da Conceição and Aeroporto (Area 3), followed by area 4 (18.26%) and area 2 (9.6%), as shown in Fig. 4.

New cases were predominately women (75%); this had been expected as it is known that women tend to frequent the health units more and respond more to health campaigns than



**Figure 1.** Distribution map of new leprosy cases in the municipality of Mossoró, between 1998 and 2002.

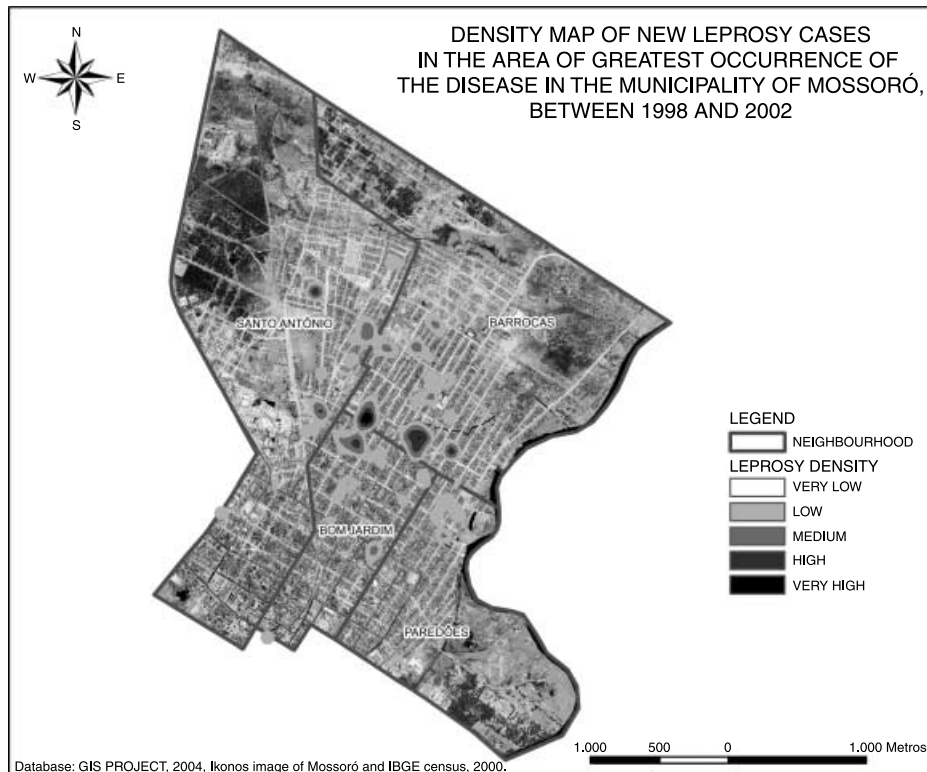
do men. The majority of cases (67%) were paucibacillary, which can be explained given that PB lesions (macules or plaques with reduced sensitivity) are more easily spotted by the population and more easily identified by health professionals. Multibacillary forms are more difficult to identify and require more experienced professionals.

The age group most affected was between 21 and 40 years (36 cases – 35%), followed by the under 15s (20 cases – 19%). All the 104 patients diagnosed were assessed for disability at the time of diagnosis, according to the WHO criteria. Of these, 29 patients (27.89%) had a disability, with 17 (16.36%) already suffering from grade II disability (Fig. 5).

#### REPERCUSSIONS OF GIS IN ACTIONS TO COMBAT LEPROSY

The use of GIS as an operational strategy to determine the most adequate areas in which to carry out campaigns was extremely effective. During 2004, 115 new leprosy cases were diagnosed; a detection rate of 5.16/10,000 inhabitants. When the four two-week campaigns were carried out in areas selected using GIS, 104 new diagnoses of the disease were made, representing 90% of the cases detected throughout the previous year.

In addition to increased detection, there was a significant reduction in costs when compared to former annual campaigns. For example, the annual campaign for 2002 spent R\$30,000 (£7,500) on drugs to treat other dermatoses to meet patient demand and needed to contract 10 dermatologists from the private sector outside the municipality. The campaign



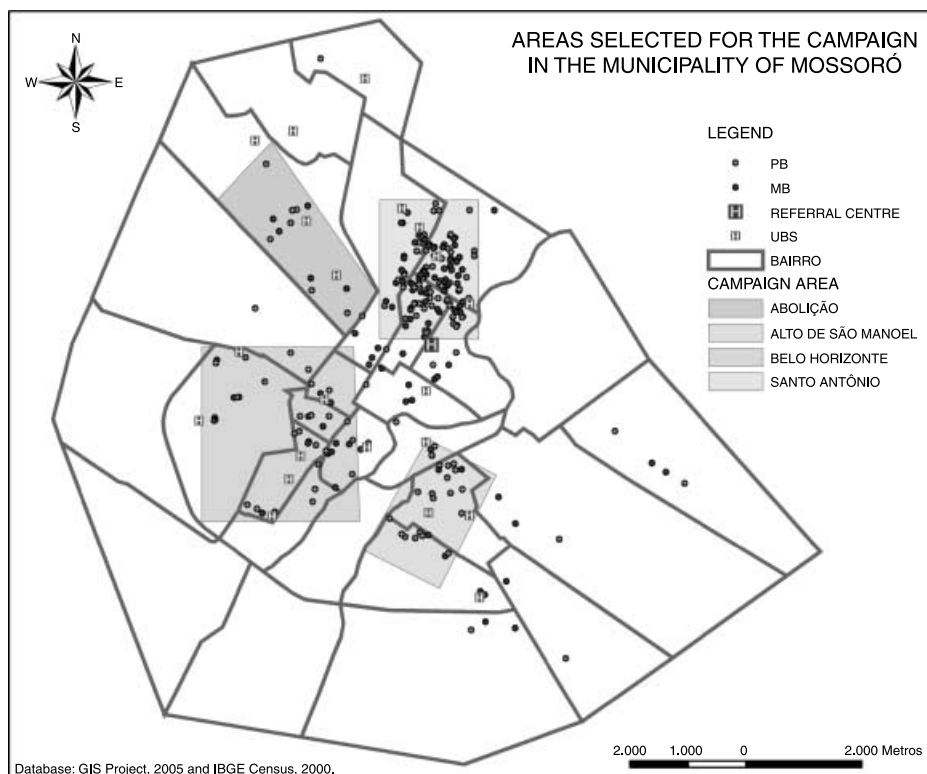
**Figure 2.** Density map of new leprosy cases in the area of greatest occurrence of the disease.

detected 28 new patients. In our new campaign model, R\$ 6,000.00 (£1,500) were spent on drugs and three leprologists diagnosed 104 new patients.

Our campaign also played an important role in the decentralisation of leprosy control activities and their integration into the primary care network, as only 7 of the 104 diagnosed cases (6.7%) were treated at the referral centre and 97 patients (93.3%) were treated at the primary care centres in the areas where the campaigns were carried out. By contrast, in 2005, before the start of the campaigns, around 75% of new cases diagnosed by the referral centre were treated in the centre itself.

## Discussion

Between 1998 and 2002, 97.28% of new leprosy cases detected in Mossoró occurred in people residing in the urban zone, confirming the findings of Sabroza *et al.*<sup>10</sup> which examine the links between health, the local environment and development. Of the cases selected for the study it was possible to geo-reference only 78.5%, which reflects a number of difficulties that we encountered including a lack of information on the morbidity notification (SINAN) forms, the size of the city (over 200,000 residents), the large number of cases, the number of patients residing in squatter areas without defined addresses (projected streets, unnumbered



**Figure 3.** Areas selected for the active case finding campaigns in the municipality of Mossoró.

houses), roads without street signs and the municipality's disorganised system for numbering houses.

We are not the first to use GIS to study the epidemiology of leprosy. Bakker<sup>11</sup> used GIS for point-to-point geo-referencing when studying the susceptibility of leprosy patients residing in a small Indonesian island with 644 inhabitants. His study, however, was restricted to the geographical distribution of inhabitants and patients without establishing relationships with epidemiological indicators. The majority of studies using GIS for leprosy geo-referenced cases per neighbourhood or census district,<sup>2,12</sup> unlike the work carried out in Mossoró where it was done on a case-by-case basis according to the address given. This type of point-to-point data collection allows a more realistic visualisation of the distribution of the disease, in addition to identifying the precise location where concentrations of cases occur. According to Câmara,<sup>13</sup> this type of geo-referencing aims to study the spatial distribution of these points, testing hypotheses about the pattern observed: whether random, regularly distributed or in clusters, for example. This kind of mapping also aids the identification of the existence of possible environmental factors as well as helping to calculate the risk of contracting the disease.

The study of the spatial distribution of leprosy in the municipality of Mossoró, using GIS, supplied data that could not have been visualised working with tabulated data alone. Geo-referencing allowed the identification of clusters of the disease, giving a geographical 'portrait' of endemicity.

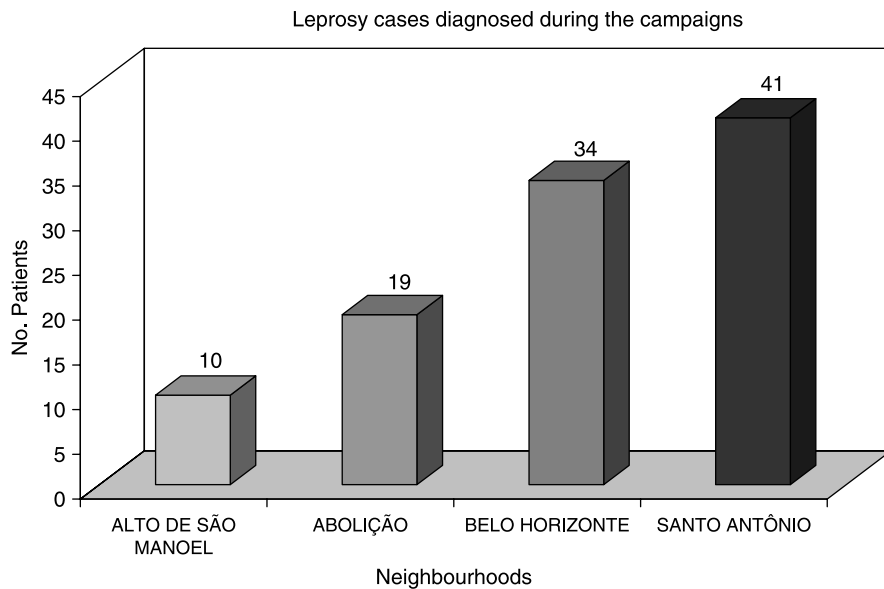


Figure 4. The number of new cases diagnosed during the active case finding campaigns in the four selected areas.

The four case-finding campaigns also contributed important epidemiological information. In the highly endemic areas there are a high proportion of child cases. Despite the fact that children, like women, participate more in health campaigns, this rate is extremely worrying. There are also many cases with grade II disabilities. This finding indicates that even with continuous training of public health sector professionals, diagnosis continues to be late, and

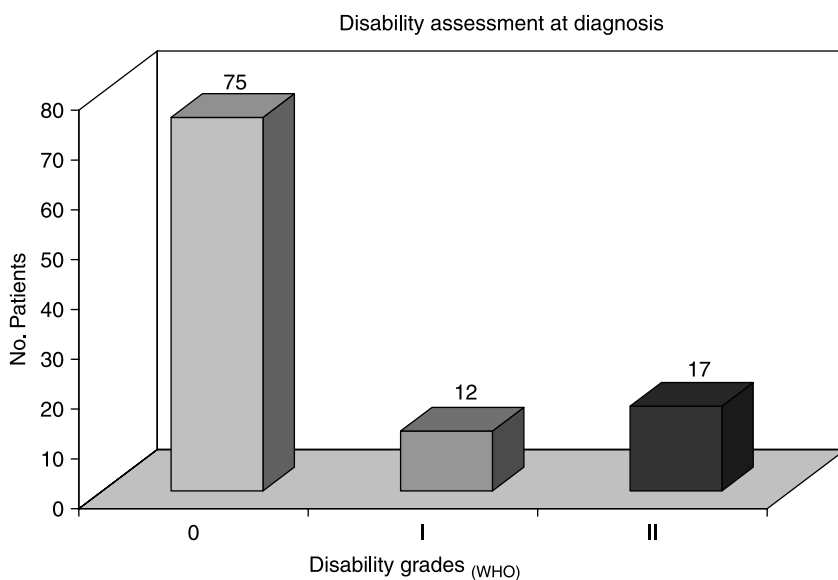


Figure 5. Disability Assessment at Diagnosis.

demonstrates the need for targeted campaigns. The diagnosis of leprosy based solely on spontaneous demand or self-referral does not have the desired result when compared with the focal case finding interventions that we describe.

Researchers and the municipality's health secretariat need to be aware that leprosy is not evenly distributed throughout the municipality but rather is concentrated in pockets that need greater attention by those responsible for its control.<sup>14</sup>

Decree N° 586/GM, of 06 April, 2004, of the Brazilian Ministry of Health recommends 'the intensification of activities to combat leprosy, seeking early diagnosis, prevention, treatment, physical and social rehabilitation and the control of leprosy through the adoption of measures such as increased access to diagnosis and treatment in the most endemic municipalities, health promotion activities and epidemiological surveillance'.<sup>15</sup> The use of GIS, linked to strategies to carry out directed case-finding campaigns, has proven effective and inexpensive in the fight against leprosy in the municipality of Mossoró. These tools could be used more widely and are applicable to other diseases beyond just leprosy, most notably tuberculosis. The project team is planning to test this hypothesis with leishmaniasis in Mossoró as well as with tuberculosis in additional municipalities in four states in 2007. Further results may be presented at a later date.

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