

# Analysis of the Tuberculosis Occurrence Through the Use of Geoprocessing

ORIGINAL

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## Abstract

**Background:** For the control of tuberculosis (TB), it must be adopted specific measures in areas of high transmission. Thus, it was aimed to identify the spatial pattern of new tuberculosis cases in Juazeiro do Norte-CE/Brazil, from 2001 to 2012.

**Methods and Findings:** It is a hybrid design, ecological study and temporal trend. The new cases reported with TB were included as subjects of research. It was outlined the socio demographic profile; the spatial analysis of cases was made through the Kernel technique and the nearest neighbor method with simulation. Among 914 new TB cases, there was a predominance of males (56.0%), aged between 20 to 39 years (42.0%), with incomplete elementary school (43.2%), pulmonary clinical form (89.1%). 79.1% of patients achieved a cure and 5.3% abandoned the treatment. In the studied period, it was identified homogeneous spatial distribution and non-random pattern, with the highest concentration of cases in the southern region of the city.

**Conclusion:** The identification of spatial pattern becomes relevant, in order that it can contribute to the strengthening of the TB control by providing information that optimizes activities such as: active search, health education, notification of new cases and supervising the treatment performed by health professionals.

## Introduction

Tuberculosis (TB), considering its high morbidity and mortality, remains over the years as a major challenge to public health in global terms.

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## Keywords

Tuberculosis; Spatial distribution; Epidemiology.

Despite it is a curable disease with a free treatment, it is estimated that one third of the world's population is infected and about one million people die every year [1, 2]

In some countries of Western Europe and North America, this disease behaves as recidivist pathology, while in Brazil it has been characterized as a stigmatized illness with great vulnerability [3].

Brazil occupies the 16th position among countries with the highest burden of disease. In 2012, 70 thousand new cases were recorded and, this number increased in 2013 to 71.123 thousand, equivalent to an incidence of 35,4/100.000 inhabitants [4].

Among the factors that aggravate even more this situation, it can be highlighted: poverty, low educational level, the late diagnosis, the treatment abandonment, the spread of HIV (Human Immunodeficiency Virus), the population growth and the demographic variations [5, 6].

The disease's epidemiological trend shows that TB control strategies have been potent or ineffective. Associated with the social inequity, in order to break the chain of the disease transmission and the reduction of its contents, it is necessary to adopt general measures, to improve living conditions, in addition, it is also necessary, specific measures aimed at areas that show high level of transmission [6, 7].

Thus, it is important to know such areas and a technique that can be used by health surveillance is the geoprocessing, which consists of a tool for spatial analysis, able to delimit the homogeneous areas and measure the risk of infection in these locations [8]. The geoprocessing provides more comprehensive situational overview and offers policies to direct specific intersectoral actions.

Thereby, this study aimed to identify the spatial pattern of new TB cases in Juazeiro do Norte/CE/ Brazil, from 2001 to 2012.

## Methods

It is an ecological study with hybrid design and temporal trend, carried out in Juazeiro do Norte, located in the South of Ceará State, in the northeast of Brazil and in the metropolitan region of *Cariri*. It is far 549 km from the capital, Fortaleza. Its land area is 248,832 km<sup>2</sup>, with an estimated population - in 2012 - of 255,648 inhabitants [9].

The study period is from 2001 to 2012, in which it was included as subjects of research the new TB cases reported of all clinical forms (Pulmonary, Extrapulmonary and Pulmonary+Extrapulmonary), inscribed in the Tuberculosis Control Program (PCT), that possessed the full address (Street, number, neighborhood and Zip Code) and they had to live in the municipality urban area.

It is understood about the term 'new case': patient that was not submitted to the anti-tuberculosis therapy; that made treatment for less than 30 days or, more than five years [10].

The data collection occurred from March to June/2013. Initially, it was done the data survey through consultation in secondary information sources from the Notification Aggravation Information System (SINAN), provided by the Epidemiological Surveillance of Municipal Health Secretariat of Juazeiro do Norte/CE/Brazil. Soon after, it was done the processing of such data the removal of duplicate cases that were reported in the city countryside and with incomplete address. Subsequently, it was done the geocoding of the occurrences using the city digital map, obtained on the data basis from the Brazilian Institute of Geography and Statistics (IBGE). This technique aims to estimate and spatialize events through the geographical position corresponding to the address sought.

In order to perform this procedure, it was organized Excel spreadsheets with the complete address description. Then, it was uploaded to *Google Fusion Tables* (a Google service whose function is to geocode addresses from Excel spreadsheets). So, it

was obtained the XY coordinates for a given address, which they were saved in KML format. With the file saved in this format, it was used the Track-Maker® software, free version for KML conversion in Shapefile. When the files were in Shapefile, it was made the maps with the spatial distribution of TB cases using the ArcGis Software, version 10.

Shortly thereafter, it was traced the patients profile using the socio demographic (gender, age and education) and clinical variables (clinical form and closure situation), by means of the R software. For the areas identification with the highest concentration of cases (warm areas), it was applied the Kernel density, with coverage radius of 500 and smoothing surface of 50. It is important to mention that the geographical unit studied in the map was the census sector - this choice was done because they are more homogeneous and they possess a higher level of unbundling.

Through the SPRING Software, it was evaluated the space autocorrelation, and for this, it was used the *nearest neighbor with simulation* Method, in order to investigate if the spatial distribution of TB occurrences succeeded at random or followed any pattern in space. The *W* function corresponds to the sum of the nearest neighbors of each event whose distance is less than or equal to *w*, divided by the number of events in the region.

The study was approved by the Ethics Committee of Universidade Estadual da Paraíba (UEPB), CAAE number 0176.0.133.000-11, taking into account the recommendations contained in the 466/12 Resolution of the National Health Council. Study conducted without any institution financing.

## Results

914 new cases of tuberculosis were geocoded from 2001 to 2012 and it can be observed that the majority of these are males (56,0%), age between 20 to 39 years (42%), who attended the incomplete elementary school (43,2%), and who

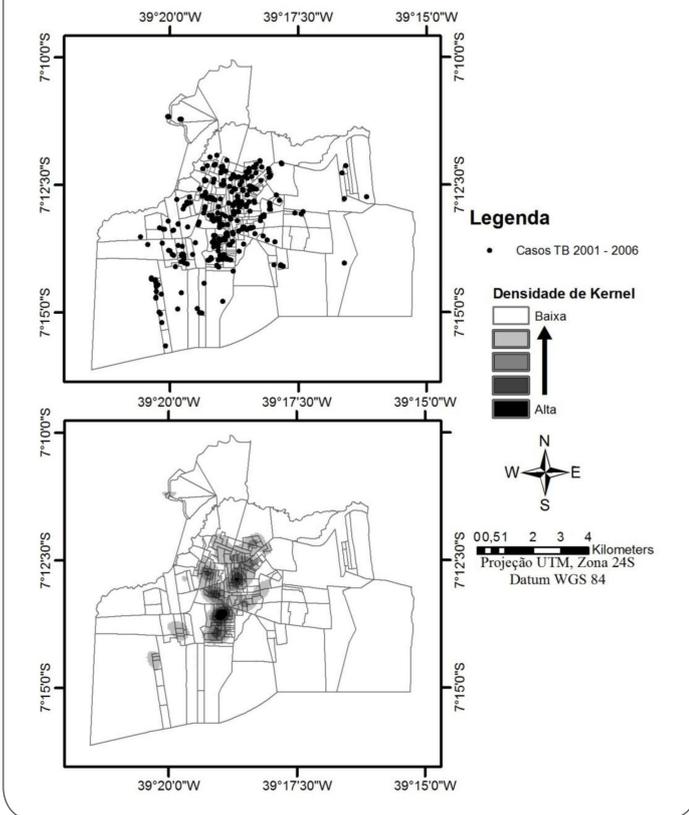
had pulmonary clinical form (89,1%), with healing percentage of 79,1% and abandonment of 5,3% (Table 1).

**Table 1.** Tuberculosis new cases according to some demographical variables, clinical form and closure situation, Juazeiro do Norte/CE/Brazil, 2001-2012.

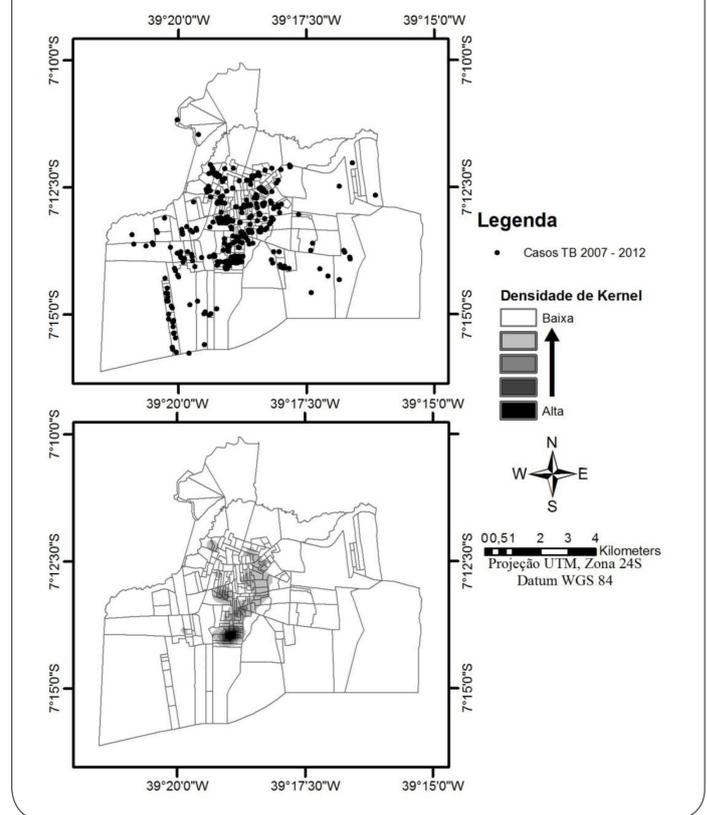
Variables	N	%
Sex		
Male	512	56.0
Female	402	44.0
Age Group (Years)		
0-9	16	1.8
10-19	66	7.2
20-39	384	42
40-59	299	32.7
60 E Mais	149	16.3
Education		
None	160	17.5
Incomplete Elementary School	395	43.2
Complete Elementary School	43	4.7
Incomplete High School	96	10.5
Complete High School	34	3.7
Incomplete Higher Education	8	9.0
Complete Higher Education	24	2.6
Ignored	89	9.7
It Does Not Be Applied	14	1.5
Blank	51	5.6
Clinical Form		
Pulmonary	814	89.1
Extra-Pulmonary	88	9.6
Pulmonary + Extra-Pulmonary	12	1.3
Closure Situation		
Cure	723	79.1
Abandonment	49	5.3
Death By TB	6	0.6
Death By Other Cases	2	0.2
Transfer	47	5.1
Change Of Diagnosis	13	1.4
Multidrug-Resistant Tb	1	0.1
Ignored	73	8.0
Total	914	100

Source: SINAN/CE: Ministério da Saúde.

**Figure 1:** Distribution of new TB cases and Kernel density, by census sector. Juazeiro do Norte/CE, 2001-2006.



**Figure 2:** Distribution of new TB cases and Kernel density, by census sector. Juazeiro do Norte/CE, 2007-2012.



The isolated maps of TB cases (**Figures 1 and 2**), which were divided in two periods - from 2001 to 2006 and 2007 to 2012 - can be used as a spatial visualization strategy of disease. However, it is important to notice that each of the points do not necessarily represent a case, because some notifications were made in the same address or with rays of vicinity which generate an overlay. So, in order to have a more accurate analysis of spatial aggregation of the episodes, it was necessary to use the statistical technique of Smoothing Kernel space to estimate the local intensity, which it can be seen also on the maps of **Figures 1 and 2**, that show the regions of highest concentrations with the darker colors.

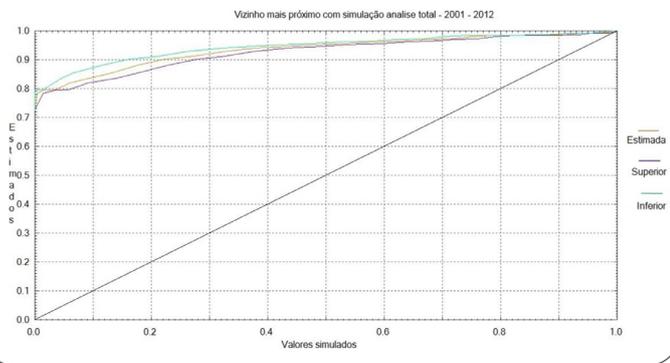
Through the observation of the map points from 2001 to 2006 (**Figure 1**), it can be identified a homogeneous distribution of the cases, which are distributed in greater intensity in the central region

of the map and some on the edge of the map. However, it is through the Kernel map (**Figure 1**) that it can be observed the area with the highest density of TB cases located in part of the southern region, which covers five census sectors, corresponding to the following neighborhoods: Pirajá and Romeirão (the darkest area of the map - **Figure 1**).

From 2007 to 2012, displayed in **Figure 2**, it can be seen in the isolated distribution map, a group in the central region and, only a few cases in the city peripheral region. In **Figure 2**, it is observed that the map with the Kernel estimator analysis indicates that the higher incidence of patients lies in the southern region (red area in **Figure 2**), and it covers two census sectors, located in João Cabral neighborhood.

According to the nearest neighbor analysis with simulation (**Figure 3**), it was detected that the TB

**Figure 3:** Analysis of the nearest neighbor with simulation. Juazeiro do Norte/CE, 2001-2012.



episodes have a non-random distribution, showing a spatial correlation -shown in **Figure 3**- in which the case behavior curves remain much above the straight line which features random distribution.

## Discussion

The demographic profile for the 12 year period, found in this study, corroborates with other scenarios [2, 11, 12] carried out in different regions of the country, as well as in other countries, making it possible to determine the disease vulnerability in some groups.

The male is more affected by TB and, it does not have a biological explanation for this fact, but it is possible to relate the life habits of this population portion, associated to the lack of healthcare [8, 11]. In countries where this disease is more controlled, the age group most affected is the elderly population [6]. This differs from what it was found in this study, in which the productive age group obtained higher percentage, which TB is considered a social problem, since this will directly affect the socio-economic life of the patient, because to the weakness state caused by the disease, the affected person may require work removal [13].

The low educational level of the subjects of this study, on the one hand, can demonstrate the relationship with social statements that have less ac-

cess to the elements that make up life with dignity, besides, potentially, it implies the misperception of the disease, which can result in less adherence to TB treatment and a non-seeking to the health services. As a result, it may occur the delay of diagnosis and treatment, with increased risk of abandonment and permanence of pathology among communities.

Tuberculosis is a disease caused by *Mycobacterium tuberculosis* and it can install itself in any body organ. However, the most common form of the disease and the responsible for the transmission chain is the lung, which corroborates with the data found in this research [10].

Even though the municipality under study priority for TB control, the closure situation, pointed to the obtained data in 12 years, highlights that the fees are below the targets, of at least 85% of cure and a maximum of 5% of abandonment, advocated by the World Health Organization [3].

Tuberculosis is a complex disease, difficult to control and easy to spread, because it is transmitted by airways between humans. However, it can present a close relationship with space and its organization, when it seeks to understand this dynamic, it is possible to leave the individual scope of pathology and enlarge to the collective dimension.

The space is modeled according to human needs - economic, social or cultural. By means of these environmental transformations, it is possible to determine the epidemiological frame of some diseases, mainly the infecto-contagious and parasitic diseases [14-16].

With the use of spatial analysis techniques in the field of public health, territorial extensions, considered a limiting factor for TB control, it enables the identification of vulnerability areas and priorities for its intervention [17].

The spatial analyses results suggest that the spatial distribution of TB cases in Juazeiro do Norte/CE/Brazil was homogeneous and non-random, showing a spatial correlation. However, such evidences are not

consistent with other researches, because the disease in other regions have presented a heterogeneous spatial pattern [1, 2, 6].

The neighborhoods where there are the highest concentration of cases (João Cabral, Franciscano, São Miguel, Santa Teresa, Salesianos, Centro, Romeirão and Pirajá) are regions of high population flow, where there is a public market in the city and various trades. That fact may suggest a more complex condition that may be influence the disease development, such as: individuals occupation, access to quality health care, urban spaces and social behavior.

The city receives tourists from various parts of the country to visit Padre Cícero Garden, located on the Garden Hill - 3 km from Juazeiro do Norte-CE, where the entire year receive the so-called pilgrims for this visitation. This factor may contribute to dispersal of tubercle bacilli, in order that migrations are known as one of the predisposing factors to the disease emergence.

The choice of the analysis unit is extremely important, because it can influence in the understanding of the phenomenon researched. Thus, it was used a unit that had aggregated information, such as census tracts, which consist of the smallest territorial unit. Through the Kernel analysis, it was able to identify the hot areas, i.e., where there were the sectors with the highest cases concentration.

## Conclusion

From this study, it was possible to understand how the occurrence of new TB cases in the municipality. It was found that the TB affects all regions with the same intensity, once the disease is more concentrated in some areas and with higher prevalence in specific groups (males, adult age and low education).

The occurrence delineation of new episodes of this pathology, by means of spatial analysis, indicated areas of greatest vulnerability to illness. This

areas identification of higher and lower concentration of disease occurrences allows for the refurbishment and adaptation of TB control politics and programs, which come with the epidemiological reality.

The geoprocessing is configured as an important technique, in the understanding of new TB cases occurrence, and it should be used in other studies that also seek to understand the distribution of the disease in space and its relationship with the territory.

In this sense, this research may contribute to the strengthening of the disease control and promote information to optimize actions such as: the active search of respiratory symptoms in areas where the disease is concentrated and which corresponds to the areas of greatest vulnerability. And it also contributes to the targeting of more specific interventions control of individual and collective form, corroborating to public health management actions.

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