

# Occurrence of tuberculosis cases in Crato, Ceará, from 2002 to 2011: a spatial analysis of specific standards

*Ocorrência de casos de tuberculose em Crato, Ceará, no período de 2002 a 2011: uma análise espacial de padrões pontuais*

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**ABSTRACT:** *Objective:* to analyze the spatial distribution of tuberculosis in Crato, Ceará, Brazil, from 2002 to 2011, aiming to check for a point pattern. *Methods:* This is an ecological, temporal trend and hybrid design study, with a quantitative approach. A total of 261 cases of tuberculosis were geo-referenced and 20 (7.1%) were considered as losses due to the lack of address. The profile of patients in 10 years of study was in accordance with the following pattern: men aged between 20 and 59 years, with low schooling, affected by the pulmonary form of tuberculosis and who were cured from the disease. *Results:* The analysis of the spatial distribution of tuberculosis points out that in the period of study, new cases of the disease were not distributed on a regular basis, indicating a clustered spatial pattern, confirmed by the L-function. The map with the density of new cases estimated by the Kernel method showed that the “hot” areas are more concentrated in the vicinity of the central urban area. *Conclusion:* The study allowed pointing out areas of higher and lower concentration of tuberculosis, identifying the spatial pattern, but it also recognized that the disease has not reached all of the population groups with the same intensity. Those who were most vulnerable were the ones who lived in regions with higher population densities, precarious living conditions, and with intense flow of people.

**Keywords:** Tuberculosis. Spatial analysis. Medical Geography. Uses of epidemiology. Epidemiological surveillance. Public health.

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**RESUMO:** *Objetivo:* Estudar a distribuição espacial da tuberculose no município do Crato, Ceará, no período de 2002 a 2011, buscando verificar se há um padrão pontual. *Método:* Trata-se de um estudo com delineamento híbrido, ecológico, de tendência temporal com abordagem quantitativa. Foram georreferenciados 261 casos e 20 (7,1%) foram considerados perdidos, devido à inexistência do endereço. O perfil dos doentes nos 10 anos de estudo obedeceu ao seguinte padrão: indivíduos do sexo masculino, na faixa etária de 20 a 59 anos, de baixa escolaridade, acometidos pela forma pulmonar da tuberculose e que alcançaram a cura da doença. *Resultados:* A análise da distribuição espacial da tuberculose aponta que no período de estudo os casos novos da doença não estão distribuídos de forma regular, indicando um padrão espacial agrupado, confirmado pela função L. O mapa com a densidade dos casos novos por meio da estimativa Kernel revelou que as áreas “quentes” se apresentam mais concentradas nas proximidades da região central da área urbana. *Conclusão:* O estudo permitiu apontar áreas de maior e menor concentração de casos de tuberculose, identificando o padrão espacial, como também reconhecer que a doença não atingiu todos os grupos populacionais com a mesma intensidade. Os mais vulneráveis habitavam regiões com maiores densidades populacionais, precárias condições de vida e por onde o fluxo de pessoas é intenso.

**Palavras-chave:** Tuberculose. Análise espacial. Geografia médica. Aplicações da epidemiologia. Vigilância epidemiológica. Saúde pública.

## INTRODUCTION

Despite being an old disease, tuberculosis (TB) still requires special attention because its control remains to be a challenge for public health in global terms. The control of this condition has been difficult, especially in developing countries, which concentrate about 95% of the TB cases; 22% of these are responsible for 80% of the global load of the disease<sup>1-3</sup>. In this ranking, which includes countries such as China, India, and South Africa, in 2012 Brazil had the 15th position in number of registered cases. In terms of disease incidence, in that same year, Brazil was at the 111th position<sup>2</sup>.

Currently, it is estimated that one of three people in the world is infected with *Mycobacterium tuberculosis*, biological agent that causes TB<sup>2</sup>; however, generally, a relatively small proportion of these individuals is likely to have the disease. The probability of getting sick is higher among people with compromised immunity, living in worse life conditions. TB is also more common among men, affecting mainly adults at economically productive age<sup>2</sup>.

In 2012, approximately 8.6 million people had TB, and 1.3 million died of it. The high number of deaths caused by TB is unacceptable, once most of them can be prevented by early diagnosis and if people underwent the therapy, which is provided for free<sup>2</sup>.

In 2012, the Notifiable Diseases Information System (SINAN) registered 71,189 new cases of the disease, corresponding to the incidence of 36.7 per 100 thousand inhabitants. In comparison to the previous year, the numbers went up again; in 2011 70,731 new

cases were notified, however, the incidence remained practically stable (36.8 per 100 thousand inhabitants)<sup>4</sup>.

In the country, according to information about the Mortality Information System, in 2011 about 4.6 thousand deaths were caused by TB, with a mortality rate of 2.4/100 thousand inhabitants; therefore, TB became the fourth cause of death for infectious and parasitic diseases, after septicemia, acquired immune deficiency syndrome (AIDS), and Chagas' disease; for those living with human immunodeficiency virus (HIV), TB is the main cause of death<sup>3</sup>.

In Ceará, in 2012, about 3,483 new cases of TB were registered; of which, 36 took place in the city of Crato, which corresponds to the incidence of 29.0 per 100,000 inhabitants; even though it is below the national incidence, it is a matter of concern for health managers and professionals. By analyzing the results of the closure situation of the city in the same year, it is observed that the percentage of cure (47.2%) and abandonment (19.4%) of the cases is not in accordance with the goals recommended by the World Health Organization (WHO), which is to heal 85% cases and reduce abandonment to 5%, at most<sup>4</sup>.

Some of the factors that contribute with the non-control of TB are social inequities, such as poverty, low schooling, and unemployment, because these situations do not allow the individual to access the minimum conditions that are essential to health. Internal and external migration movements also collaborate with the transmission of the disease due to their influence on the circulation of the etiological agent among people; besides, there are no restrictions for migration in some countries. Also, the lack of new investments in research for the development of new drugs and vaccines, the high prevalence of multidrug resistance, and the association with the HIV and deficient health systems make it more difficult to control the disease<sup>2,5</sup>.

With this epidemiological scenario, it is necessary to include the use of new instruments that can provide subsidies to national, state, and local administrator, thus subsidizing the decision-making, the organization, and the planning of actions addressed to the occurrence of health problems, especially infectious conditions such as TB.

Geoprocessing is a tool that enables the conduction of spatial analysis. It can be defined as a set of techniques of collection, treatment, manipulation, and presentation of spatial data; when used in health, it allows the mapping of diseases, risk assessment, planning of actions, and evaluation of care networks<sup>5,6</sup>.

The use of geoprocessing techniques applied to public health can contribute to the understanding of the current sanitary situation and its tendencies, by building approaches addressed to health surveillance practices, such as identification of critical areas, concentration of population groups, and prioritizing actions and resources, besides enabling the verification of possible associations with local characteristics of the social environment in which patients live<sup>7</sup>.

Spatial distribution allows identifying the occurrence of events in one territory, thus providing information about the diffusion of diseases, such as TB, which is directly associated

with the demographic conditions and the socioeconomic aspects, as well as with its infecto-contagious aspect, which favors its propagation in the environment<sup>8</sup>.

In this sense, this study aimed at studying the spatial distribution of TB in the city of Crato, from 2002 to 2011, to verify if there is a point pattern.

## METHODS

This is a hybrid, ecological temporal trend study with a quantitative approach, conducted in Crato, in the state of Ceará. It was chosen for being one of the priority locations by the Ministry of Health regarding TB control.

The study population comprised 365 new cases of TB, notified in SINAN under all clinical forms, from 2002 to 2011. The following cases were included: records with full address (street, number, and neighborhood) and people living in the urban zone of Crato, Ceará. Therefore, the sample accounted for 281 cases; of which, 261 were geo-referenced and 20 (7.1%) were excluded for being losses, due to the non-location of the address.

Data were collected from December 2012 to February 2013, in subsequent stages. At first, the digital net of the city was captured in the Secretary of Planning, as well as secondary data from patients in SINAN, provided by the Coordination of the Tuberculosis Control Program. Afterwards, they were organized regarding duplicity, lack of information, and exclusion of cases of inhabitants of the rural zone. Finally, the households of the patient were manually geo-referenced with the Global Positioning System (GPS) by two previously trained researchers.

The territorial unit of data analysis was the census sectors, chosen for presenting the advantage of being the most disaggregated level of population and socioeconomic groups, which are composed of a set of blocks with clear limits; there is an average of 300 houses in a population of about 1,500 inhabitants, national standards<sup>9,10</sup>.

The elaboration of maps and spatial analyses was conducted using the software ArcGis, version 9, by Esri. The R software was used for the characterization of study subjects, and data were submitted to calculations of absolute and relative frequency, considering the sociodemographic variables (sex, age group, and schooling), clinical form of the disease, and situation of case conclusion (cure, death, abandonment, change in diagnosis, and transfer to another health service or city).

The spatial distribution of points was used to assess the behavior of the point pattern. Afterwards, to observe the concentration of cases and map “hot areas”, the Kernel density estimator was used, with an influence ray of 500 meters and flattening surface of 20 meters. This function counts all of the points inside a region of influence by weighing them according to distance from the location of interest<sup>6</sup>. Despite being useful, because it provides a general view of the distribution of the disease, this estimator is not a method to detect cluster, but instead a technique that allows exploring the point pattern of health data<sup>6,7</sup>. Besides, the

interpretation of the obtained results is subjective and depends on the previous knowledge of the study area<sup>6</sup>.

Therefore, the K-function method was applied and used as a tool to compare the empirical estimation and the resulting estimation of a pattern process of random spatial points. To compare the K estimation of a set of data, the L function was plotted with simulation by using the parameters: minimum distance, 0; maximum distance, 5,000; interval, 50; and simulation, 50. The L graph in function of the h distance indicates that positive peaks above the superior envelope show clusters in the scale, whereas negative depressions below the inferior envelope show regularity in all scales<sup>6</sup>.

The research project was approved by the Ethics Committee of Universidade Estadual da Paraíba (UEPB), CAAE number 0176.0.133.000-11, meeting the recommendations in Resolution 466/12, from the National Health Council.

## RESULTS

Two hundred and sixty-one new cases of TB were geo-referenced, corresponding to approximately 93% of all patients living in the urban zone of the city. In Table 1, it is possible to see that the profile of patients in the 10 years of the study followed this pattern: male individuals aged between 20 and 59 years old, with low schooling, affected by the pulmonary form of TB. It is also observed that a considerable number of elderly people developed the condition and, in the schooling variable, some information was ignored and was not filled out.

As to the situation of case conclusions, most of the analyzed patients were cured; however, the obtained percentage was lower to that recommended by the Ministry of Health<sup>5</sup> (85%), as well as the proportion of treatment abandonment, which is much higher than the acceptable level (5%). Regarding the proportion of deaths, the categories death by TB (1.1%) and death by other causes (3.4%) were grouped to obtain this indicator.

With the distribution of TB points in the city of Crato, it was possible to visualize that new cases of TB were not distributed regularly, once some points are very close to each other, thus indicating a clustered spatial pattern, especially in the north, northeast, northwest, and southwest regions of the central area of the map. This shows that these events were not random; therefore, they did not follow a random pattern. After applying the L function, shown in Figure 1, the results confirmed that the distribution of points is not random, but clustered.

The peak distances for each graph corresponded to the mean dimensions of these clusters. By assessing the distribution of points in the space, it is possible to notice the presence of lines or regularities between the points, which can be a reflex of occurrences in the same street or block. These data indicate that in these places, there is a predisposition to the onset of new cases and that information can be useful both for the disease surveillance and to work on TB determinants.

Table 1. Distribution of the new cases of tuberculosis according to gender, age group, schooling, clinical form, and case conclusion, Crato, CE, 2002 to 2011.

Variables	n	%
Gender		
Male	167	64.0
Female	94	36.0
Age group (years)		
0 – 9	4	1.5
10 – 19	17	6.5
20 – 39	101	38.7
40 – 59	91	34.9
60 or older	48	18.4
Schooling		
None	25	9.6
Incomplete elementary school	154	59.0
Complete elementary school	15	5.7
Incomplete high school	13	5.0
Complete high school	4	1.5
Incomplete higher education	3	1.1
Complete higher education	8	3.1
Ignored	12	4.6
Does not apply	4	1.5
Unfulfilled data	23	8.8
Clinical form		
Pulmonary	209	80.1
Extrapulmonary	48	18.4
Pulmonary + extrapulmonary	4	1.5
Case conclusion		
Cure	201	77.0
Abandonment	33	12.6
Death*	12	4.5
Transfer	7	2.7
Change in diagnosis	8	3.1

\*Death by tuberculosis + death by other causes.

Source: Ministry of Health. Notifiable Diseases Information System (SINAN/CE).

Figure 2 presents the map with the density of cases by the Kernel method, and it is possible to observe that the “hot” areas were concentrated in the vicinities of the central region of the map. Besides, the gradient of colors shows that the further from the center of the map, the lower the concentration of cases. The maximum area of concentration

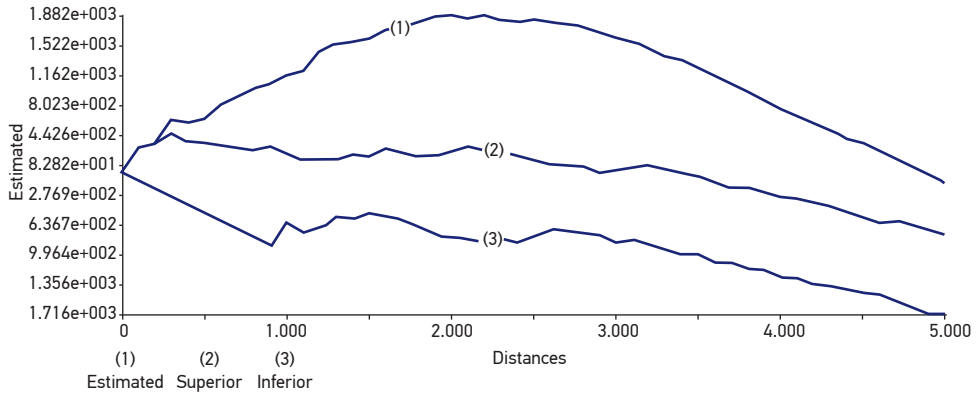


Figure 1. K-function with simulation for new cases of tuberculosis from 2002 to 2011, in the urban zone of Crato, CE.

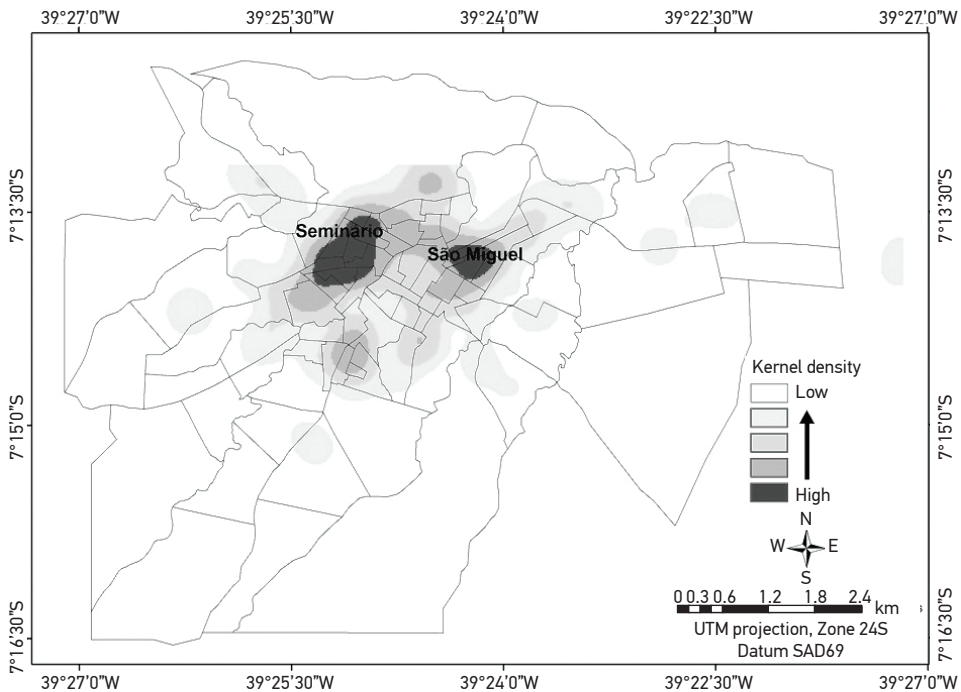


Figure 2. Kernel density in cases of tuberculosis in the urban zone of Crato, CE, 2002 to 2011.

is located in the central-northeast and central-northwest regions, that is, neighborhoods São Miguel and Seminário, respectively. Intermediate density was identified in TB cases in the census sectors composing the neighborhoods Parque Recreio, Vila Alta, Centro, Pinto Madeira, Alto da Penha, Pimenta, and Novo Crato. Low density was found especially in neighborhoods Gizélia Pinheiro, São Gonçalo, Lameiro, Granjeiro, Coqueiro, Lobo, Barro Branco, São José, Muriti, and São Bento.

## DISCUSSION

The profile of patients identified in the study is not different from that found in other analyses conducted in Brazil<sup>10-12</sup>. The national incidence by gender in 2012 showed that approximately twice as many men (48.8 / 100 thousand inhabitants) had TB in comparison to women (23.1 / 100 thousand inhabitants)<sup>4</sup>.

Despite the space earned by women throughout the years, in some societies and families men are still the only or the main providers of the house, which could lead to the higher exposure to *Mycobacterium tuberculosis* outside the household (industries, fairs, commerce, construction sites). This fact would also lead to late diagnosis, once primary care and medium complexity services have restricted working hours, which are the same as the working hours of these individuals. So, they do not look for care for fear of losing their job, in case they miss or arrive late due to the disease<sup>13-15</sup>. Even though most cases and deaths caused by TB occur among men, the disease load among women is also high. In 2012, the global estimation was of 2.9 million new cases and 410 thousand deaths by TB among women<sup>2</sup>.

TB affects the poorer parts of the population; therefore, the fact that people at the economically active age group are becoming sick is worrisome, and influences the socioeconomic condition of the sick person. The disease wears out the strength of the individual, leading this person to progressive malnutrition, debility, and inanition. The person feels weak and unable to perform daily activities, thus generating unemployment and problems given the financial situation of the person and relatives.

The high incidence in this gender and age group is also justified by particular life habits of this group, such as the use of alcohol, smoking, illicit drugs, irregular meal hours, less interest in health self-care, and more exposure to crowds in places of work and leisure<sup>1,16,17</sup>.

TB among the elderly is more common in developed countries<sup>18</sup>. However, a relevant number of people aged 60 years old or more has been identified in our results. This situation can be explained by the growing number of elderly in the country, generated by the increasing life expectancy, which would lead to the development of the disease due to immunological deficiencies caused by aging. Additional factors, such as the difficulty to access health services, confinement in care homes, and delay to look for a doctor for confusing the symptoms of this disease with those of others must also be considered<sup>19</sup>.



The low schooling of the patients may have a negative effect on the acquisition of information, once schooling favors the understanding the knowledge about living with the disease or being sick<sup>1,11,16</sup>. Also, the low schooling could increase the vulnerability to TB by reflecting individual and uneven access to information, goods, and the health service itself, so it works as a marker of the poor life conditions and higher vulnerability to TB.

The sick person who has the pulmonary clinical form, whose sputum bacilloscopy is positive, is considered to be the main source of infection and the main transmitter of the disease. After diagnostic confirmation, the treatment must begin as early as possible, which would reduce the transmission because the positive bacilli, if untreated, can infect around 10 to 15 people in a year<sup>5,20</sup>.

High healing percentages are a consequence of the effectiveness of treatment, working as an indicator of the result of actions to control TB and as a marker for the quality of the service provided, because it translated the fulfillment of the protocol and the level of competence of health teams<sup>21</sup>. The decreasing proportion of healed cases consequently increases the levels of abandonment, thus presenting a direct relationship with the dissemination of the disease and the onset of multiresistant strains<sup>2</sup>.

Mortality also shows the effects of the institutional component, being considered as a good indicator of the efficiency of the work to control the disease and its operation<sup>22</sup>. Characteristics related to the previous treatment, such as abandonment of treatment, multiresistance, and coinfection TB/HIV, have been associated with deaths in cases of TB<sup>23</sup>. A study carried out in 2008 in Recife, Pernambuco, showed that the previous abandonment was a risk factor for the occurrence of death among patients with TB<sup>24</sup>. Therefore, to obtain good results regarding adherence to treatment, the Ministry of Health recommends the sensitization and the formation of professionals to work in the perspective of the directly observed treatment; organization of the flow of patients and one place in the unit to supervise the daily intake of medication; control the absences, household visits, and provision of social incentives for the patients<sup>5</sup>.

It was possible to identify that the space, object of study in geography, was essential in the investigation and understanding of the occurrence and distribution of TB in the groups because data on health and disease have a spatial dimension and can be expressed in this context, in which space is the place of circulation of the infectious agent, which, under specific conditions, causes the disease.

The spatial distribution of new cases of TB showed the presence of different points in the random pattern, and the presence of clusters was confirmed by the L function. These data suggest that, in these regions, there may be a common source of exposure or that individuals living in these locations are more prone to getting sick, and that can be related to the TB health/disease process involving conditions of the geographic space inhabited by the patient, difficulties to access health services, as well as intrinsic and extrinsic factors of the individual.

As aforementioned, the predominant clinical form was the pulmonary one, the transmissible form of the disease and treatment abandonment were high, which may

have contributed to infect individuals living close to these sick people. A study showed that sick people that cough have 11 times more chances to look for care late<sup>25</sup>, that is, for some people, coughing does not mean being sick; so, it leads to the delay in the search for a health service<sup>26</sup>.

The untreated and undiagnosed person with TB also walks around other places in the city, especially the central region, which concentrates activities of exchange and social interaction. It facilitates the transmissibility of the condition to other places other than the household. This fact reinforces the concept of space defended by Santos<sup>27</sup>. For him, it should be a system of objects and actions a set of establishments and flows.

The intense movement of people favors the circulation of the bacillus causing TB, therefore, "hot areas" were identified in the census sectors involving neighborhoods that are close to downtown, as shown in the Kernel density map (Figure 2). The neighborhood Seminário, in the center-northwest region, is one of the most populous ones, and its residents have poor life conditions. São Miguel, located in the central-northeast region, is a commercial neighborhood concentrating supermarkets, colleges, and technical school, so, the flow of people coming of many locations is large.

Crato is located approximately 13 km away from Juazeiro do Norte, which welcomes pilgrims from all over the country, who are often visiting Horto do Padre Cícero. Some of them also visit the Church of Sé, located in the urban center of the city. There are many students, and all of them are considered to be strong agents of disease dispersion. In other studies that analyze the spatial distribution of TB, a concentration of cases was shown close to the central region of the city<sup>12,28</sup>.

The reference service of the city is also located near the analyzed neighborhood, which makes it easier for users living in the region to access the service. However, this access is difficult for those living in the suburbs, where a few cases were notified throughout the 10 years of study. In general, the suburbs are considered to have little infrastructure; these are developing neighborhoods, which are crowded due to irregular occupation of land, precarious settlements, or slums. Most patients who live in these places have lower purchasing power and need transportation to get to the reference service<sup>28</sup>.

Most of the interviewed people with TB, in a study conducted in Ribeirão Preto, São Paulo<sup>29</sup>, looked for public services that were closer to their houses, so there were no costs of care and transportation. In this sense, it is important to reinforce activities regarding the contact with individuals with TB and the active search for respiratory symptomatic patients in the regions indicated in the map with higher concentration of cases, besides other people who attends health services, regardless of motive to do so<sup>5</sup>. The activities of active search must also be conducted, especially in the suburbs of the city, because the results showed there were no cases notified during the period of the study, to understand why no patients appeared in those regions.

The results of this study enabled to assume that the patterns of TB transmissibility are also conditioned by transformations in the space. This is the result of the action of society over nature because its configuration gathers social structure and its dynamics. The geographic

space shows the symbolic dimension of social relations, which express the factors associated with the development and the dissemination of diseases, besides their distribution among the several social groups<sup>30,31</sup>.

Barcellos et al.<sup>7</sup> stated that if the disease is considered to be a manifestation of the individual, then the life conditions are the expression of the place where this person lives because these places are the result of historical, environmental, and social situations that generate particular conditions for the production of diseases. Therefore, the health status can not only be understood in its individual dimension, it should also be contemplated in its social and collective dimension<sup>5,6</sup>.

## CONCLUSIONS

This study enabled to point out areas of higher and lower concentration of TB cases by identifying the spatial pattern, as well as to recognize that the disease did not affect all of the population groups with the same severity. Those who were more vulnerable lived in regions with higher population densities, poor life conditions, and with an intense flow of people.

The methodology used confirmed that the geoprocessing techniques allow visualizing the cases of the diseases distributed by territory, so it is possible to identify vulnerable population groups, besides providing visibility regarding the rates of disease detection per neighborhood and/or region. Therefore, it is possible to contribute with the epidemiological surveillance service.

By assessing the individual characteristics of the patients, it is possible to observe that the sociodemographic profile of people with TB is in accordance with the global and national reality. This is relevant because it identified groups that need more surveillance. It was also possible to assess health care by indicators of cure, abandonment, and death, which make significant contributions for redirecting basic care actions, and generally guide the formulation of public health policies.

It is expected that knowing the distribution of TB cases in an individual and collective level can collaborate with the Tuberculosis Control Program because it makes information available about the spatial pattern of TB and the identification of vulnerable areas; these must be a priority both regarding the need for social improvement and the understanding of the social geographic space and the conduction of concentrated control actions.

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