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Epidemiological indicators and space-time distribution of tuberculosis in an endemic municipality

ABSTRACT | Objective: To describe the epidemiological indicators of tuberculosis and to analyze space-time distribution. Methods: Ecological study, carried out with data from the Grievances Notification Information System. Variables: incidence rate; mortality; clinical form; tuberculosis/HIV co-infection; cure and abandonment. For analysis we used the simple linear regression, Gross incidence rates were softened by the Bayesian Empirical Global and Local Method. Results: A total of 5,529 cases and 319 deaths were studied. The pulmonary form reached 96.2/100 thousand inhabitants, the co-infection tuberculosis/HIV, 10.6/100 thousand inhabitants, the lowest percentage of cure was 69.0% and, the highest percentage of abandonment, 10.9%. Global Bayes indicated an irregular and heterogeneous pattern of the disease and the local Bayes revealed a higher concentration of cases in some regions. Conclusion: Tuberculosis is distributed non-randomly and its control remains a challenge.

Keywords: Tuberculosis; Geographic Information Systems; Spatial Analysis; Epidemiology; Public Health.

RESUMEN | Objetivo: describir los indicadores epidemiológicos de la tuberculosis y analizar distribución espacio-temporal. Métodos: Estudio ecológico, realizado con datos del Sistema de Información de Enfermedades de Notificación. Variables: tasa de incidencia; mortalidad; forma clínica; coinfección por tuberculosis/VIH; curación y abandono. Para el análisis, se utilizó regresión lineal simple. Las tasas brutas de incidencia se suavizaron mediante el Método Bayesiano Empírico Local y Global. Resultados: se estudiaron 5.529 casos y 319 defunciones. La forma pulmonar alcanzó 96,2 / 100 mil habitantes, coinfección tuberculosis / VIH 10,6 / 100 mil habitantes, el menor porcentaje de curación fue 69,0% y el mayor porcentaje de abandono 10,9%. Bayes Global indicó un patrón irregular y heterogéneo de la enfermedad, y Bayes local reveló una mayor concentración de casos en algunas regiones. manera espacial, indican heterogeneidad en la Conclusión: La tuberculosis se distribuye de forma no aleatoria y su control sigue siendo un desafío.

Palabras claves: Tuberculosis; Sistemas de Información Geográfica; Análisis espacial; Epidemiología; Salud pública.

RESUMO | Objetivo: descrever indicadores epidemiológicos da tuberculose e analisar a distribuição espaço-temporal. Métodos: Estudo ecológico, realizado com dados do Sistema de Informação de Agravos de Notificação. Variáveis: taxa de incidência; mortalidade; forma clínica; coinfeção tuberculose/HIV; cura e abandono. Para análise utilizou-se regressão linear simples. As taxas brutas de incidência foram suavizadas pelo Método Bayesiano Empírico Global e Local. Resultados: Foram estudados 5.529 casos e 319 óbitos. A forma pulmonar alcançou 96,2/100 mil habitantes, a coinfeção tuberculose/HIV 10,6/100 mil habitantes, o menor percentual de cura foi 69,0% e, o maior percentual de abandono, 10,9%. O Bayes Global indicou padrão irregular e heterogêneo da doença e, o Bayes local revelou maior concentração de casos em algumas regiões. Conclusão: A tuberculose se distribui de forma não aleatória e seu controle permanece um desafio.

Palavras-chaves: Tuberculose; Sistemas de Informação Geográfica; Análise Espacial; Epidemiologia; Saúde Pública.

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INTRODUCTION

In the dynamics of health services, especially in primary care, actions to control tuberculosis (TB) have been strongly absorbed by nursing, from the reception of the respiratory symptom to the discharge of the person who received the specific treatment. The Ministry of Health considers that it is the nurse's duty to: identify respiratory symptoms, carry out nursing consulta-

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tions, advise on sputum collection, prescribe the basic scheme, notify TB cases, among others.¹

The epidemiological profile of the disease in countries classified as low- and middle-income, with high rates of illness and mortality, are of concern to health authorities, who have systematically been presenting plans and strategies to contain its spread. According to the World Health Organization (WHO), the highest mortality rates from infectious diseases in the world are from TB, above HIV. In 2018, there were 10 million cases of the disease in the world.² Brazil, being a country with an endemic area of the disease, is among the 30 countries with the highest number of cases.²

In 2014, the WHO drafted international TB control guidelines, known as the End TB Strategy, in line with the Millennium Development Goals (MDGs), succeeded by the Sustainable Development Goals (SDGs),^{2,3} which aims to reduce the number of deaths by 95% and the incidence rate by 90% by 2035, 2 in addition to eliminating the disease as an epidemic by 2030.³

In 2019, 73,684 new cases were reported in Brazil, with an incidence rate of 35,0/100.000 inhabitants and a mortality rate of 2,2/100.000 inhabitants.⁴ In the same year, Pará notified 4.459 new cases of the disease, being the state with the highest number of cases in the North region. In the municipality of Belém, there were 1.354 cases and an incidence rate of 90,7/100.000 inhabitants, being the second capital city with the highest mortality rate in the country, 6,0/100.000 inhabitants.⁴

The analysis of epidemiological indicators, together with the resources of the Geographical Information System (GIS), can provide data for a more rigorous assessment and, consequently, a more effective planning that leads to better disease control. Spatial analysis techniques make it possible to represent, through maps, geographic regions at high risk of developing diseases and

allow the search for associations of TB with demographic, epidemiological and environmental factors.⁵ In this sense, this study aims to describe the epidemiological indicators of TB and analyze its spatiotemporal distribution.

METHODS

Epidemiological, ecological study developed with TB data, notified in the service network of the city of Belém in the period from 2013 to 2016. Belém is the priority capital for the control of the disease, with an estimated population for 2019 of 1.492.745 people and demographic density of 1.315,26 inhabitants per square kilometer.⁶ This article is the result of a multicenter project that investigates neglected diseases in different municipalities in Brazil. It is derived from the study that explored tuberculosis associated with living conditions in Belém.⁷

The data come from the Notifiable Diseases Information System (SINAN) and were made available by the Municipal Health Department of Belém (SES-MA). The epidemiological indicators studied were: incidence rate of all forms of TB; extrapulmonary TB incidence rate; incidence rate of bacilliferous pulmonary TB; TB mortality rate; proportion of cured TB cases; proportion of TB cases who dropped out of treatment and TB/HIV ratio. And sociodemographic variables: year of notification; age; sex and education.

As inclusion criteria, all TB cases notified in Health Units in the city of Belém from January 2013 to December 2016 were defined. In possession of the database, a thorough criticism was carried out, not finding inconsistencies in the study variables, consequently no cases were excluded. On that occasion, the variables were organized and grouped using Microsoft Office Excel® 2010.

The analysis process was developed in four stages: in the first, the description of the epidemiological indicators was

made according to the variables: gender; age and education.

In the second stage, the calculation of the incidence and percentage rates of epidemiological indicators of new TB cases notified to SINAN in the period from 2013 to 2016 was carried out, using population data provided by the IBGE, from the 2010 census. The calculations were performed by 100.000 inhabitants. To identify the trend of the studied indicators, simple linear regression analysis was performed, and the adjustment of the regression function was evaluated by the coefficient of determination (R²) considering a significance level of 5%, using the statistical program Bioestat 5.4.

In the third stage, a geographic database (BDGEO - banco de dados geográficos) was built with the notified cases. Therefore, the formatting and spelling correction of the spreadsheet with the addresses of residence was carried out. The vector files of the digital cartographic databases, by meshes from the census sector of the municipality of Belém were obtained from the IBGE website.

Then, the addresses were geocoded in the Universal Transverse Mercator projection (UTM), zone 22, where the municipality of Belém is located, using the batch geocoding site that uses the Google Earth® database called "doogal.co.uk" (<https://www.doogal.co.uk/BatchGeocoding.php>). Geographical analyzes were performed using TerraView 4.2.2 software from the National Institute for Space Research – INPE.

In the fourth stage, the global and local empirical Bayesian model was applied, considering that the calculations of gross rates of small geographic areas are not suitable for performing spatial analysis, as they may be influenced by the fluctuation of calculations due to a small number of cases.

The thematic maps were built using the free software QGIS version 3.14, made available by the Open Source Geospatial Foundation (OSGEO).

This study followed the provisions of Resolution No. 466/12 of the National

Health Council. It began after approval by the Research Ethics Committee of the Undergraduate Nursing Course, on February 15th, 2019, under opinion 3.148.828 and signature of the Term of Authorization for Access to the Database - TAABD (Termo de Autorização de Acesso ao Banco de Dados) by the technician responsible for making the data available at the Health Department of the Municipality of Belém.

RESULTS

In the period from 2013 to 2016, 5.529 new TB cases were registered, with a decreasing trend in the incidence of 2,9 cases/100.000 inhab. each year. As for deaths, there were 319, with a reduction until the year 2015 and a slight increase in 2016 (Table 1).

The profile of the cases studied revealed a predominance of males, with 3.427 (62%) cases and aged 15 to 29

years, with 1.1815 (32,8%) records, followed by 30 to 44 years, with 1.650 (29,8%). Regarding education, 1.728 (30,8%) had incomplete primary education, 1.646 (29,8%) had incomplete or complete secondary education, 357 (6,5%) had incomplete or complete higher education, 339 (6,1%) complete elementary school, 1.282 (23,2%) had ignored schooling and 121 (2,2%) had not.

Regarding the clinical form, the most prevalent was pulmonary TB (4.616 cases/83,5%), especially in 2016, which reached 84,5% of cases, followed by extrapulmonary TB (733 cases/13,2%) and Pulmonary + extrapulmonary TB (180 cases/3,2%). It is noted that in this period, the rates of the extrapulmonary form reduced and those of the pulmonary form increased (Table 2).

With regard to treatment outcomes, 4.150 (75%) cases evolved to cure, with a reduction of 3,0 cases/100 inhab

among the years studied. Treatment dropout records represented 10,3% (571) of the cases reported in the period, with the lowest proportion being 9,7% (134) in 2015 (Table 2).

According to table 3, TB/HIV co-infection cases were unstable over the years, increasing from 2013 to 2015 and decreasing from 2015 to 2016. Co-infection was detected in 588 cases, especially in 2015 which presented an occurrence of 11,6 cases/100 inhab., therefore, higher than the other years.

Figure 1 shows the spatial behavior of TB in the municipality of Belém from the application of the Global Bayesian method, revealing a heterogeneous and irregular pattern of risk for illness. Smoothed rates fluctuated from 1.25 to 6.93 indicating declining variation. The most peripheral neighborhoods such as Jurunas, Guamá, Telegrafo, Sacramento, Barreiro, Miramar, Cabanagem and Chapéu Virado had the highest rates,

Table 1. Proportion of new cases and deaths from TB in the period from 2013 to 2016, in the city of Belém. Belém, PA, Brazil, 2017.

Year	New cases (n)	Death cases (n)	Incidence Coefficient (/100.000 inhab.)	R ² (/100.000 inhab.)	Mortality coefficient (/100.000 inhab.)
2013	1.426	86	100,0		6,0
2014	1.409	82	98,3	2,9	5,7
2015	1.375	74	95,5		5,1
2016	1.319	77	91,2		5,3
Total	5.529	319	96,2		5,5

Source: SINAN/SESMA.

Table 2. Proportion of new TB cases according to clinical form, cured cases and treatment dropout in the period from 2013 to 2016, in the city of Belém (n=5.529). Belém, PA, Brazil, 2017.

Year	2013		2014		2015		2016		Total		R ²
	N	%	N	%	N	%	N	%	N	%	
Clinical Form											
Extra pulmonary	189	13,3	194	13,8	184	13,4	166	12,6	733	13,2	
Pulmonary	1.197	83,9	1167	82,8	1138	82,8	1.114	84,5	4616	83,5	
Pulmonary + Extra	40	2,8	48	3,4	53	3,9	39	3,0	190	3,2	
Treatment Result											
Heal	1.107	77,6	1.112	78,9	1.025	74,5	910	69,0	4.150	75	-3,0
Abandonment	155	10,9	140	9,9	134	9,7	142	10,8	571	10,3	

Source: SINAN/SESMA.

with values between 3.95 and 6.93, the other neighborhoods, mostly, had rates between 2.80 and 3.94. The more central neighborhoods had lower proportions of cases and abnormal clusters, such as: Batista Campos, Nazaré and Reduto.

The distribution of smoothed rates by the Local Bayesian method illustrated in

Figure 2 indicates a variation from 0.00 to 20.0 in the indices. The local index enabled another configuration on the map, different from figure 1, as most of the locations presented lighter tones, meaning lower indexes. Guamá, Cremação, Condor, Jurunas and Miramar had the highest rates, ranging from 10.01 to 20.00. The local Bayesian analysis reve-

aled a higher concentration of cases in some regions, configuring a non-random spatial distribution.

DISCUSSION

The results of the study indicate an annual decrease in the number of TB cases in the city of Belém and a low performance of the program, seen in the proportions of cure and treatment dropout. Cases are randomly distributed across geographic space.

The socioeconomic profile showed a predominance of males, also identified in other studies, which indicates greater vulnerability to the disease, attributed to difficulty in accessing health services, greater exposure to risk factors and impaired self-care.^{8,9}

It was identified greater involvement in young, economically active adults, which may affect family income. This finding corroborates the study¹⁰ which identified, among the risk factors for illness, the work activities of constant contact with the public, as well as extensive workloads. TB remains with a higher incidence in groups with a low level of education, also evidenced in studies that identified an association between level of education and family income, as well as housing conditions, access to information and health services.^{11,12}

The incidence of TB in the city of Belém showed a reduction that can be explained by the early detection of cases, reducing contagion, the increase in preventive actions, or even by underreporting in the records.¹³ However, other analyzes showed an increase in the incidence coefficient in the subsequent years of the study: 2017, 2018 and 2019.⁴

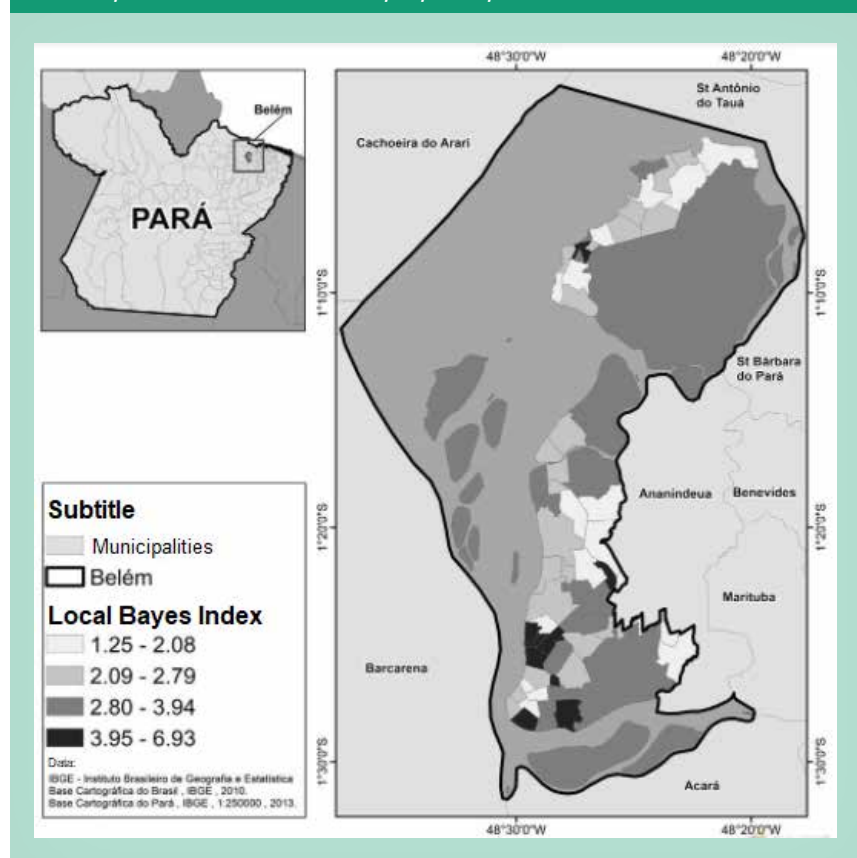
Deaths decreased from 2013 to 2015, and in the last year there was an increase in the mortality rate. A similar study¹⁴ carried out in the state of Pará, in the period 2006-2010, identified 258 deaths from TB, and a lower incidence compared to the present study. Other findings in other regions of the country

Table 3. Proportion of TB/HIV co-infection cases from 2013 to 2016, in the city of Belém. Belém, PA, Brazil, 2020.

Ano	Nº de casos	TB/HIV	Ocorrência TB/HIV
2013	1.426	144	10,1
2014	1.409	154	10,9
2015	1.375	160	11,6
2016	1.319	130	9,9
Total	5.529	588	10,6

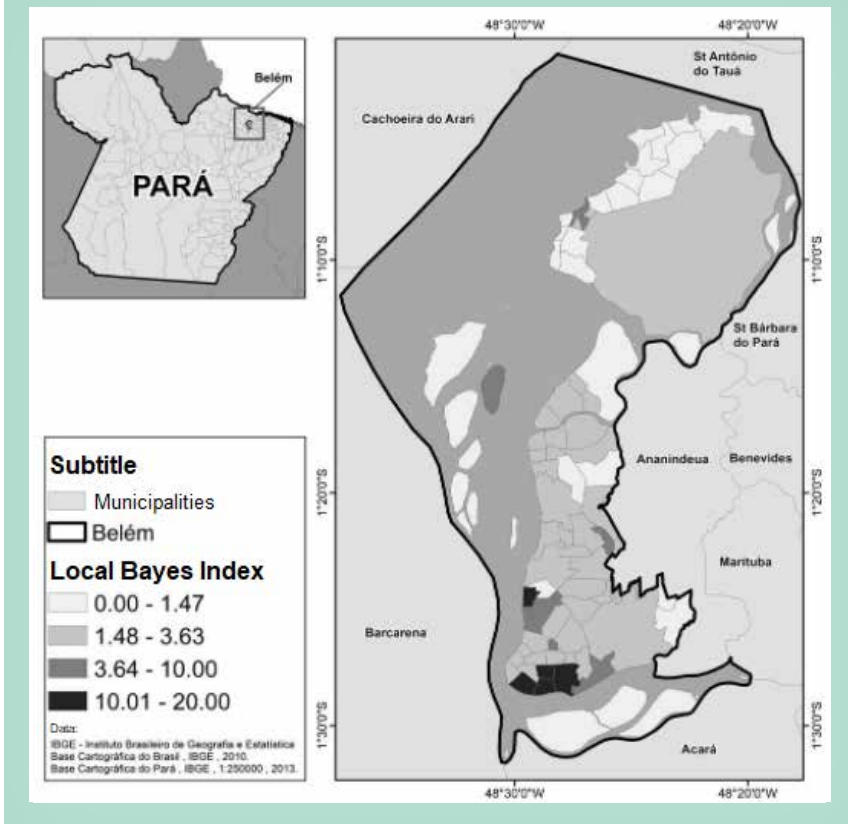
Source: SINAN/SESMA.

Figure 1. Thematic map of the Global Bayes Index of tuberculosis cases in the city of Belém, from 2013 to 2016. Belém, PA, Brazil, 2020.



Source: SINAN/SESMA.

Figure 2. Bayes Estimator Location of tuberculosis cases in the city of Belém, from 2013 to 2016. Belém, PA, Brazil, 2020.



Source: SINAN/SESMA.

and the world also demonstrated this reduction.¹⁵

Among the cases, the pulmonary form reached between 80% and 90%, similar to other studies.^{9,16} Nevertheless, the extrapulmonary form is a concern, especially for public administrators, due to the greater complexity of clarifying the diagnosis, considering that its manifestation may occur in several organs, whose exams are not always available for ready access by the population.^{16,17}

Regarding the result of the treatment, the cure has been reduced in recent years, remaining below 85%, a parameter recommended by the Ministry of Health.⁴ The treatment outcome follows the socioeconomic and behavioral factors of those affected, although men have a greater chance of cure, seek less the health

service. Low education is also associated with difficulty in curing, highlighting that the level of education reflects on the family economy.¹⁸

Among the enhancers for the current epidemiological panorama of TB, the TB/HIV co-infection is identified, whose data showed to be high, with a slight increase in the last year. Studies attribute this pattern to the increase in people living with HIV/AIDS (PLWHA).^{19, 20} To detect the coinfection, it is necessary to test all cases diagnosed with TB, an impaired goal in the evaluation of the program in Belém, which, in 2019, had the fourth worst performance in the Brazilian context, testing only 62,0% of cases, while the country tested 76,2% of diagnosed cases.⁴

The identified data denote weakness in the execution of TB control actions

and, when studied in a spatial way, indicate heterogeneity in the distribution of the disease. Most neighborhoods with a high incidence rate are also the most populous and have the lowest income, confirming results obtained in previous studies.^{7, 21} This is a recurrent scenario in the assessment of disease behavior, in which the highest rates of illness are in more populous cities, affecting mainly people with low education, more socially excluded and belonging to large families.^{8,21,22}

Studies exploring the subject found this dynamic and heterogeneous disease in space.^{14,21,23,24} Strengthening the explanation of the heterogeneous spatialization, a research that analyzed the association of TB with the Adapted Living Conditions Index identified a positive correlation between the disease and population strata in a situation of social exclusion.⁷ In addition, socio-demographic factors enhance this distribution, referring to the need to value access to health services for early detection of cases and more accurate investigations focused on the interruption of transmissibility.^{21,22,23}

TB is an airborne disease, therefore, its occurrence is associated with the proximity of neighboring areas with high rates of the disease.²⁴ The use of the Bayesian method allowed to reduce the variability of data from populations at risk of transmission and made it possible to make more informative maps.

Further studies are needed to identify associations of TB epidemiological indicators with socio-spatial factors, in order to direct interventions in high-risk areas and health practices, especially by nursing, protagonists in the development of control actions.

This study was limited by using secondary data sources, which may have information deficiencies, either due to underreporting of data or inadequate filling, which may have caused possible geocoding losses.

CONCLUSION

TB behaved randomly across neighborhoods, mostly with high Bayesian rates in populous and low-income territories. This scenario, which favors the perpetuation of the disease, points to the need for intersectoral actions that include programs/projects that offer adequate housing, access to income, education and quality health services. Therefore, despite the role of nursing in fighting TB, the reach of impact on epidemiological

and operational indicators depends on joint action between government and civil society.

Thematic maps and static calculations showed relevant aspects for the planning of actions and control of TB. These analyzes indicate that the control of the disease proposed by the PNCT still remains a challenge for epidemiological surveillance and for health care. Therefore, in the TB coping plan, it is essential to contemplate the various aspects responsible for triggering and

maintaining the disease in the social environment, in articulation with the action of health professionals, essentially nursing.

The search for the respiratory symptomatic, the diagnosis and treatment of cases and the monitoring of indicators, which are inherent to the routine in health services, must be combined with the confrontation of social ills and individual needs resulting from social exclusion, present in communities where the illness is more incident. 🌱

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