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Deaths by Tuberculosis in a Priority City for Disease Control in the Brazilian Northeast: Sociodemographic-Operational Characteristics and Vulnerable Territories

ORIGINAL

Marcelino Santos Neto[1], Francisca Bárbara Gomes da Silva[2], Mariana Borges Sodré[2], Mellina Yamamura[3], Floriacy Stabnow Santos[1], Ana Cristina Pereira de Jesus Costa[1], Maria Aparecida Alves de Oliveira Serra[1], Ariadne Siqueira de Araujo Gordon[4], Jaisane Santos Melo Lobato[4], Livia Maia Pascoal[1], Janaína Miranda Bezerra[1], Leonardo Hunaldo dos Santos[1], Hamilton Leandro Pinto de Andrade[4], Iolanda Graepp Fontoura[5], Flávia Menegheti Pieri[6], Ricardo Alexandre Arcêncio[7]

1 Ph.D., Professor in the Nursing Course at the Center of Social Sciences, Health and Technology of the Federal University of Maranhão, Imperatriz, Maranhão, Brazil.
2 Undergraduate Student in the NursingCourse at the Center of Social Sciences, Health and Technology of the Federal University of Maranhão, Imperatriz, Maranhão, Brazil.
3 Postdoctoral fellow, Interunit Doctoral Program of School of Nursing and Ribeirão Preto College of Nursing, University of São Paulo, São Paulo, Brazil.
4 Master, Professor in the Nursing Course at the Center of Social Sciences, Health and Technology of the Federal University of Maranhão, Imperatriz, Maranhão, Brazil.
5 Ph.D. Student in PostgraduateProgram in Health Sciencesat the Federal University of Maranhão, São Luís, Maranhão, Brazil.
6 Ph.D., Professor in the Department of Nursing at theState University of Londrina, Londrina, Paraná, Brazil.
7 Ph.D., Professor in the Ribeirão Preto College of Nursing, University of São Paulo, São Paulo, Brazil.

Contact information:

Marcelino Santos Neto.

Address: Rua Urbano Santos, s/n Centro, Imperatriz, Maranhão, Brazil.
CEP 65.900-410.
Tel/Fax: (+55) (99) 98137-3510

marcelinosn@gmail.com

Abstract

Background: Incorporating spatial approaches into epidemiological research is a challenge in public health research. The goal in this study was to analyze the spatial distribution of cases of deaths by tuberculosis in Imperatriz – MA (Brazil) and to characterize these events according to sociodemographic and operational characteristics.

Methods and Findings: In this ecological study, all deaths from tuberculosis as the primary causeregistered in the Mortality Information System from 2005 to 2014 were considered. The research variables were subject to descriptive analysis, point density analysis (Kernel Intensity Estimation) and area analysis.

Fifty cases of deaths by TB were identified, particularly the pulmonary clinical form. Male patients were predominant, with a median age of 59 years, mulatto race/color, single, who had finished secondary education. Most deaths happened at the hospital, with medical care before death and without autopsy. Most events happened at the hospital, with medical care delivery by an assistant physician and without autopsy. The point density revealed heterogeneity in the spatial distribution of the deaths, with rates of up to 2.33 deaths/km^2. The

area analysis by census sector presented age standardized mortality rates of 0.00 to 4.00 deaths/100,000 inhabitants-year. As limitations, we highlight the occurrence of underreporting of deaths due to the disease and gaps in filling out the records.

Conclusion: The results contributed to the knowledge on the spatial distribution of cases of deaths by Tuberculosis and their characteristics in the research scenario. The importance of space is highlighted as a methodological alternative to support the planning, monitoring and assessment of health actions, targeting interventions to the control of the disease in vulnerable territories.

Keywords
Tuberculosis; Health Information Systems; Mortality; Spatial Analysis.

Introduction

Tuberculosis (TB) is considered one of the eldest infectious diseases in the history of mankind and, although effectively treatable, it remains an important global public health problem, due to its wide geographical dispersion, emergence of multiple drug resistant cases and HIVco-infection [1]. Internationally, the World Health Organization (WHO) appoints that 22 countries concentrate about 80.0% of TB cases and Brazil is part of this group, ranking 16th in absolute case numbers; India, China and South Africa, in turn, are the countries with the highest disease burden [2].

According to Ministry of Health [3], TB demonstrates a direct relation with poverty and is associated with social exclusion and the marginalization of part of the population submitted to bad living conditions, such as precarious housing, malnutrition and difficulties to access public services and goods. The noteworthy and continuing influence of the living conditions in the transmission process of TB has highlighted a profound picture of socioeconomic inequalities that result in social inequities in health [1].

Health surveillance is an important model for the territorial monitoring of the health situation; that is so because it is in the geographical space where people produce and reproduce socially that the needs and health problems should be captured and the intervention priorities should be defined [4]. The integration of health surveillance and care, information and action should be considered the target of best practices in health care, so that TB surveillance is truly capable of knowing and identifying the cases, hospitalizations and deaths and their locations, in order to guide the control actions with a view to interrupting the transmission chain and assessing the result of these actions [5].

In that perspective, geoprocessing, a set of collection, treatment and exhibition techniques of geographically referenced information, serves as a tool to visualize health events on maps [6], associated with statistical methods to analyze spatial data. This makes it an important field of epidemiological research on the role of space in the production and dissemination of diseases [7].

Studies inherent in TB mortality have been encouraged as they are considered an important tool for the detection of health system errors [8]. The investigation of this problem permits outlining the profile of TB, monitoring the individual in different disease situations besides permitting additional analyses on

case surveillance and patient care [9]. In addition, it is important to emphasize that TB figures on the list of avoidable causes of death. If appropriate health promotion, protection and recovery actions were established for the individuals and families through local health systems, these events would not take place [10].

Through a literature review in indexed databases, such as the*Medical Literature Analysis and Retrieval System on-line* (MEDLINE), *Latin-American Literature in Health Sciences* (LILACS) and*Scientific Electronic Library Online* (SCIELO), few studies published in Brazil were found that specifically address the mortality by TB [1, 11, 12,13, 14, 15]. None of these studies discussed the scenario of Imperatriz-MA, one of the 181 priority cities in Brazil for TB control and one of the eight priority cities in the state [3].

In that sense, it is important to use spatialization equipment, through the geoprocessing technique, in combination with a comprehensive view of the health-disease process, to identify contexts of vulnerabilities to TB in the city under investigation, and act not only in the clinical and biological spheres, but also on the social determinants of health-disease [7].

In view of the relevance of equipping managers and workers in the areas most affected by TB, evidencing the regions with inequitable access, the goal was the analyze the spatial distribution of deaths by the disease in the city of Imperatriz – MA between 2005 and 2014, as well as to characterize these events according to sociodemographic and operational characteristics.

Methods

Study design and scenario

An ecological, descriptive and exploratory study was undertaken in Imperatriz-Ma, in the Brazilian Northeast **(Figure 1)**, with an estimated population

Figure 1: Map of Brazil, highlighting the state of Maranhão and the city of Imperatriz.

Source: Adapted from geographical bases [16].

of 252,320 inhabitants, a territory of 1,368.98 km^2 and 102 health establishments registered in the Unified Health System (SUS). The city is located at 626 km from the state capital São Luís and is the second largest population, economic, political and cultural hub in Maranhão, with only 23% of sewage network and 86% of tap water and 9.7% of illiteracy [16].

Population, data collection and selection criteria

The study population consisted of all deaths from tuberculosis as primary cause registered in the Mortality Information System (SIM) from 2005 to 2014. The International Disease Classification (ICD) covered all clinical forms of TB in codes A15.0 to A19.9. The SIM is the Brazilian national information system, which provides epidemiological and clinical

information on the cases of deaths [17]. The data were collected in July 2015 through the SIM of the Health Surveillance System of the Municipal Health Department (SEMUS) in Imperatriz.

Data analysis

The research variables for this study were obtained from the death certificate (DC) used in Brazil and included sociodemographic characteristics like age, sex, race/color, marital status, education and occupation, besides operational variables like the place of death, medical care, autopsy, basic cause and physician responsible for the death certificate. To analyze these data, the quantitative parameters were subject to descriptive analysis, calculating the average, median and standard deviation for the age variable and absolute and relative frequencies for the categorical variables.

After the consistency analysis of the collected data, these were converted for use in IBM SPSS, where the variables and analyses were recategorized. What the age variable is concerned, the individuals who evolved to death were categorized based on the median age, and were therefore classified as superior or inferior to the obtained median.

To analyze the spatial distribution of the deaths by TB, the cartographic base for the city of Imperatriz was used, purchased from the company Imagem/Esri. Initially, for the geocoding, the individual addresses where deaths by TB happened in the urban and rural regions of the city were standardized and matched with the cartographic base in projection UTM/WGS84, available with the extension.*shp* (Shapefile).

Next, using the software TerraView version 4.2.2, the actual geocoding took place, which corresponds to the linear interpolation of the full address to one point in the corresponding address segment, permitting the elaboration of event points. Thus, the geocoding of the data involved a process of associating the tabular data that did not present an explicit spatial reference in the case of TB deaths, transporting them to a map (cartographic base of the city) previously incorporated in a Geographic Information System (GIS) environment [18].

In view of the occurrence of non-geocoded cases, as a complement, the tool Batch Geocode (available in http://batchgeo.com/br/) was used to register deaths not located in the cartographic base, which looks for the address coordinates on Google Earth.

The research team visited the homes where the deaths took place to obtain the geographic coordinates of these events using the GPS, for the addresses that were not located in the address/street arrangement database and using the Batch Geocode tool. These geocoding procedures were adopted in view of the possibility for spatial geo-referencing of the largest number of events (deaths), followed by the spatial analysis. Next, the geocoded cases were spatially distributed in the respective census sectors of the city that were considered as ecological analysis units in this study.

It should be mentioned that Kernel estimation is very useful to provide a general view on the distribution of the sampling points, as well as an indication of clusters, suggesting spatial dependence [18]. Therefore, the point density analysis technique was applied, defined as Kernel estimation, which consists in exploratory interpolation, producing a density surface for the identification and visualization of hot spots [19], in this case areas with higher densities of deaths by TB, that is, areas that are potentially more vulnerable to the presence of this event.

In addition, the spatial analysis per area was performed [19], using the census sectors of the city as the spatial analysis units with a view to obtaining the age standardized mortality rates by TB (*TMTBi*) for each census sector in the analysis period. The direct standardization of rates is important to compare health indicators on a more realistic base. It is indicated in case of the unwanted unequal distribution of a given characteristic in two or more populations [20]. After the standardization, the compari-

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sons were made under equal conditions, respecting the controlled variable.

Thus, the age standardized mortality rates by TB were calculated per census sector and for the research period, dividing, respectively, the sum of the standardized deaths by the standard population in the middle of the period (urban population of Imperatriz) for each census sector multiplied by 100,000 and finally divided by 10, related to the years of study, as evidenced below:

$$TMTBi = \left(\frac{\Sigma\ age\ standardized\ deaths}{\Sigma\ standard\ population} x\ 100{,}000\right) / 10$$

This procedure was processed in the software ArcGis version 10.1, which consists of a software package by ESRI® (Environmental Systems Research-Institute) that permits the elaboration and manipulation of vector and matrix information for the use and management of thematic bases [21]. Finally, the thematic map of the distribution of mortality rates by TB was obtained, grouped in quintiles.

All information was managed and the thematic maps were elaborated in *ArcGis version 10.1*.

Ethical aspects

In compliance with the premises of Resolution 466/2012, the research project was submitted to the Ethics Committee for Research Involving Human Beings at Universidade Federal do Maranhão. Approval was obtained under opinion 1.140.668, issued on 06/29/2015.

Results

Between 2005 and 2014, 50 deaths by TB were registered in Imperatriz – MA, 37 (74.0%) of which refer to Pulmonary Tuberculosis (PTB) and 13 (26.0%) to Extrapulmonary Tuberculosis (ETB). Among the basic causes registered under PTB, 30 (60.0%) were registered as PTB without bacteriological or histological confirmation (ICD A16.2); 3 (6.0%) PTB without bacteriological or histological examination (ICD A16.1); one (2.0%) PTB with confirmation by unspecified means (ICD A15.3); and, finally, three (6.0%) PTBwith confirmation by sputum microscopy with or without culture (ICD A15.0) **(Table 1)**.

Table 1. Basic causes of deaths due to tuberculosis. Imperatriz - MA (2005-2014).

ICD 10 Code	Definition	n	%
Basic cause			
A15.0	Tuberculosis of lung, confirmed by sputum microscopy with or without culture	03	6.0
A15.3	Tuberculosis of lung, confirmed by unspecified means	01	2.0
A16.1	Tuberculosis of lung, bacteriological and histological examination not done	03	6.0
A16.2	Tuberculosis of lung, without mention of bacteriological or histological confirmation	30	60.0
A16.5	Tuberculous pleurisy, without mention of bacteriological or histological confirmation	01	2.0
A16.9	Respiratory tuberculosis unspecified, without mention of bacteriological or histological confirmation.	10	20.0
A18.3	Tuberculosis of intestines, peritoneum and mesenteric glands	01	2.0
A19.9	Miliary tuberculosis, unspecified	01	2.0
Total		50	100.0

Obs: ICD: International Classification of Diseases

The mean age of the individuals who died of TB in the research period was 54.6 years, standard deviation (SD) 19.97, while the median was 59 years. The youngest patient was 22 and the eldest 93 years.

Table 2 presents the sociodemographic and operational characteristics of the people who evolved to death by TB in Imperatriz-MA. The results were ranked in decreasing order according to the response category. For the research period, most deaths referred to men (n= 31; 62.0%), mulatto (n=33; 66.0%), single (n= 26; 52.0%). The predominant education level was finished secondary education (n=18; 36.0%) and retired individuals or pensioners

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Table 2. Sociodemographic and operational characteristics of deaths by tuberculosis. Imperatriz - MA (2005 till 2014)

Variables	N	%
Age		
≤ 59 years	25	50.0
> 59 years	25	50.0
Sex		
Male	31	62.0
Female	19	38.0
Race/color		
Mulatto	33	66.0
White	11	22.0
Black	05	10.0
Yellow	01	2.0
Marital Status		
Single	26	52.0
Married	12	24.0
Widowed	10	20.0
Fixed Partner	02	4.0
Education		
Secondary education	18	36.0
5th to 8th grade	13	26.0
1st to 4th grade	10	20.0
Unfinished higher	05	10.0
No education	02	4.0
Finished higher	01	2.0
Unknown	01	2.0
Occupation		
Retired/Pensioner	15	30.0
Maintenance	09	20.0
Agricultural worker	09	20.0
Housewife	05	10.0
Trader	03	6.0
Driver	02	4.0
Unknown	02	4.0
Teacher	01	2.0
Craftsman	01	2.0
Fisherman	01	2.0
Prospector	01	2.0
Student	01	2.0
Place of Death		
Hospital	40	80.0
Home	10	20.0
Medical Care		
Yes	40	80.0
No	09	18.0
Unknown	01	2.0
Autopsy		
No	48	96.0
Yes	01	2.0
Unknown	01	2.0
Death certified by physician		
Assistant	21	42.0
Substitute	14	28.0
SVO[a]	12	24.0
IML[b]	01	2.0
Unknown	02	4.0
Total	50	100.0

Obs.: [a]: SVO: Death Surveillance Service; [b]: IML: Institute of Forensic Medicine.

stood out in terms of occupation (n=15; 30.0%). As for the operational indicators, most deaths happened at the hospital, (n=40; 80.0%) and received medical care before they died (n=40; 80.0%). In most cases, the assistant physician was responsible for the registers (n=21; 42.0%). In addition, the absolute majority of the deaths (n= 48; 96.0%) were not submitted to autopsy, one (2.0%) was submitted to autopsy and this information was unknown in the death certificate for one (2.0%) individual.

The standardization procedure to geocode the cases of TB deaths led to the successful geo-referencing of 47 cases (94.00%). Three cases (6.00%) were excluded due to address inconsistencies, as they were impossible to identify even with the help of tools, such as *Batchgeo* Find Latitude and Longitude (Batch Geocode) and *in loco* visits to collect the coordinates.

Considering the distribution of deaths per census sectors in the city under analysis, the absolute majority happened in the urban area (about 98%), while only one case was geocoded in the rural area.

Figure 2 reveals the application result of the Kernel technique to identify the point density. For this purpose, the map of all census sectors in the city

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Figure 2: Density of deaths by tuberculosis, Imperatriz - MA (2005 till 2014).

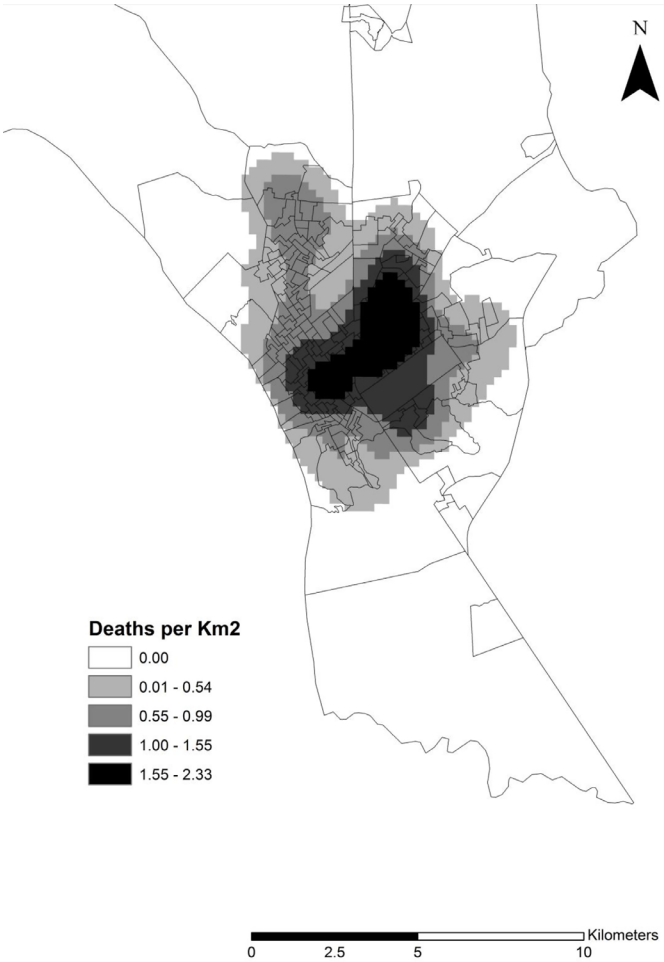
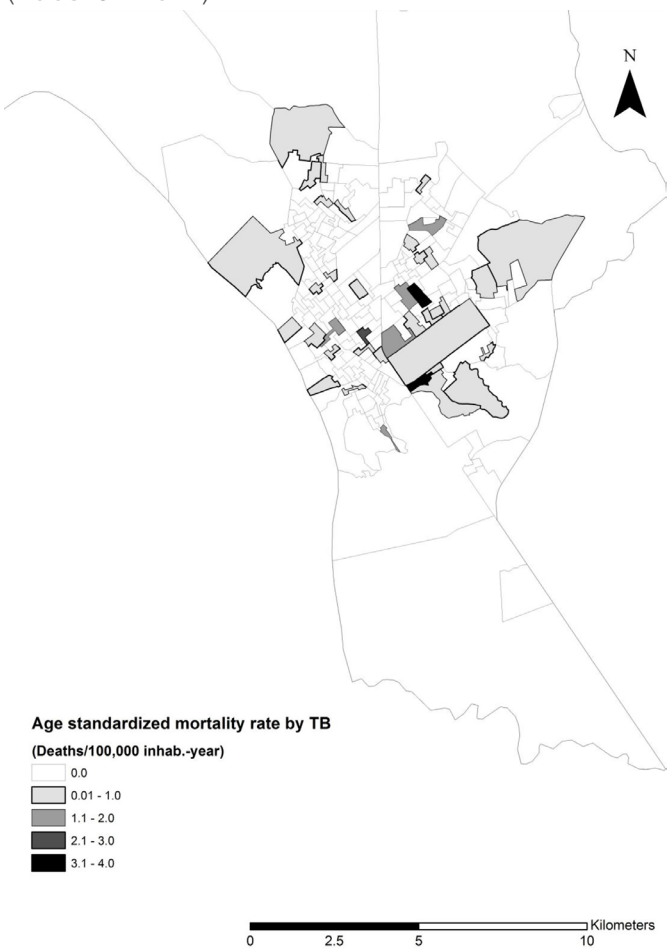


Figure 3: Mortality rates by tuberculosis standardized by age (deaths/100,000 inhabitants-year) according to census sectors, Imperatriz - MA (2005 till 2014)



was used, published by the IBGE, in accordance with data from the 2010 Census. The places with the highest density of deaths per square kilometer (km²), also known as "hot spots", are highlighted in black. In addition, a heterogeneous distribution with possible clusters can be evidenced, mainly concentrated in the central region towards the south of the city, where the neighborhoods with the largest number of TB deaths were recorded.

The spatial analysis by area **(Figure 3)** demonstrates the distribution of the *TMTBi* according to census sectors, with rates ranging between 0.00 and 4.00 deaths/100,000 inhabitants-year, confirming the heterogeneous distribution evidenced in the analysis of hot spots (Kernel).

Discussion

The analysis of the main sociodemographic characteristics described for the study population revealed the predominance of mulatto, adult men with low education level. These results are in line with the Brazilian standard of TB in distinct scenarios and with studies developed in other regions of the country [11, 12, 14].

TB more frequently affects men than women in all age ranges. This factcan be explained by the different exposure to risk factors among men, such as alcoholism, alcohol abuse, illegal drugs abuse and greater prevalence of HIV infection [22], although

these variables were not explored in this research. Without a biological explanation to justify this difference, it is reasonable to admit that this fact can be due to cultural differences in role performance among the sexes, which includes, among others, men's limited visit of health services [1,5].

In terms of race/color, the results are equivalent to the study undertaken in Campo Grande [23], São Luís [11] and other priority cities in Mato Grosso do Sul [24] for TB control, indicating that most deaths involved mulatto individuals, in line with the morbidity problem in the country [25,26] and different from studies developed in the state of São Paulo [12,13] where the white race/color prevailed.

What the age is concerned, the same proportion of deaths by TB was evidenced in individuals over and under 59 years of age, therefore emphasizing results found in studies developed in Brazil, in cities like in the state of São Paulo and Salvador [13, 14, 27].

In this research, it was also observed that the marital status that stood out among the cases of death was single, in line with studies developed in the city of São Luís, in the states of Minas Gerais and Rio de Janeiro [8, 11, 12, 23].

The education and occupation data found in this research differed from some studies [11, 13, 23, 24, 28] that report the inexistence or low level of education and lack of income among the patients who died.

Specifically for occupation, financially lessprivileged people face a greater probability of developing the disease [11,13,23,24] but, in Imperatriz,death mainly affected people who had finished secondary education and were mainly retired or pensioners, evidencing the vulnerability of elderly people to this problematic illness [26].

It should also be highlighted that, according to Silva et al [29], education significantly influenced the individuals' access to knowledge and ability to understand. Therefore, it is emphasized that the predominantly low education level in the TB patients reflects a set of unfavorable socioeconomic conditions that increase the vulnerability and are responsible for the higher incidence of this disease, besides contributing to lack of treatment compliance and the increase of treatment abandonment and, consequently, of avoidable hospitalizations and unacceptable deaths from the perspective of social justice [11, 30].

What the operational characteristics are concerned, about 80.0% of the deaths analyzed happened inside hospitals. This situation is similar to Brazilian studies undertaken in the states of Rio de Janeiro [8], São Paulo-SP [13], Mato Grosso do Sul [24], Ribeirão Preto - SP [12] and in the city of São Luís-MA [11] with records of 80.0% or higher. A population-based cohort in Brazil and in Latin America, China and India [31] also revealed that most deaths happened in hospitals.

Perrechi and Ribeiro [32] appoint that, although diagnosing TB is relatively simple, most cases are still diagnosed in hospitals, representing high costs for the health system and sequelae for the patients [33].

It should be highlighted that the evolution to death of patients hospitalized by TB suggests difficulties of Primary Health Care (PHC) in management, in the supply of diagnostic resources or in case management and in the referral system to other health services [34]. Another factor that helps to explain this result is treatment abandonment, which predicts the development of multiple drug resistance (MDR) and, thus, hospitalizations [35].

In that sense, it is relevant to restructure and strengthen the TB control actions, prioritizing the sputum microscopy and rapid molecular test for the diagnosis, control and monitoring of the disease, as well as the improvement of the records and the Health Information Systems (HIS) [26].

As for the operational variable medical care, 80.0% of the deaths received that care, in line with other studies [11, 12] in which most deaths also received medical care before death.

With regard to the confirmation of TB by means of an autopsy, it was observed that this examination was not performed in 96.0%, acknowledging that the lack of confirmation of the death by TBthrough an autopsy expresses exactly the weakness and insufficiency of the health service systems to reduce the social inequities in health, as evidenced Curtis [36], who emphasized the TB Geography dimension "use and access to health services". In that sense, the need for restructuring is fundamental, as well as the strengthening of TB control actions in Primary Health Care.

What the geocoding of the cases is concerned, the percentage (94%) is considered excellent when working with addressing in a database, in accordance with Davis Jr and Alencar [37]. Those authors affirm that the use of addresses in the location of points of interest is routinely used and widely known, especially in cities. Therefore, addresses are usually included as attributes in conventional information systems.

In that sense, it is relevant to emphasize that one limitation in the geocoding was the incompleteness of the data informed in the SIM, mainly in the address registers. The quality of health information is fundamental to apprehend the reality, monitor diseases and problems distributed across the territory. Therefore, it is a necessary instrument to encourage strategies and the elaboration of public policies in the three governmental spheres [38].

In addition, the behavior of TB, like other endemic conditions, is strongly influenced by the midst. It can be evidenced that the association between TB and precarious socioeconomic conditions dates back to the origins of this disease's epidemiology, therefore underlining the need for research and intervention, taking into account its spatial distribution [11].

In that line of reasoning, the spatial distribution of deaths by TB, particularly the heterogeneous distribution observed in the city of Imperatriz, should be considered the starting point for a research and surveillance process, which can trigger a focus on problem areas and the identification of weak links in the health care system for the target population.

The point density map visually appoints the locations most vulnerable to the occurrence of deaths by TB per km^2, spatially indicating the so-called "hot spots", which permits evidencing inequalities among events, in this case deaths, in geographical areas of the city.

The areas with the highest density of deaths per km^2 were found in census sectors located in the neighborhoods of*Bacuri, Santa Rita, Parque Alvorada, Centro, Parque Anhanguera, Vila Cafeteira, Vila Lobão, Jardim* São *Luís, Nova Imperatriz* and *Parque Santa Lúcia*, which are also areas classified as precarious in terms of housing conditions and residence quality, mainly concerning the urban agglomeratio [39]. The urban growth of Imperatriz without preliminary planning resulted in areas that are considered subnormal, lacking public and mostly essential services [40].

The occurrence of deaths by TB in the city under analysis also experiences the social scenario cited in Curtis [36] concerning these areas of greater social inequity. The spatial analysis per area revealed the *TMTBi* distribution according to census sectors, ranging from 0.00 to 4.00 deaths/100,000 inhabitants-year, confirming the heterogeneous distribution evidenced in the analysis of the hot spots (Kernel).

Census sectors in the urban region of the city that obtained *TMTBi* superior to three deaths/100,000 inhabitants are considered areas that demand special attention from health services, with a view to the intensification of disease control actions, considering that these rates exceed the Brazilian and state rates, which corresponded to 2.4 and 2.9 deaths/100,000 inhabitants, respectively, in 2014 [41].

In that sense, it should be mentioned that the largest number of deaths by TB among the poorest regions from the social perspective implies and

justifies the intensification of activities linked to the search for patients with respiratory symptoms with a view to early case detection, treatment and the achievement of cure. In addition, the enhanced social inequality in Brazil, observed in the access to health resources, in education, income distribution, basic sanitation and other elements of the populations' standard of life favor divergences in the risk of illness and, consequently, of death in the different social groups [22].

Concerning health problems requiring reporting, like in the case of TB, using data available in the HIS permits monitoring the problem, contributes to the identification of relevant aspects and encourages the search for new interventions to control the disease [11, 34]. Thus, the data collected from the SIM revealed the dynamics and behavior of TB in the city of Imperatriz – MA.

It should be mentioned that the SIM, as an information source to study deaths in a certain region, comes with some weaknesses. One of them is the underreporting in the country [24, 26]. The gaps in the completion of the registers are also highlighted, which provides relevant information for management and planning in health. In that perspective, improving the quality of the records in terms of completing the gaps and updating the data from the HIS are fundamental for the sake of reliable epidemiological analysis [11].

Despite the limitations, this research offers potential, highlighting its originality, as no other studies were found in which the spatial distribution of deaths by TB was assessed in the research scenario. In addition, the study can support managers and health workers in the planning of health actions,surveillance and control of TB cases in the affected territories.

Finally, these research results undoubtedly contributed to the knowledge on the spatial distribution of TB in the city, underlining the importance of the space category as a methodological alternative to support the planning, monitoring and assessment of health actions, guiding interventions to control the disease in vulnerable territories.

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Competing and Conflicting interest

The authors declare that they have no competing interest.

Abbreviations

TB: Tuberculosis; WHO - World Health Organization SIM: Mortality Information System; ICD-10: International Disease Classification version 10; TMTBi: Deaths Rate from Tuberculosis standardized by age; IBGE: Brazilian Institute of Geography and Statistics; SVO: Death Surveillance Service; IML: Institute of Forensic Medicine

References

1. San Pedro A, Oliveira RM. Tuberculose e indicadores socioeconômicos: revisão sistemática da literatura. Rev Panam Salud Pública. 2013; 33:294-01.
2. World Health Organization (WHO). Global tuberculosis report 2015 [internet].. Geneva: WHO; 2015. 192p [cited 2017 Jan 16]. Available from: http://apps.who.int/iris/bitstream/10665/191102/1/9789241565059_eng.pdf
3. Ministério da Saúde (BR). Secretaria de Vigilância em Saúde. Departamento de Vigilância das Doenças Transmissíveis. Panorama da tuberculose no Brasil: indicadores epidemiológicos e operacionais. Brasília (DF): Ministério da Saúde; 2014. 92p.
4. Hino P, Santos CB, Villa TCS, Bertolozzi MR, Takahashi RF. Controle da tuberculose na perspectiva da vigilância da saúde. Esc Anna Nery. 2011; 15 (2):417-21.

5. Theme Filha MM, Daumas RP, Alves LC, Leimann BCQ, Engstrom EM. Análise da tuberculose em uma unidade de Atenção Primária à Saúde na cidade do Rio de Janeiro: perfil clínico, resultado de tratamento e qualidade dos registros. Cad Saúde Colet. 2012; 20 (2):169-76.
6. Santos CB, Hino P, Cunha TN, Villa TCS, Muniz JN. Utilização de um sistema de informação geográfica para descrição dos casos de tuberculose. Boletim de Pneumologia Sanitária. 2004; 12 (1):5-10.
7. Araujo KMFA, Figueiredo TMRM, Gomes LCF, Pinto ML, Silva TC, Bertolozzi MR. Evolução da distribuição espacial dos casos novos de tuberculose no município de Patos (PB), 2001-2010. Cadernos Saúde Coletiva. 2013; 21 (3):296-02.
8. Selig L, Belo M, Cunha AJLA. Óbitos atribuídos à tuberculose no Estado do Rio de Janeiro. J Bras Pneumol. 2004; 30:417-24.
9. Sousa LMO, Pinheiro RS. Óbitos e internações por tuberculose não notificados no município do Rio de Janeiro. Revista de Saúde Pública. 2011; 45 (1):31-9.
10. Malta DC, França E, Abreu DX, Oliveira H, Monteiro RA, Sardinha LMV, et al. Atualização da lista de causas de mortes evitáveis (5 a 74 anos de idade) por intervenções do Sistema Único de Saúde do Brasil. Epidemiologia e Serviços de Saúde. 2011; 20 (3):409-12.
11. Santos Neto M, Yamamura M, Garcia MCC, Popolin MP, Silveira TRS, Arcêncio RA. Análise espacial dos óbitos por tuberculose pulmonar em São Luís (MA). J Bras Pneumol 2014; 40:543-51.
12. Yamamura M, Santos Neto M, Santos RAN, Garcia MCC, Nogueira JA, Arcêncio RA. Características epidemiológicas dos casos de óbito por tuberculose e territórios vulneráveis. Rev. Latino-Am. Enfermagem. 2015; 23 (5):910-18.
13. Lindoso AAB, Waldman EA, Komatsu NK, Figueiredo SM, Taniguchi M, Rodrigues LC. Perfil de pacientes que evoluem para óbito por tuberculose no município de São Paulo, 2002. Cadernos de Saúde Pública. 2008; 42 (5):805-12.
14. Mota FF, Vieira da Silva LG, Paim JS, Costa MCN. Distribuição espacial da mortalidade por tuberculose em Salvador, Bahia, Brasil. Cad. Saúde Pública. 2003; 19 (4):915-22.
15. Vicentin G, Santo AH, Carvalho MS. Mortalidade por tuberculose e indicadores sociais no municíp io do Rio de Janeiro. Ciência& Saúde Coletiva. 2002; 7 (2):253-63.
16. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo demográfico 2010: resultados gerais da amostra. Rio de Janeiro: IBGE, 2012. p. 51. [cited 2016 Dez 21] Available from: ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010/Resultados_Gerais_da_Amostra/resultados_gerais_amostra.pdf.
17. Rocha MS, Oliveira GP, Aguiar FP, Saraceni V, Pinheiro RP. Do que morrem os pacientes com tuberculose: causas múltiplas de morte de uma coorte de casos notificados e uma proposta de investigação de causas presumíveis. Cad. Saúde Pública. 2015; 31 (4): 709-21.
18. Câmara G, Monteiro AMV, Druck S, Carvalho MS. In: Análise espacial e geoprocessamento. Planaltina: EMBRAPA, 2004.
19. Carvalho MS, Câmara G. Análise espacial de áreas. In: Análise de eventos pontuais e de área. Planaltina: EMBRAPA, 2004.
20. Medronho RA, Carvalho DM, Block KV, Roner LB, Werneck V, Guilherme L. Epidemiologia. São Paulo: Editora Atheneu; 2006.
21. Andrade FR. Ocorrência da dengue em Santana de Parnaíba e relação com medidas de controle. [Especialização em Saúde Pública]. Faculdade de Saúde Pública da Universidade de São Paulo; 2012.
22. Hino P, Takahashi RF, Bertolozzi MR, Egry EY. A ocorrência da tuberculose em um distrito administrativo do município de São Paulo. Esc Anna Nery. 2013; 17 (1):153-59.
23. Espindola LCD. Estudo da mortalidade por tuberculose em Campo Grande - MS, 2001 a 2008 [dissertation]. Campo Grande: Escola Nacional de Saúde Pública; 2010.
24. Larroque MM. Mortalidade por tuberculose em municípios prioritários do estado de Mato Grosso do Sul, 1999-2008 [dissertation]. Campo Grande: Universidade Federal do Mato Grosso do Sul; 2011.
25. Ministério da Saúde (BR). Secretaria de Vigilância em Saúde. Departamento de Vigilância Epidemiológica. Manual de Recomendações para o Controle da Tuberculose no Brasil. Brasília (DF): Ministério da Saúde; 2011. 284p.
26. Oliveira GP, Torrens AW, Bartholomay P, Barreira D. Tuberculosis in Brazil: last ten years analysis 2001-2010. Brazilian Society of Infectious Diseases. 2013; 17 (2):218-33.
27. Oliveira HB, Marín-León L, Cardoso J C. Perfil de mortalidade de pacientes com tuberculose relacionada à comorbidade tuberculose-Aids. Rev Saúde Pública. 2004; 38 (4):503-10.
28. Augusto CJ, Carvalho WS, Gonçalves AD, Ceccato MGB; Miranda SS. Características da tuberculose no estado de Minas Gerais entre 2002 e 2009. Jornal Brasileiro de Pneumologia. 2013; 39 (3):357-64.
29. Silva CCAV, Andrade MS, Cardoso MD. Fatores associados ao abandono do tratamento de tuberculose em indivíduos acompanhados em unidades de saúde de referência na cidade do Recife, Estado de Pernambuco, Brasil, entre 2005 e 2010. Epidemiol. Serv. Saúde. 2013; 22 (1):77-85.
30. Oliveira GP, Pinheiro RS, Coeli CM, Barreira D, Codenotti SB. Uso do sistema de informação sobre mortalidade para identificar subnotificação de casos de tuberculose no Brasil. Rev Bras Epidemiol. 2012; 15:468-77
31. Ferri CP, Acosta D, Guerra M, Huang Y, Llibre-Rodriguez JJ, Salas S et al. Socioeconomic Factors and All Cause and Cause-Specific Mortality among Older People in Latin America, India, and China: A Population-Based Cohort Study. PLOS Medicine. 2012; 9 (2):114-22.
32. Perrechi MCT, Ribeiro SA. Tratamento de tuberculose: integração entre assistênci a hosp italar e rede básica na cidade de São Paulo. Jornal Brasileiro de Pneumologia. 2009; 35 (11):1100-06.

33. Lönnroth K, Castro KG, Chakaya JM, Chauhan LS, Floyd K, Glaziou P et al. Tuberculosis control and elimination 2010-50: cure, care,and social development. The Lancet, 2010; 375:1814-29.
34. Selig L, Kritski AL, Cascão AM, Braga JU, Trajman A, Carvalho RMG. Proposta de vigilância de óbitos por tuberculose em sistemas de informação. Revista de Saúde Pública. 2010; 44 (6):1072-78.
35. Kayigamba FR , Bakker MI, Mugisha V, De Naeyer L, Gasana M, Frank Cobelens et al. Adherence to Tuberculosis Treatment, Sputum Smear Conversion and Mortality: A Retrospective Cohort Study in 48 Rwandan Clinics. PLOS Medicine. 2013; 8 (9):112-19.
36. Curtis S. Health and Inequality: Geographical Perspectives. London: Sage Publications; 2009.
37. Davis Jr CA, Alencar RO. Evaluation of the quality of an online geocoding resource in the context of a large Brazilian city. Transactions in GIS. 2011; 15 (6): 851-68.
38. Medeiros D, Sucupira ED, Guedes RM, Costa AJL. Análise da qualidade das informações sobre tuberculose no município de Belford Roxo, Rio de Janeiro, 2006 a 2008. Cad. Saúde Coletiva. 2012; 20 (2):146-52.
39. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo demográfico 2010: resultados do universo por setor censitário [internet]. Rio de Janeiro: IBGE, 2010.[cited 2017 Jan 16]Available from: http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default_resultados_universo.shtm
40. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo demográfico 2010:aglomerados subnormais [internet]. Rio de Janeiro: IBGE, 2010. [cited 2017 Jan 16]Available from: http://www.ibge.gov.br/home/estatistica/populacao/censo2010/aglomerados_subnormais_informacoes_territoriais/default_informacoes_territoriais.shtm.
41. Ministério da Saúde (BR). Secretaria Executiva. Departamento de Informática do SUS (DATASUS) [internet]. 2017. [cited 2017 Jan 16] Available from: http://datasus.saude.gov.br