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Trend of tuberculosis in Brazilian indigenous people in the 2011-2017 period

Thaís Furtado Ferreira (https://orcid.org/0000-0003-3841-2919) [1]
Alcione Miranda dos Santos (https://orcid.org/0000-0001-9711-0182) [1]
Bruno Luciano Carneiro Alves de Oliveira (https://orcid.org/0000-0001-8053-7972) [1]
Arlene de Jesus Mendes Caldas (https://orcid.org/0000-0001-7087-8781) [2]

Abstract *This paper aims to analyze the trend of tuberculosis (TB) in Brazilian indigenous people from 2011 to 2017. This ecological study was carried out with all new TB cases in indigenous people reported in the Notifiable Diseases Information System during the 2011-2017 period. Thematic maps were prepared to monitor the spatial-temporal evolution of TB in the indigenous population each year, and the Prais-Winsten generalized linear regression model was used to analyze the trend. A total of 6,520 TB cases were reported in indigenous people during the study period. The overall incidence of TB in Brazilian indigenous people for the period was 109/100,000 inhabitants. In the analysis by region of the country, the highest incidence occurred in the Midwest, North, and Southeast regions. In the UF analysis, the highest incidence was found in Mato Grosso, São Paulo, Rondônia, Mato Grosso do Sul, Acre, Maranhão, Pará, and Rio de Janeiro. The trend of the disease in the indigenous was stable both in the country and in most of its regions and UFs. TB disproportionately affects Brazilian indigenous people, and this study can contribute to the elaboration and strengthening of more specific control actions by identifying priority regions and UFs.*

Key words *Tuberculosis, Health of indigenous people, Time series studies*

[1] Departamento de Saúde Pública, Universidade Federal do Maranhão (UFMA). Av. dos Portugueses 1966, Vila Bacanga. 65080-805 São Luís MA Brasil. tatafurtadof@hotmail.com
[2] Departamento de Enfermagem, UFMA. São Luís MA Brasil.

Introduction

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis*, and, although it is curable when appropriate treatment is implemented, it is still a serious global public health problem. In 2017, 10 million people became ill with TB worldwide. Of these, 1.3 million died due to complications of the disease[1]. A total of 69,569 new TB cases were reported in Brazil in 2017. That same year, the incidence rate was 33.5/100 thousand inhabitants. In 2016, 4,426 TB deaths were recorded, resulting in a mortality rate of 2.1/100 thousand inhabitants[2].

In all, 370 million indigenous people are estimated globally, distributed in more than 70 countries[3]. According to the UN, indigenous people are those who count on a historical continuity of societies before the invasion and colonization occurred in their territories and consider themselves distinct from other sectors of society. They are determined to preserve, develop, and transmit to future generations their ancestral territories and ethnic identity, as the basis of their continued existence as people, as per their cultural standards, social institutions, and legal systems[4].

Indigenous people in high-, middle- or low-income countries have a high and disproportionate TB incidence, but this burden varies widely between groups and regions[3]. The most recent studies suggest that the indigenous groups that fall ill from TB the most are located in small Latin American regions, followed by tribes in India and Africa, and the groups that fall ill the least live in high per capita income countries[3].

Latin America is known to be home to 34 million indigenous people organized in 450 groups[5]. According to data from the last demographic census[6], the Brazilian indigenous population consists of 817,963 thousand people who declared themselves indigenous, representing 0.4% of the total Brazilian population. Indigenous people are distributed throughout the country, mostly in the North (48.6%), Northeast (20.4%), and Midwest (19.1%), followed by the Southeast (8.1%) and South (3.7%).

High TB rates were found in indigenous peoples across Latin America, especially in Brazilian Amazonian groups, with an incidence many times greater than 1,000/100,000 inhabitants or at least 20 times greater than the incidence in the overall Brazilian population[7-13]. Such studies reveal that indigenous people are disproportionately affected by TB vis-à-vis other ethnicities/skin colors, but it is still unclear which factors explain such discrepancies.

In Brazil, epidemiological studies of this nature are still incipient, with data referring to the 1997-2009 period and limited to indigenous groups in the Amazon region, despite their presence throughout the national territory.

Given the above, this study aims to analyze TB's trend among Brazilian indigenous people in the 2011-2017 period.

Methods

This is an ecological study of TB time series in indigenous people in Brazil during the 2011-2017 period. All new TB cases in indigenous people reported in the Notifiable Diseases Information System of the Brazilian Ministry of Health (SINAN) were selected.

The self-referred "indigenous" at the time of notification of the disease were considered indigenous for the study. Cases without information or classified as unknown in the ethnicity/skin color field were not included in the study.

The TB incidence coefficients were calculated, where: TB incidence in indigenous people = number of TB cases in indigenous people/ indigenous population x 100,000. The 1.1% annual growth rate was employed to calculate the population variation in each period, which is the geometric mean annual growth rate of the indigenous population of the 1990-2010 Demographic Censuses[6].

The TB incidence rates among indigenous people were standardized by the direct method to allow adequate analysis and comparison between regions and federative units (UF), considering the Brazilian population in 2010 as the standard. TB incidence in the indigenous people was assessed concerning the age group (<1 year, 1-4 years, 5-9 years, 10-14 years, 15-19 years, 20-39 years, 40-59 years, 60-64 years, 65-69 years, 70-79 years and ≥ 80 years) and gender (male and female).

Thematic maps of the distribution of TB incidence were made for each year to monitor the spatial-temporal evolution of TB in the indigenous population, using the QGis® Program version 3.2.3.

The generalized linear regression model by Prais-Winsten was used to study the trend of TB in Brazilian indigenous people since it takes into account the serial autocorrelation, that is, the dependence of a serial measure with its values at different previous times[14]. This procedure

allowed the evaluation of variations as increasing, decreasing, or stable, from the analysis of the growth measure and the level of significance ($p<0.05$). The total variation was calculated as the proportional difference between the 2011 and 2017 incidence values. The incidence and trend calculations were performed using the Stata® Program version 14.0 using three units of analysis: Brazil, its regions, and the federative units (UF).

This study was approved on April 27, 2017, by the Research Ethics Committee of the Federal University of Maranhão, and by the National Research Ethics Committee on June 6, 2017, as per requirements of Resolution N° 466/2012 of the National Health Council, which regulates Human Research, and Resolution N° 304/2000, which regulates the rules for Indigenous People research[15].

Results

A total of 608,701 TB cases were reported in Brazil during the 2011-2017 period, with 554,551 cases in other ethnicities/skin color (91.1%), and 6,520 cases in indigenous people (1.1%). A total of 47,630 cases (7.8%) were excluded from the study due to the impossibility of defining ethnicity/skin color. The annual mean was 931.4 cases of TB in indigenous people.

The mean TB incidence in Brazil for indigenous people in the studied period was 109/100,000 indigenous inhabitants. The highest incidence was observed in 2011 (120.2/100,000 indigenous inhabitants), and the lowest in 2014 (101.5/100,000 indigenous inhabitants). In the analysis by region, higher incidence rates were observed in the Midwest (202.5 ± 38.3), North (124.9 ± 11.1), and Southeast (121.8 ± 38.8) regions. In the analysis by UF, the highest levels of incidence were found in Mato Grosso (303.6 ± 146.0), São Paulo (202.0 ± 79.5), Rondônia (201.5 ± 65.3), Mato Grosso do Sul (191.4 ± 49.9), Acre (172.3 ± 36.2), Maranhão (168.1 ± 17.9), Pará (165.5 ± 38.0) and Rio de Janeiro (152.1 ± 37.6) (Table 1).

Thematic maps describe the behavior of incidence rates in the UFs over the period studied. Thus, in most UFs, incidence varied irregularly over time. However, in Rondônia and Roraima, despite the high incidence rates, a declining trend was observed over the period studied. On the other hand, in Mato Grosso, we observed that the 2014-2016 triennium showed significantly increased incidence rates than the 2011-2013 triennium, with a decreased incidence in 2017. Also noteworthy is Pará, which showed higher levels of the incidence in the 2015-2017 triennium, especially in 2017 (Figure 1).

The general trend of TB among Brazilian indigenous people was stable during the study period. However, in the regional analysis, all regions showed a stable trend, except the Southeast region, which evidenced a decreasing trend with a variation rate of -12.30% (Table 2).

Concerning UFs, Rondônia, Piauí, Sergipe, Bahia, Rio de Janeiro, and São Paulo showed decreasing trends, with the most significant falls in Piauí (-38.48%), São Paulo (-14.20%) and Rondônia (-13.24%), and the other UFs had stable trends. Only Maranhão showed an increasing trend (+ 3.33%) (Table 2).

Discussion

Analyzing TB among Brazilian indigenous people is a significant challenge due to its territorial extension. Thus, we analyzed our data using three units of analysis (Brazil, its regions, and the UFs), which allowed a better observation of the studied event by reducing the units of analysis. This study showed the relevance and high incidence of TB in the Brazilian indigenous population, with higher concentrations in the Midwest, North and Southeast regions, and a stable disease trend in the country and most of its regions and UFs.

As a limitation, data may have been underestimated by underreporting TB cases in SINAN and 7.8% of losses due to failures in completing the ethnicity/skin color field of the notification forms. It is noteworthy that the inclusion of the ethnicity/skin color field in the Ministry of Health databases following the IBGE standard is recent, and this field is still frequently not valued when completing the notification forms, which hinders the analysis of the TB cases by ethnicity.

However, we have advanced in this direction. In the study by Sidon[11], also carried out with data from SINAN, the ethnicity/skin color field was not completed for more than half of TB cases. At the time, classification errors were common since the interviewer determined the ethnicity/skin color. This issue seems to have been solved with the modification to the self-referred classification from the 2010 Census, which also contributed to the higher completion rates of the field.

As other limitations, the calculation of the indigenous population for the inter-census periods

Table 1. Incidence* of tuberculosis in indigenous people in Brazil, their regions, and UF in the 2011-2017 period. Brazil, 2018.

Variables	Mean	Standard Deviation	Minimum	Maximum
Brazil	109.0	6.5	101.5	120.2
North	124.9	11.1	112.8	145.7
Rondônia	201.5	65.3	136.2	282.0
Acre	172.3	36.2	108.7	208.0
Amazonas	120.1	16.5	101.6	148.3
Roraima	77.5	14.4	58.8	102.4
Pará	165.5	38.0	118.6	218.2
Amapá	66.8	40.7	25.6	134.7
Tocantins	140.9	65.4	84.2	282.4
Northeast	60.3	6.1	54.5	71.9
Maranhão	168.1	17.9	132.3	189.4
Piauí	54.9	86.0	0.0	238.3
Ceará	87.7	30.7	55.9	137.0
Rio Grande do Norte	146.6	72.6	51.4	242.1
Paraíba	36.0	27.4	13.2	90.7
Pernambuco	32.1	14.7	7.9	47.4
Alagoas	38.8	12.8	17.8	53.1
Sergipe	26.4	13.8	12.3	49.0
Bahia	37.4	7.6	26.5	46.8
Midwest	202.5	38.3	160.1	257.6
Mato Grosso do Sul	191.4	49.9	144.4	291.0
Mato Grosso	303.6	146.0	176.8	561.9
Goiás	21.6	12.7	0.0	38.9
Distrito Federal	12.0	16.3	0.0	44.7
Southeast	121.8	38.8	77.7	187.5
Minas Gerais	28.8	7.6	17.1	39.7
Espírito Santo	27.6	17.7	8.6	64.7
Rio de Janeiro	152.1	37.6	113.3	212.9
São Paulo	202.0	79.5	114.1	344.5
South	53.9	8.9	47.2	73.3
Paraná	35.0	10.2	16.5	51.6
Santa Catarina	38.3	13.1	16.9	61.2
Rio Grande do Sul	77.3	21.1	59.0	120.5

* Standardized by the direct method according to gender and age.

did not take into account that the growth occurs unevenly in the Brazilian regions and also depends on the location of the household, whether in urban or rural areas. The mean growth rate of the indigenous population living in an urban area is -1.9%, while for residents in rural areas, it is +3.7%[6]. For this study, the mean growth rate of 1.1% was adopted[6].

This study's strength is the possibility of updating the TB scenario in the indigenous population since the latest studies date from the period between 1997-2009. This is also a national study and not only limited to the Amazon region, allowing health authorities to establish priorities and, thus, guide resources and interventions for indigenous people.

TB has been distributed heterogeneously in Brazil for both indigenous people and the general population. In 2017, the incidence coefficient in the general population ranged from 9.5/100,000 inhabitants (Tocantins) to 74.1/100,000 inhabitants (Amazonas), and the highest incidence rates were in Amazonas, Rio de Janeiro, and Pernambuco[2]. On the other hand, we find variations

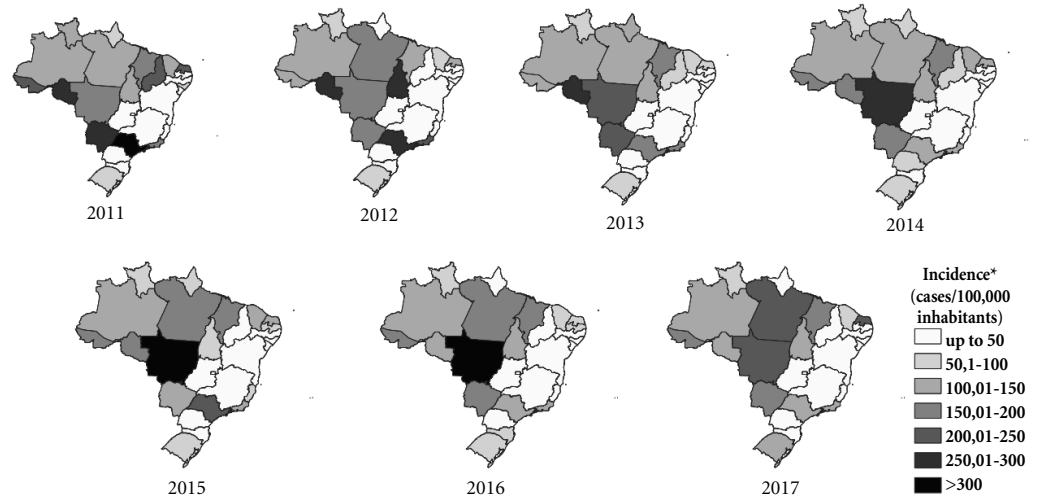

Figure 1. Spatial-temporal distribution of tuberculosis among indigenous people in Brazil in the period 2011-2017. Brazil, 2018.

* Standardized by the direct method

of 12/100,000 inhabitants in indigenous people (Federal District) to 303.6/100,000 inhabitants (Mato Grosso), and the highest UF incidence rates were found in Mato Grosso, São Paulo, Rondônia, Mato Grosso do Sul, Acre, Maranhão, Pará, and Rio de Janeiro.

Studies by Sidon[11] and Melo et al.[16], both carried out in Rondônia, also found a far superior TB incidence in indigenous people than in people of other ethnicities/skin colors. The incidence coefficients were 415-515/100,000 inhabitants in the two studies among indigenous people and 35.5-36/100,000 inhabitants in other ethnicities/skin colors. In Rio Grande do Sul, indigenous people also had higher incidences than in other ethnicities/skin colors, calling attention to the increased incidence in the 2008-2012 period (61.7/100,000) compared to the 2003-2005 period (31.2/100,000)[17].

Regarding the disease trend, in the last 10 years, the TB incidence coefficient in the general population declined from 39/100,000 inhabitants (2008) to 33.5/100,000 inhabitants (2017), with an annual drop of 1.6%[2]. In the indigenous population, we found a different trend pattern, remaining stable in most regions and UFs.

The stability of TB among indigenous people amid a scenario of a decrease in this problem in the general population allows us to believe that specific risk factors for the indigenous population must be investigated, or that general TB control actions have not yet effectively reached this population.

The cultural diversity of the Brazilian indigenous people, consisting of 305 ethnic groups distributed in all UFs in the country, who speak 274 languages, reaffirms the country's multicultural identity and is a challenge for the development and implementation of public and differentiated policies[18].

The challenges of indigenous health are diverse. Among them are the problematic access to Brazilian indigenous communities and lack of local infrastructure and resources, contributing to discontinuous health actions[19].

Faced with this problem, since 2012, the National TB Control Program has acted in strengthening specific control actions for the indigenous population, such as monitoring and evaluation visits in priority states and municipalities, scaled-up control actions in the Indigenous Health Districts, offer of TB Rapid Molecular Tests, and greater adherence to Directly Observed Treatment (DOT)[20].

Despite the difficulties mentioned above, in 2012, 71.7% of new TB cases in indigenous peo-

Table 2. Tendency of tuberculosis in indigenous people in Brazil in the period 2011-2017. Brazil, 2018.

Variables	Coefficient	p-value	Tendency	Variation rate
Brazil	-.0043	0.190	Stable	-------
North	-.0012	0.799	Stable	-------
Rondônia	-.0617	0.002	Decreasing	-13.24
Acre	.0215	0.173	Stable	-------
Amazonas	.0132	0.175	Stable	-------
Roraima	-.0130	0.085	Stable	-------
Pará	.0242	0.230	Stable	-------
Amapá	.0705	0.135	Stable	-------
Tocantins	.0350	0.223	Stable	-------
Northeast	-.0093	0.111	Stable	-------
Maranhão	.0142	0.008	Increasing	3.33
Piauí	-.2110	0.031	Decreasing	-38.48
Ceará	-.0001	0.997	Stable	-------
Rio Grande do Norte	-.0309	0.277	Stable	-------
Paraíba	.0678	0.109	Stable	-------
Pernambuco	-.0792	0.102	Stable	-------
Alagoas	.0076	0.742	Stable	-------
Sergipe	-.0478	0.041	Decreasing	-10.43
Bahia	-.0348	0.007	Decreasing	-7.71
Midwest	.0113	0.411	Stable	-------
Mato Grosso do Sul	-.0317	0.089	Stable	-------
Mato Grosso	.0444	0.263	Stable	-------
Goiás	.0205	0.172	Stable	-------
Distrito Federal	-.0199	0.901	Stable	-------
Southeast	-.0570	0.002	Decreasing	-12.30
Minas Gerais	.0048	0.836	Stable	-------
Espírito Santo	-.0444	0.394	Stable	-------
Rio de Janeiro	-.0449	0.002	Decreasing	-9.82
São Paulo	-.0665	0.006	Decreasing	-14.20
South	.0170	0.087	Stable	-------
Paraná	.0186	0.392	Stable	-------
Santa Catarina	.0222	0.523	Stable	-------
Rio Grande do Sul	.0114	0.368	Stable	-------

ple underwent DOT. The ideal would be 100% coverage. However, this percentage is almost double that of the general population and is an essential operational indicator to evaluate the treatment of TB in the indigenous people[21].

However, the study by Nogueira et al.[22] identified essential gaps in the therapeutic itinerary of an indigenous group in Pará concerning the active search for respiratory symptoms, monitoring of cases treated for TB, and control of contacts. The study also highlights the failure to perform DOT in villages, with patients with suspected TB promptly referred to the Indigenous Health Support Houses, where they are confined until the end of treatment.

Thus, the control actions aimed at the indigenous population must be in line with the general population's actions since we are talking about an infectious disease. In 2012, the Brazilian Network of TB Control Committees, distributed in 13 UFs in the country, was created to develop communication, advocacy, and social mobilization actions for TB control based on the demands and individual characteristics of each location[2]. On the other hand, there are no such committees in UFs in the Midwest region and most UFs in the North region, which may be contributing to the high incidence of the disease in these regions.

It is also necessary to highlight the difficulties related to the transculturation process that re-

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quire greater sensitization of the teams working in indigenous communities, to balance the care of health professionals with traditional belief systems and healing practices[19].

Greater incorporation of biomedical practices in the context of TB treatment in indigenous communities is observed despite traditional indigenous medicine's predominance. However, such health systems have not acted exclusively but complementarily in solving health problems[22]. In some indigenous communities, the decision on the type of treatment (whether based on beliefs or biomedical) is dependent on the "origin of the disease", which in the indigenous viewpoint may be spiritual or due to contact with non-indigenous people[23].

Thematic maps show that there has been a change in the TB pattern among indigenous people over time. When comparing the 2017 map with that of 2011, in general, we see an improved TB scenario for indigenous people, except for the State of Pará.

As of 2013, Rondônia, São Paulo, Rio de Janeiro, and Mato Grosso do Sul had the highest incidence levels of the disease. However, in 2014, we observed a declining incidence in these UFs and a significant hike in Mato Grosso until 2016. The high demographic density in the UFs in Rio de Janeiro and São Paulo may have contributed to the high incidence of TB in the indigenous people in the Southeast region, but does not seem to be the determining factor. Their vulnerability to TB may be because they are a minority in these spaces.

The relationship between health-disease and racial minorities can be the result of social inequalities/racial discrimination and biological and genetic factors. Racial discrimination can have a significant impact on individuals, besides being a trigger for diseases[24].

However, there has been a decline in the indigenous population, mainly in the UFs of São Paulo and Rio de Janeiro, and a higher return to rural areas, which can be seen by the more significant growth of the indigenous population residing in rural areas compared to the urban one. Such a phenomenon, called ethnogenesis or re-ethnicization, may be related to favoring migration back to the original lands[6].

Unfortunately, the return migration to the lands of origin seems to have only spatially shifted the TB problem in the indigenous peoples from the Southeast to the Midwest and North, which can be explained by the negligible impact of existing social and health policies on the living and health conditions of the Brazilian indigenous population. The Ministry of Social Development informs that more than 80% of indigenous families receive the *Bolsa Família* (Family Grant) benefits, and almost 40% live in extreme poverty, showing their vulnerability[25].

Thus, it is urgent to recognize that isolated actions in the health sector are not enough to affect TB control in the indigenous population, and the construction of intersectoral interventions[26] is necessary.

Thus, it is concluded that TB in Brazil disproportionately affects indigenous people, and the trend of the disease is stable in most regions and Brazilian UFs. Thus, identifying the priority regions and UFs, we can contribute to the elaboration and strengthening of more specific control actions and their social protection measures.

Collaborations

TF Ferreira: Worked on the conception, design, analysis, and interpretation of data, and drafting the paper. AM Santos: Worked on the conception, design, and analysis and interpretation of data. AJM Caldas: Worked on the conception, design, critical review of the paper, and approval of the final version. BLCA Oliveira: Worked on data analysis and interpretation, critical review of the article and approval of the version to be published.

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