

Spatial distribution of tuberculosis in indigenous and non-indigenous populations in the state of Pará, Brazil, 2005-2013

Distribuição espacial de tuberculose nas populações indígenas e não indígenas do estado do Pará, Brasil, 2005-2013

Distribución espacial de la tuberculosis en indígenas y no indígenas del estado de Pará, Brasil, 2005-2013

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ABSTRACT

Objective: To analyze the incidence of tuberculosis in indigenous and non-indigenous residents in the state of Pará from 2005-2013. **Method:** An ecological study was performed with data from SINAN, stratified for the 13 existing Regional Health Centers in Pará. The tuberculosis incidence rates were calculated for indigenous and non-indigenous populations in the 13 regions and maps were prepared to visualize the magnitude of the occurrence of tuberculosis. **Results:** Significant differences in the incidence of tuberculosis were found among non-indigenous and indigenous populations, reaching 7,812/100,000 inhabitants and 118/100,000 inhabitants respectively. **Conclusion:** Tuberculosis was distributed heterogeneously among the indigenous and non-indigenous populations. Moreover, it was possible to identify areas with high risk for this disease. It is important to note that knowledge about priority areas for tuberculosis control can help health service management to improve indicators that assess this disease and to develop different policies for indigenous peoples.

Keywords: Tuberculosis; Indigenous Population; Spatial Analysis.

RESUMO

Objetivo: Analisar a ocorrência de tuberculose nas populações indígenas e não indígenas residentes no estado do Pará entre 2005-2013. **Método:** Estudo ecológico realizado a partir de dados do SINAN, estratificados para os 13 Centros Regionais de Saúde existentes no Pará. Foram calculadas taxas de incidência de tuberculose para indígenas e não indígenas nas 13 regiões e confeccionados mapas para visualização da magnitude da ocorrência de tuberculose. **Resultados:** Encontraram-se diferenças marcantes na incidência de tuberculose entre população indígena e não indígena, alcançando 7.812/100 mil habitantes e 118/100 mil habitantes, respectivamente. **Conclusão:** Observou-se que a tuberculose se distribuiu heterogeneamente entre a população indígena e não indígena, sendo possível identificar regiões com alto risco de adoecimento. É importante ressaltar que o conhecimento de regiões prioritárias para o controle de tuberculose, pode auxiliar a gestão dos serviços de saúde para melhores indicadores que avaliam a doença, bem como desenvolver políticas diferenciadas para os povos indígenas.

Palavras-chave: Tuberculose; População Indígena; Análise Espacial.

RESUMEN

Objetivo: Analizar la incidencia de la tuberculosis en los residentes indígenas y no indígenas en el estado de Pará entre 2004-2013. **Método:** Estudio ecológico partir de datos del SINAN, estratificado para los 13 Centros Regionales de Salud existentes en Pará. Se calcularon las tasas de incidencia de tuberculosis en indígenas y no indígenas en las 13 regiones, y se confeccionaron los mapas para visualizar la magnitud de la incidencia de la tuberculosis. **Resultados:** Se encontró diferencias significativas en la incidencia de la tuberculosis entre la población no indígena y indígena, llegando a 7.812/100 mil habitantes y 118/100 mil habitantes. **Conclusión:** Se observó que la tuberculosis presenta una distribución heterogénea entre la población indígena y no indígena, y se pudo identificar las zonas con alto riesgo de la enfermedad. Es importante tener en cuenta que el conocimiento de las áreas prioritarias para el control de la tuberculosis puede ayudar a la gestión de los servicios de salud, para mejorar los índices que evalúan la enfermedad y desarrollar diferentes políticas para los pueblos indígenas.

Palabras clave: Tuberculosis; Población Indígena; Análisis Espacial.

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INTRODUCTION

Tuberculosis (TB) is a relevant endemic disease that affects indigenous populations.¹ According to the *Programa Nacional de Controle da Tuberculose* (PNCT - Brazilian Program on Tuberculosis Control), this group is considered to be vulnerable to such disease.² Scientific evidence³⁻⁵ indicates that the incidence of TB is high in these populations, reaching rates^{3-6,7} that are ten times higher than those found in the general Brazilian population.

A total of 9.6 million new cases of tuberculosis were estimated in 2014. Worldwide, 1.5 million individuals died of this disease.⁸ According to the 2015 Epidemiological Bulletin,⁹ the TB incidence rate for the general population was 44.4/100,000 inhabitants in Northern Brazil and 39.2/100,000 inhabitants in the state of Pará, higher than the Brazilian mean of 33.5/100,000 inhabitants.

Although representing only 0.4% of the Brazilian population¹⁰ in 2014, nearly 1.1% of all new cases of TB were reported for this segment of the population in Brazil.⁹

In the context of indigenous populations being infected with TB, it should be noted that there is insufficient knowledge about the epidemiological profile of these populations, due to vulnerabilities in the data record system for mortality and morbidity, among others.¹¹ These vulnerabilities are associated with incomplete data and possible underreporting, as a result of the geographical characteristics of the spaces where they are produced.

Moreover, in Brazil, these databases originated from the health services provide important information that can be used to support the development of public policies, planning and service management.¹² When analyzed with spatial analysis techniques, such as geoprocessing, they can contribute to increase knowledge about the behavior of a disease in a certain geographical area, aiming to outline appropriate strategies for disease reduction and transmission that prioritize more vulnerable populations, such as indigenous populations.¹³

In the 2010 census,¹⁰ the Brazilian indigenous population totaled nearly 896,917 individuals, of which 342,800 lived in Northern Brazil. In the state of Pará, there were 39,081 indigenous people divided into 30 ethnic groups (Mundurucu, Kaiapó and Parakanã, among others), spread across 298 villages. Indigenous lands covered 24.52% of the total area of this state.¹⁴

Health services caring for indigenous populations are organized according to the Indigenous Health Care Subsystem, which is part of the *Sistema Único de Saúde* (SUS - Unified Health System). Decree number 3156, issued on August 27th 1999, regulated the *Política Nacional de Atenção à Saúde dos Povos Indígenas* (PNASPI - National Policy on Indigenous Health Care) and recommended the implementation of a distinct complementary model of organization of services for indigenous health protection, promotion and recovery.¹⁵

PNASPI operationalization occurs through 34 *Distritos Sanitários Especiais Indígenas* (DSEI - Special Indigenous Health Districts). These DSEI are operational units that seek to

respect the culture, political relations and ancestral indigenous population distribution. Thus, there are specific geographical and technical-operational criteria not coinciding with the territorial boundaries of states and/or cities in which the indigenous lands are located. For this reason, the DSEI are under the responsibility of the federal government and they are associated with the *Secretaria Especial de Atenção à Saúde Indígena* (SESAI - Special Department of Indigenous Health Care).¹⁵ In the state of Pará, this operationalization occurs through the following four DSEI: Altamira; Guamá Tocantins, Kaiapó Pará and Rio Tapajós.¹⁶

The present study aimed to spatially identify and describe the occurrence of tuberculosis in indigenous and non-indigenous populations living in the state of Pará between 2005 and 2013, aiming to contribute to greater disease control, as it indicates regional health centers and the respective cities with higher incidence of tuberculosis in indigenous and non-indigenous populations.

METHODS

An ecological study was performed from data on TB reported to the *Sistema de Informação de Agravos e Notificação* (SINAN - Notifiable Diseases Information System). The study setting was the state of Pará, Northern Brazil, which is divided into 144 cities and has an estimated population of 7,969,654 inhabitants.¹⁷ Researchers chose to gather data on cities according to the group of 13 *Centros Regionais de Saúde* (CRS - Regional Health Centers), which organize this state for health management purposes.

In accordance with Presidential Decree number 7508/2011, a health region is a continuous geographical space formed by cities that share cultural, economic and social identities, and communication and transport networks, aiming to integrate, organize, plan and execute health services and actions.¹⁸ To evaluate tuberculosis cases according to such geographic units provides resources for better planning and strengthening of SUS coordinators. As a result, this reaffirms the assumptions made by Law 8080/1990¹⁹ and Decree 4279/2010²⁰ that emphasize the importance of regionalization as a structure foundation for the Management Pact, which foresees the decentralization of health services and actions and the organization of the Health Care Network. This takes into consideration that managers coordinating the Regional Health Centers must improve their planning according to territorial demands, epidemiological profile and social indicators. As a result, this will enable better resolvability of problems affecting the population.

Calculations took into account the total number of cases reported to the SINAN between January 1st 2004 and December 21st 2013, regardless of ethnicity. Data were obtained from the State Coordination for Tuberculosis Control of the *Secretaria de Estado de Saúde Pública do Estado do Pará* (SESPA - Pará State Department of Public Health) and made available as a database including the following variables: number of new cases of TB by ethnicity, according to city of occurrence.

For data treatment, depuration was initially performed using the EpiInfo 7 software program, aiming to select the most relevant variables to achieve the study objectives and avoid possible biases, such as incompleteness, redundancies and inconsistencies.

Next, the *Banco de Dados Geográfico* (BDGEO - Geographic Database) on reported cases in the study area and period was constructed. After data consistency was analyzed, a total of 34,495 cases were exported to a 2010 Microsoft® Office Excel® spreadsheet. This enabled the calculation of TB incidence rates in each city, using demographic data originated from the 2010 IBGE (Brazilian Institute of Geography and Statistics) census through the following expression: N of new cases of a disease occurring in a population in a certain period x 1,000/N of individuals at risk of being infected by this disease during the same period.²¹

TB incidence rates were subsequently associated with geographical coordinates (latitudes and longitudes) of each city obtained from the IBGE website, aiming to transform data into spatial information. Next, this information was processed using the ArcGis 10.2 software program to generate maps, according to the study objective.

Aiming to better visualize the georeferenced data on maps, the years analyzed were grouped into three-year periods: 2005-2007, 2008-2010, 2011-2013. A historical series of TB incidence coefficients was constructed for the indigenous and non-indigenous populations by city, grouped according to CRS composition.

In accordance with Resolution 466/2012 - CNS/MS, which regulates research on human beings, the present study was submitted to the Research Ethics Committee of the UEPA Nursing Course and approved on June 24th 2014, under official opinion number 698247. Before data were obtained from the Pará State Department of Public Health, the *Termo de Autorização de Acesso ao Banco de Dados* (TAABD - Database Access Authorization Term) had to be signed and all ethical principals were followed.

RESULTS

Among the indigenous and non-indigenous populations living in the state of Pará between 2005 and 2013, there were 31,071 new cases of TB, reaching an annual mean of 3,452 reports. When these cases were stratified, 98.6% (n=30,666) corresponded to non-indigenous individuals. There were 405 new cases (1.3% of the total number) in the indigenous population.

The coefficient of mean incidence of TB in the state of Pará between 2005 and 2013 was 45.8/100,000 inhabitants for the general population; 46.0/100,000 inhabitants for the non-indigenous population; and 115.16/100,000 inhabitants for the indigenous population. According to the city of residence, the spatial analysis of incidence rates showed significant differences in mean coefficients of incidence of TB between indigenous and non-indigenous populations in several health regions.

Regarding the non-indigenous population, in the three-year period of 2005-2007, the 1st, 3rd, 4th, 6th, 9th and 10th CRS showed high incidence rates equal to or higher than 50 new cases per 100,000 inhabitants. The cities of Belém (1st CRS), Ananindeua (1st CRS), Marituba (1st CRS), Maracanã (3rd CRS), Cachoeira do Piriá (4th CRS), Capanema (4th CRS), São João de Pirabas (4th CRS), Novo Progresso (9th CRS), Oriximiná (9th CRS), Barcarena (6th CRS) stood out, as they had incidence rates between 60.3 and 83.6 new cases per 100,000 inhabitants, according to Figure 1.

In this same three-year period, there was a great difference in coefficients of incidence between the indigenous and non-indigenous populations. Among the indigenous people, values of coefficient of mean incidence higher than 100 new cases per 100,000 inhabitants were identified in the 1st CRS, 3rd CRS, 5th CRS, 9th CRS, 10th CRS, 11th CRS and 12th CRS. In the 12th CRS, there were significantly higher values in the cities of Santana do Araguaia, with 7,462.6 new cases per 100,000 inhabitants; Tucumã, with 7,812 new cases per 100,000 inhabitants; and Banach, with 1,602.5 new cases per 100,000 inhabitants (Figure 1).

In the three-year period of 2008-2010, the map of data on the non-indigenous population showed a reduction in the rates in certain regional health centers, except for the 1st CRS, 3rd CRS, 4th CRS and 9th CRS, which still had high rates in this period, ranging between 57.2 and 78.2 new cases per 100,000 inhabitants. In the same period, the 2nd CRS showed an incidence rate between 53.6 and 62 new cases per 100,000 inhabitants, thus higher than the previous three-year period (Figure 1).

Additionally, in the three-year period of 2008-2010, although there was a reduction in the coefficients of incidence among the indigenous population in the 1st CRS, 3rd CRS, 5th CRS, 9th CRS, 10th CRS, 11th CRS and 12th CRS, these values remained higher than 100 new cases per 100,000 inhabitants, except for Jacareacanga (9th CRS) and Santana do Araguaia (12th CRS), whose rates were lower than 50/100,000 inhabitants (Figure 1).

In the last three-year period analyzed, 2011-2013, the rates for the non-indigenous population in the 1st CRS, 2nd CRS, 4th CRS and 9th CRS remained high, especially in Belém, with 101.7 new cases per 100,000 inhabitants, and Santa Izabel do Pará, with 118 new cases per 100,000 inhabitants (Figure 1).

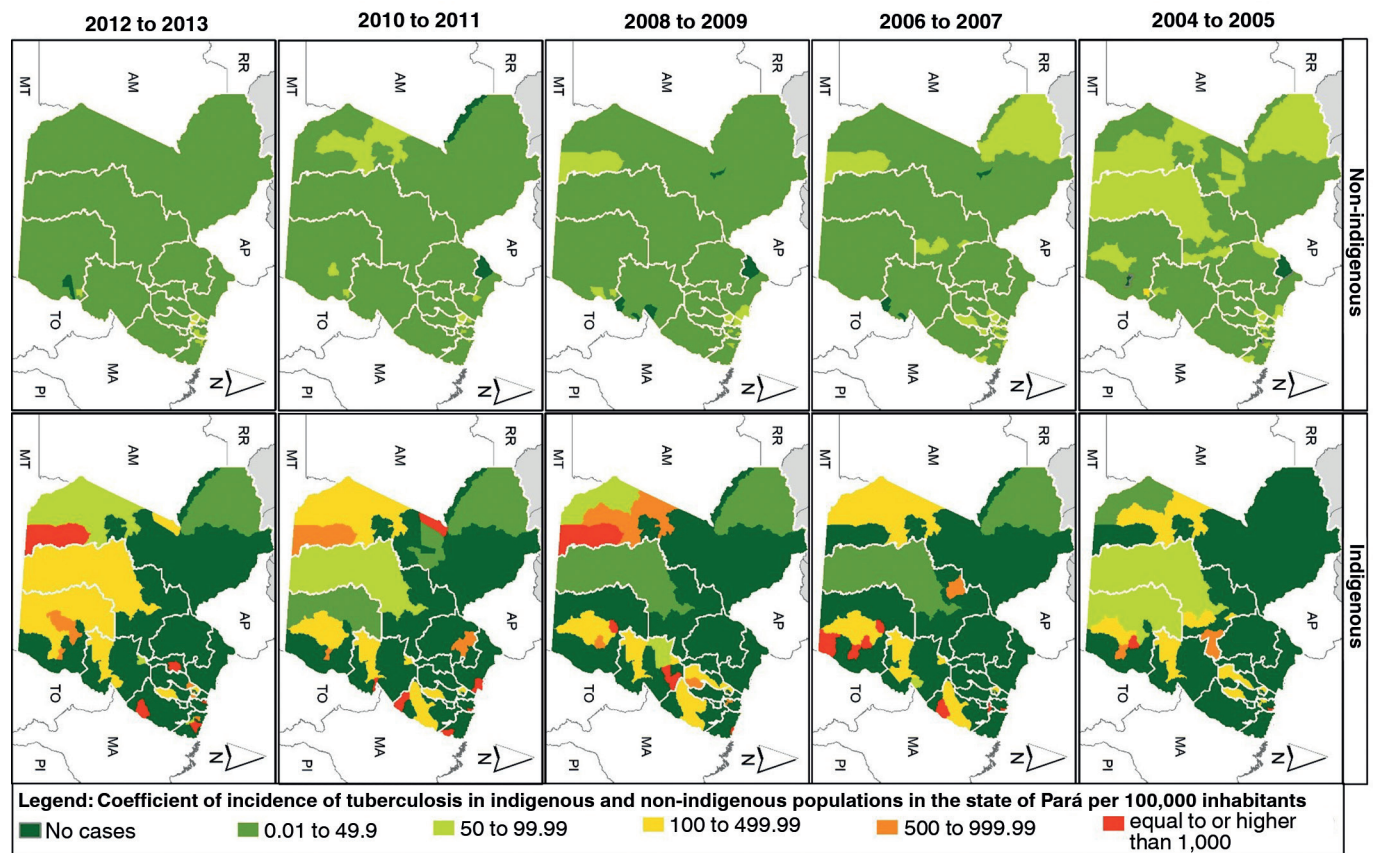
Likewise, among the indigenous population, there were coefficients of incidence higher than 100 new cases per 100,000 inhabitants in almost all Regional Health Centers, varying from 132 to 1,149 new cases per 100,000 inhabitants, except for the 5th CRS, 7th CRS and 10th CRS, which almost always showed lower values, ranging from 0 to 90 new cases per 100,000 inhabitants (Figure 1).

It should be emphasized that the cities of Bragança (4th CRS), Cametá (13th CRS), Curuçá (3rd CRS), Novo Progresso (9th CRS) and Ulianópolis (5th CRS) showed incidence rates higher than 1,000 new cases per 100,000 inhabitants in the three-year period of 2011-2013, as shown in Figure 1.

Spatial distribution of tuberculosis

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Figure 1. Distribution of TB cases in the indigenous and non-indigenous populations reported between 2005-2013, state of Pará, Northern Brazil, 2017. Source: *Sistema Nacional de Agravos e Notificação (SINAN - Notifiable Diseases National System)*, 2005-2013.



DISCUSSION

Through spatial analysis of health, TB was found to have spread among indigenous and non-indigenous populations heterogeneously. Thus, it is possible to visualize the CRS and, consequently, the cities covered by them where there are high values and significant differences between such populations, reaching 7,812 new cases per 100,000 inhabitants among indigenous populations and 118 new cases per 100,000 inhabitants among non-indigenous populations, values considered to be higher than the mean for Pará state.

The representativeness of TB reports among indigenous populations was 1.3% of the total recorded in the SINAN on average. However, this population group represents nearly 0.47% of the total population in the period analyzed. These data show a higher incidence in such population, according to studies which concluded that indigenous groups are the most vulnerable to TB infection.²²⁻²⁵

Regarding the georeferenced analysis of TB cases in non-indigenous populations, few cities showed a decrease in the mean coefficient of incidence during the transition from the 2005-2007 to the 2008-2010 three-year period. Nonetheless, there was a steady reduction in the incidence of cases in the group of cities included in the 6th and 10th CRS. This evidence could be a reflection of the implementation of control actions

in both regions. However, the data available do not enable any further analyses in this sense.

Moreover, among non-indigenous populations, the three-year period of 2011-2013 showed a coefficient of incidence of 118 new cases per 100,000 inhabitants for the 1st CRS in the city of Santa Izabel, suggesting a possible worsening of the measures for disease control in this CRS. Santa Izabel do Pará is part of the metropolitan area of the city of Belém, where there is insufficient infrastructure and basic sanitation to meet the population needs. The high incidence rate of TB in this city is probably associated with socioeconomic conditions. Some studies²⁶⁻²⁹ point to TB incidence being higher in areas with poorer socioeconomic and housing conditions and low level of education.

More high incidence rates were found in other studies of Brazilian cities. However, they are not as high as the value found for the non-indigenous population in these cities, in the state of Pará. A study³⁰ on the spatial distribution of TB performed in the city of Teresina, Piauí state, between 2005 and 2007, found a mean incidence rate of 39.3 new cases per 100,000 inhabitants.

The georeferenced analysis of data on the indigenous populations was found to be significantly different from that performed with data from the non-indigenous populations, as coefficients of incidence were much higher. This epidemiological condition can be justified by the low level of socioeconomic

development and poor health service conditions found in indigenous areas, which has been confirmed in studies on TB cases and socioeconomic conditions.^{31,32}

A study³³ performed with an indigenous population in the city of Dourados, Mato Grosso do Sul state, revealed that appalling conditions of health and malnourishment were associated with an increase in TB. Moreover, it showed that malnourishment combined with very poor housing conditions with a high density of residents and a single room without ventilation facilitated TB infection.

During the three three-year periods, among indigenous populations, the values of coefficients of incidence remained high and did not vary significantly between 132 and 1,149 new cases per 100,000 inhabitants. However, the three-year period of 2008-2010 stood out with high rates in the cities of Santana do Araguaia, Tucumã and Banach, which can be partly explained by the possible vulnerabilities of TB control actions in this period in neighboring cities or greater demand for indigenous health services in such cities.

The city of Banach has an indigenous health clinic. Additionally, the DSEI Kaiapó of Pará state is comprised of this city and four other cities (Cumarú do Norte, Pau D'arco, Ourilândia do Norte and São Felix do Xingú) and located in its Southern region, on the border with Mato Grosso and Tocantins states. In this DSEI, the indigenous population includes 4,879 individuals from the Kayapó ethnic group, distributed into 1,578 families living in 45 villages.³⁴

In this sense, high rates of TB infection were also found in studies on spatial distribution performed in indigenous lands and cities in the state of Rondônia,³⁵ with coefficients of incidence of 415.03/100,000 inhabitants for the indigenous population between 1997 and 2006, and, in cities in the Amazon region on the border between Brazil, Colombia, Peru and Venezuela, with a mean coefficient of incidence ranging between 202.3 and 65.6/100,000 inhabitants for the indigenous population from 2001 to 2010.³⁶

Additionally, the three-year period of 2011-2013 should be emphasized, when the 3rd CRS (Curuçá), 4th CRS (Bragança), 5th CRS (Ulianópolis), 9th CRS (Novo Progresso) and 13th CRS (Cametá) showed an incidence higher than 451 new cases/100,000 inhabitants. Among all these cities, Novo Progresso is the only one that has a specific service for indigenous populations, thus suggesting better investigation of TB cases or even the migration of indigenous populations from other cities, seeking better health care. The city of Novo Progresso is in the area covered by the DSEI Rio Tapajós, located in Southwest Pará state with a population of 8,121 indigenous individuals, distributed across 86 villages. In this DSEI, the Mundurucu ethnic group predominates.³⁷

A study³⁸ concluded that the migration of human groups has contributed to the dissemination of infectious diseases such as TB. Another study³⁹ on the dynamics of migration in the Mediterranean Sea and the differences in infectious diseases from the places of origin raised the question of whether public

health actions are sufficient to prevent the transmission of infectious diseases.

It is possible to identify that the geographical dynamics of occurrence of TB behaves differently in terms of ethnic groups, which were indigenous and non-indigenous populations in the case of the present study. Consequently, as this finding is appreciated, the city or even regional health management can implement TB control actions, aiming to structure an effective service network that includes culturally diverse care, aiming to meet the requirements of indigenous populations.

The organizational model for health management in the state of Pará should be emphasized, regulated by regionalization and with cities being grouped according to the criteria established by the *Comissão Intergestores Bipartite* (CIB - Bipartite Inter-Manager Committee).⁴⁰ Thus, studies with this format can provide resources for the planning and implementation of health care actions. Although all the DSEIs are responsible for primary health care for indigenous populations, they are located in geographical spaces comprising regional health centers. Therefore, they should be valued, as indigenous populations often go to urban areas in cities for different reasons, promoting frequent contact.

Finally, the analysis of the present study revealed inequalities in TB indicators between indigenous and non-indigenous populations, avoiding the need for specific actions in the cities, according to the human group most vulnerable to this disease. To achieve this, investment is essential to improve health service structuring, so that TB cases present in the community can be diagnosed and treated, thus meeting the goals established for disease control. Furthermore, the results of this study reflect the challenge of including appropriate strategies for TB control in minority ethnic groups of the Brazilian population into the health services.

The present study has limitations and data must be interpreted with caution. This is because the analysis of data on TB incidence was based on SINAN records, which provides information subject to data incompleteness, underreporting and incorrect recording, like other health information systems in Brazil.

CONCLUSION

Based on the findings of the present study, it could be concluded that the indigenous populations in the state of Pará need more attention regarding adequate TB control. The use of spatial analysis allowed for knowledge about the distribution of TB among indigenous and non-indigenous populations and the clear visualization of areas with higher concentration of cases according to the Regional Health Centers.

Mapping of the coefficients of incidence of TB in the entire state enabled the identification of priority areas that require a special intervention. Additionally, if appreciated in the epidemiological surveillance routine, this can be useful to outline appropriate strategies to reduce TB transmission, apart from contributing to measures recommended by the PNCT being prioritized in these locations. Thus, a more favorable context for TB control in this state can be more easily achieved.

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