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ORIGINAL ARTICLE

Spatial Pattern of Tuberculosis in a Priority Municipality in The State of Mato Grosso - Brazil

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Highlights:
1. The state of Mato Grosso has stood out due to a high incidence of TB.
2. Between 2011 and 2020, 337 cases of tuberculosis were reported.
3. Health units were not determinants for the occurrence of the phenomena.

ABSTRACT

Objective: to analyze the characteristics of people affected by tuberculosis and the spatial distribution of reported cases, treatment abandonment, as well as health units in the municipality of Barra do Garças – State of Mato Grosso. **Method:** ecological study with cases of tuberculosis reported from 2011 to 2020 in the municipality of Barra do Garças-MT. Data were obtained by the Notifiable Diseases Information System, being investigated as sociodemographic and clinical-operational variables of tuberculosis. It was the incidence rate of reported cases for each year of the study. Afterward, the spatial distribution was carried out, according to the districts of the municipality, of the number of notified cases and treatment abandonment, as well as health units belonging to primary care. **Results:** 337 cases of tuberculosis were reported, with a predominance of males (n=230; 68.25%), indigenous people (n=120; 35.61%), aged between 15 and 59 years (n=242; 71.81%), and having between 1 to 8 years of study (n=159; 46.88%). As for the clinical-operational data, most were new cases (n=269; 79.82%), who did not undergo sputum culture (n=305; 90.50%), and 41.25% (n=139) the directly observed treatment was not performed (n=110; 57.29%) and only 56.97% (n=192) evolved to cure. The average annual incidence was 54.62 cases per 100,000 inhabitants. The *Santo Antônio* and *Centro* neighborhoods had the highest number of reported cases as well as treatment abandonment. The presence of family health strategy units and polyclinics were not determinants for the occurrence of the investigated phenomena. **Conclusion:** this study made it possible to identify the profile of the most hospitalized people, as well as the most critical areas in relation to the number of cases and treatment abandonment. The results obtained can be used to direct health actions aimed at controlling tuberculosis, mainly by indicating the neighborhoods that are emerging outbreaks of the disease.

Keywords: Spatial analysis; Epidemiology; Mycobacterium tuberculosis

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INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis* or *Koch*'s bacillus, present in several countries and is the 13th leading cause of death and the second leading cause of infectious death after the COVID-19[1-3] pandemic.

In 2020, approximately 9.9 million people developed TB, and 1.5 million died[1]. Brazil is one of the countries with the highest number of cases, with 68,271 new cases of TB recorded in 2021, with an incidence rate of 32.0 cases per 100,000 inhabitants[1]. Despite being a disease with diagnosis and treatment offered free of charge by the Unified Health System (SUS), the country is among the 30 countries with a high incidence of TB, which makes it a priority for the World Health Organization (WHO) to control it[1,4-5].

As a way of tackling the disease and in line with international policies, in 2017 the Ministry of Health (MH) launched the National Plan to End Tuberculosis as a Public Health Problem[5]. This document guides the end of TB in the country and sets targets of fewer than 10 cases per 100,000 inhabitants and fewer than 230 deaths from the disease by the year 2035[4-5].

However, the implications of the pandemic are likely to have a marked and lasting impact on the diagnosis and control of TB worldwide, leading to an approximate additional 6.3 million cases between 2020 and 2025, as well as 1.4 million more deaths during this same period. This setback is due to interruptions in health services, as well as delays in the early diagnosis of the disease and the availability of treatment[2-3]. It is estimated that the pandemic has caused a delay of 5 to 8 years in achieving the targets set for TB control[6].

As a result, in the Americas region, the number of new cases of the disease fell between 15% and 20% between 2019 and 2020, a condition that threatens progress towards the end of TB by 2050[4].

The state of Mato Grosso has stood out due to its high incidence of TB. In 2021, the state registered 902 cases, with an incidence of 25.8 cases per 100,000 inhabitants, making it the second state in the Center-West of Brazil with the highest incidence of the disease. As for the operational indicators for treatment completion in 2020, 62.1% of cases were cured and 12.1% abandoned treatment[4]. Among the most affected municipalities in Mato Grosso is Barra do Garças, which is among the 10 municipalities with the highest incidence of TB in the state, making it a priority municipality for controlling the disease in the state[7].

Actions aimed at the places most at risk are fundamental, especially those carried out at the primary care level, which plays a key role in managing strategies to deal with the disease. It is at this level of care that it is recommended to identify risk groups, diagnose and start treatment early, and monitor the outcome of treatment[8-9].

Thus, considering the worrying scenario of TB in Barra do Garças - Mato Grosso, and because it is a municipality considered a priority for the development of actions to contain and control the increasing number of TB cases, it is of paramount importance to identify areas with the highest number of cases in order to better target actions, especially by the primary care network, which can consequently reflect more effective results in terms of TB control in the municipality. Therefore, this study aims to analyze the characteristics of people affected by tuberculosis and the spatial distribution of notified cases, treatment abandonment, and health units in a priority municipality in Mato Grosso.

METHOD

Research design and setting

This is an ecological study carried out in the municipality of Barra do Garças, in the state of Mato Grosso, located in the Central West region of Brazil. The municipality has a total population of 61,702 inhabitants and an area of 8,713.673 km^2. The municipality's municipal human development index (MHDI) is 0.748 and the Gini index is 0.590. The municipality's primary care network includes 15 Family Health Strategies (FHS) and two polyclinics. The FHS is the primary care model, which is based on the work of multi-professional teams in an assigned territory and develops health actions based on knowledge of reality. A polyclinic is a health unit that provides outpatient care in various specialties, including or not basic specialties, and can also offer other non-medical specialties[10].

Study population and sources of information

The study population consisted of TB cases living in the urban area and notified in the municipality between 2011 and 2020.

Data on TB cases was obtained from the Notifiable Diseases Information System (SINAN), through the Mato Grosso State Health Department's Information Systems Data Repository (DwWeb/SES-MT). The estimated population data for 2020 was obtained from the Brazilian Institute of Geography and Statistics (IBGE). Information on the notifying health units came from the database of the National Register of Health Establishments (CNES).

Data Analysis

Initially, the data was subjected to exploratory analysis, calculating absolute and relative frequencies of sociodemographic characteristics (gender, age, race/color, and schooling) and clinical--operational characteristics (type of admission, clinical form, sputum culture, chest X-ray, supervised treatment carried out, closure status and diseases (AIDS (Acquired Immunodeficiency Syndrome), alcoholism, diabetes, mental illness, and other diseases)). The analyses were carried out using Microsoft Office Excel and presented in tables and graphs.

The incidence of TB cases was then calculated for the municipality by year of study, in accordance with the Pan American Health Organization's recommendations for calculating basic health indicators in Brazil[10].

Spatial analysis

For the spatial distribution, the neighborhood was used as the aggregation unit. The geographical grid of the municipality with the indication of the neighborhoods (n=83) was used to make the thematic maps, in which the darker colors represent the most critical locations. The number of cases and abandonment of TB treatment were presented geographically according to the neighborhoods of the municipality under study. In addition, the municipality's health units (FHS and polyclinics) were geocoded, and their latitudes and longitudes were obtained using Google Maps. ArcGis software version 10.7 was used for the spatial analysis.

Ethical and legal aspects

The study was approved by the Research Ethics Committee, in accordance with the Guidelines and Regulatory Norms for Research on Human Beings, Resolution 466/2012 of the National Health Council (CAAE: 32128820.3.0000.5587).

RESULTS

A total of 337 TB cases were reported in the study municipality between 2011 and 2020, whose sociodemographic characteristics are described in Table 1. TB was prevalent among males (n=230; 68.25%), indigenous people (n=120; 35.61%), and white people (n=109; 32.34%). In terms of age, the majority were between 15 and 59 years old (n=242; 71.81%) and had between 1 and 8 years of schooling (n=59; 46.88%).

Table 1 - Sociodemographic characteristics of tuberculosis in the municipality of Barra do Garças, Mato Grosso, Brazil (2011-2020).

Sociodemographic characterization	**N**	**%**
Sex		
Female	107	31.75%
Male	230	68.25%
Age range		
<14 years	44	13.06%
15-59 years	242	71.81%
>60 years	51	15.13%
Race/color		
Brown	90	26.71%
White	109	32.34%
Black	11	3.26%
Yellow	2	0.59%
Indigenous	120	35.61%
Unknown/blank	5	1.49%
Schooling		
No schooling	33	9.79%
1 to 8 years	159	46.88%
9 to 11 years	67	19.88%
12 years or more	25	7.42%
Not applicable	18	5.34%
Unknown/blank	36	10.68%
Area of residence		
Urban	202	59.94%
Rural	47	13.94%
Unknown/blank	88	26.12%

Source: Elaborated by the authors.

As for the clinical-operational data, 79.82% (n=269) were new cases and 92.28% (n=311) had a pulmonary clinical form. Of the total, 90.50% (n=305) did not undergo sputum culture and only 42.14% (n=142) underwent directly observed treatment. Regarding the outcome, 56.97% (n=192) were cured, followed by treatment abandonment with 12.46% (n=42) and death from TB with 5.04% (n=17). When evaluating the associated conditions, it was noted that in 100% of cases, AIDS was blank or ignored, 18.10% (n=61) had an alcohol use disorder and 5.04% (n=17) had diabetes mellitus, as described in Table 2.

Table 2- Clinical and operational characteristics of tuberculosis in the municipality of Barra do Garças, Mato Grosso, Brazil (2011-2020).

Clinical-operational variables	N	%
Type of admission		
New case	269	79.82%
Recurrence	25	7.42%
Readmission after abandonment	20	5.93%
Transfer	17	5.04%
Clinical presentation		
Pulmonary	311	92.28%
Extrapulmonary	13	3.86%
Pulmonary + Extrapulmonary	13	3.86%
Sputum culture		
Not performed	305	90.50%
Negative	14	4.15%
Positive	9	2.67%
In progress	9	2.67%
Chest X-ray		
Not performed	10	2.97%
Normal	10	2.97%
Suspicious	309	91.69%
Blank / ignored	8	2.37%
Directly Observed Treatment (DOT)		
No	139	41.25%
Yes	142	42.14%
Ignored / blank	56	16.61%
Closure status		
Cured	192	56.97%
Abandonment	42	12,46%
Diagnosis change	11	3.26%
Death from tuberculosis	17	5.04%
Death from other causes	9	2.67%
Multidrug-resistant TB	4	1.19%
Others	62	18.5%
AIDS		
No	0	0.00%
Yes	0	0.00%
Ignored / blank	192	100.00%
Alcohol use disorder		
No	128	37.98%
Yes	61	18.10%
Unknown/blank	148	43.92%

Diabetes Mellitus		
No	134	39.76%
Yes	17	5.04%
Unknown/blank	186	55.20%
Mental disorder		
No	142	42.14%
Yes	3	0.89%
Ignored / blank	192	56.97%
Other illnesses		
No	80	23.74%
Yes	16	4.75%
Ignored / blank	241	78.13%

Source: Elaborated by the authors.

Figure 1 shows the number of reported cases and the incidence rate in the municipality of Barra do Garças between 2011 and 2020. It can be seen that 2013, 2018, and 2019 were the years with the highest incidence, with an average annual incidence rate of 54.62 cases per 100,000 inhabitants over the 10 years of the study.

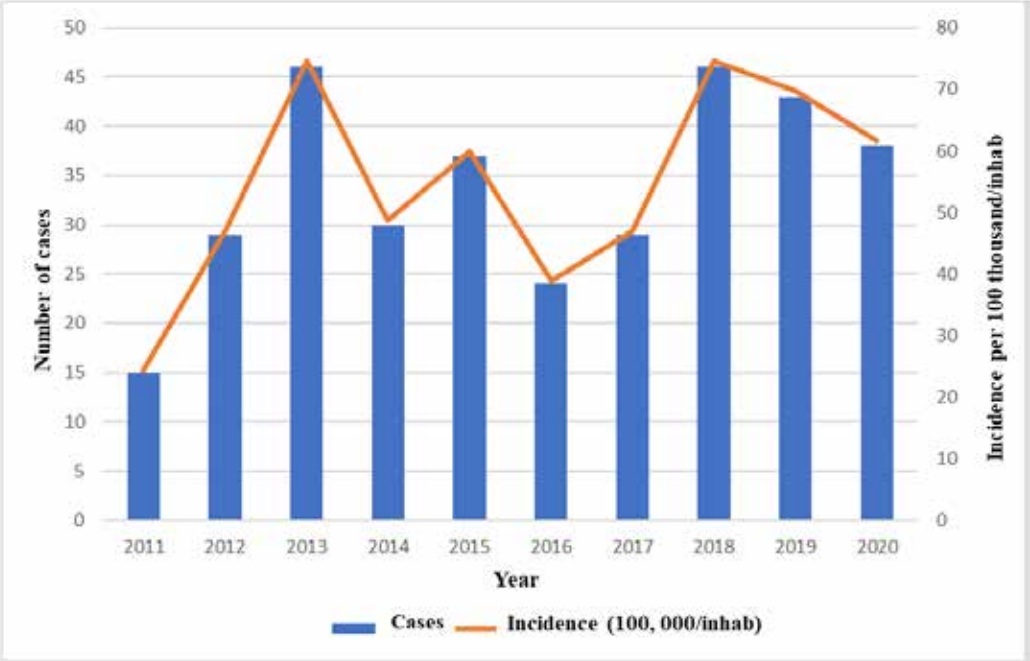

Figure 1 - Number of notified cases and incidence rate of tuberculosis per year. Barra do Garças, Mato Grosso, Brazil, (2011-2020).

Source: Elaborated by the authors.

Figure 2 shows the spatial distribution of notified cases and treatment abandonment according to neighborhoods in the municipality. It can be seen that the *Santo Antônio* and *Centro* neighborhoods, represented by the darker color, had the highest number of notified cases, with 34 and 40 cases respectively. When looking at treatment abandonment, the *Centro* and *Santo Antônio* neighborhoods were also the most affected, with 6 and 4 cases, respectively.

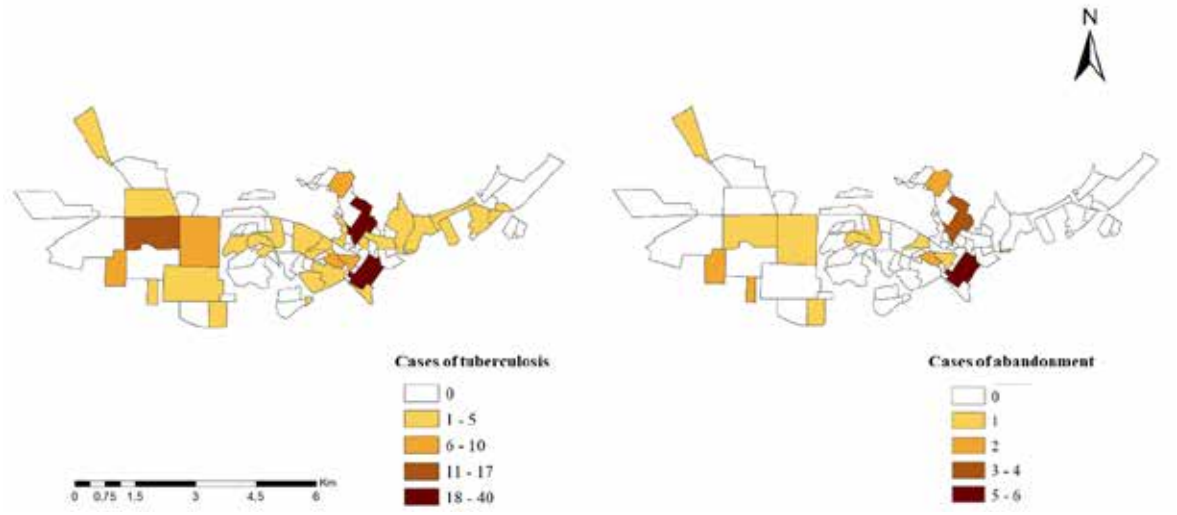

Figure 2 - Spatial distribution of notified TB cases and treatment abandonment according to neighborhoods in the municipality of Barra do Garças, Mato Grosso, Brazil, (2011-2020).

Source: Elaborated by the authors.

Figure 3 shows the health units of the FHS and polyclinics in the municipality of Barra do Garças. It can be seen that the health units that report TB cases are present throughout the territory, with spatial gaps and lower density in the eastern region of the municipality. Figures 2 and 3 show that of the three neighborhoods with the highest number of cases, two have no FHS or polyclinic located within the neighborhood. The *Santo Antônio* neighborhood, with 34 reported TB cases, has a polyclinic and an FHS located on the border with the adjacent neighborhood. The third neighborhood with the highest number of cases (n=15) is located in the eastern region and does not have a health unit, but is adjacent to the neighborhood where a polyclinic is located. It is noteworthy that many neighborhoods that have FHS units or polyclinics did not register cases of treatment abandonment. On the other hand, even the neighborhoods with these health units also recorded cases of treatment abandonment.

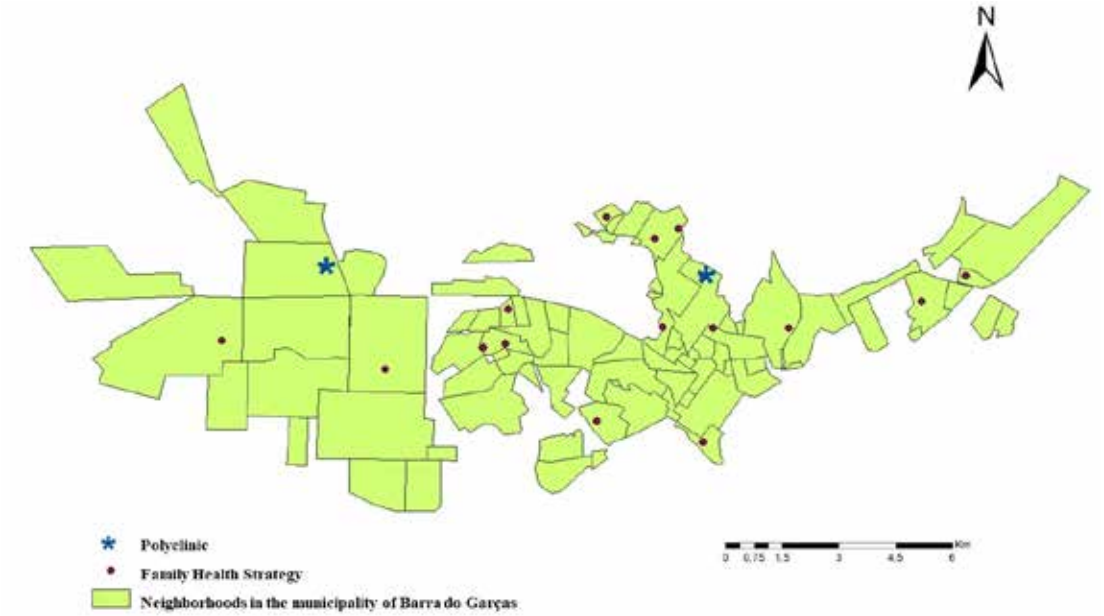

Figure 3 - Spatial distribution of health units (Family Health Strategy- FHS and Polyclinics) in the municipality of Barra do Garças, Mato Grosso, Brazil, (2011-2020).

Source: Elaborated by the authors.

DISCUSSION

The aim of this study was to analyze the characteristics of people affected by tuberculosis and the spatial distribution of notified cases, treatment abandonment, and health units in a priority municipality in Mato Grosso. It can be seen that the municipality has an epidemiological trend similar to that shown in national[7,11-13] and international1[4-15] studies. TB is a disease with a high potential for transmissibility, and health professionals and managers need to be able to identify territories at risk in order to intensify health strategies aimed at tackling it. In this sense, it is essential to carry out research that identifies the spatio-temporal distribution and geographical clusters with a high risk of TB, since this approach favors and directs actions to control the disease in priority territories, whether at state and/or municipal level[15].

The results indicate that the sociodemographic profile of TB cases corroborates other studies in terms of gender, age, and schooling, with the majority being men of economically active age and with few years of schooling, which may be directly related to the situation of poverty and characteristics of social vulnerability. Another important factor is that men usually take less care of their health and attend health services less often[12-13,16]. In addition, TB patients with this profile are more likely to have an unfavorable outcome such as abandoning treatment and eventually dying[17].

In terms of race and skin color, there was a predominance of indigenous people, which differentiates the municipality from other places in Brazil, where the majority of people affected are brown or white.[18] This result is justified mainly by the composition of the population in the Mato Grosso region and the municipality of Barra do Garças, which stands out for the large number of indigenous lands belonging to its territory. Barra do Garças, along with three other municipalities, has the largest population (75.1%) of indigenous people from the *Xavante* ethnic group living in rural areas. It should be noted that the *Xavante* ethnic group has a population of around 19,259 indigenous people, 91.6% of whom live in rural areas[18].

The presence of the indigenous population in the municipality may explain the higher occurrence of TB in these individuals. When looking at the data in detail, it can be seen that many notification forms did not fill in the area of residence, however, the other address fields indicated villages as the place of residence. This is due to the lack of complete and correct information on the notification forms, which often leads to dubious interpretations of the epidemiological data, as well as a tendency for populations to live in urban areas.

Historically, the indigenous population has been more socially vulnerable than the general population, as they have more infectious and chronic diseases, as well as high rates of malnutrition and obesity. There is also the social issue that increases the susceptibility of these individuals to diseases due to their low income and low consumer purchasing power. In addition, there are socio-cultural specificities and their way of life, such as overcrowded housing, which significantly increase the chances of transmitting diseases such as TB[19-20]. Although this study focused on geoprocessing data on urban cases, it is important to emphasize the eminent need for TB control strategies that include the indigenous population living in rural areas.

As for schooling, this has a direct link to health problems, as low schooling affects quality of life, and self-care, hinders early diagnosis, and influences profession and consequently income, thus making these patients more susceptible to TB infection and treatment abandonment. Furthermore, TB is a disease that is related to poverty and directly influences access to health services as well as timely diagnosis and effective treatment[21]. Given that the lower an individual's level of education, the lower their understanding of health guidelines and protective measures.

A study carried out in Kenya that sought to describe the main predictors of treatment abandonment highlighted the importance of sociodemographic characteristics such as schooling and

income[22]. Although the municipality's MHDI has grown in recent decades, schooling and income, which are data that make up this index, still seem to be a problem, which has an impact on the number of notified TB cases. This reinforces the idea that TB is a disease that requires control strategies that go beyond the health sector and act on the population's living conditions[23].

One result that stood out was sputum culture, which although it is considered the gold standard, most of the notified cases did not undergo this diagnostic method. This may be due to the long wait for a conclusive culture result, which will delay the start of specific treatment, leading to a delay in interrupting the chain of transmission and contributing negatively to disease control. Another difficulty encountered in adhering to this test in health services is that public health laboratories do not have a suitable structure or qualified professionals to use this technology[23].

The predominant outcome was cure, but this percentage is lower than the national figure (68.4%)[9]. This result reflects the urgent need for advances in terms of disease control and proper monitoring of treatment, since patients who do not have a cure as an outcome can develop severe forms of the disease and even die[18]. It is worth noting that when this individual does not undergo the correct TB treatment, one of the outcomes is the development of drug-resistant TB, a consequence that complicates the monitoring situation and can lead to further complications and maintain the cycle of TB transmission in the area[6,17].

Another concern in relation to TB cases is the consumption of psychoactive substances, whether licit (alcohol and tobacco) or illicit (marijuana, cocaine, crack, among others), which are a risk factor for the development of TB as well as for the occurrence of unfavorable outcomes[24]. One study found that a history of alcohol consumption caused a significant delay in the conversion rate of sputum smear microscopy when compared to patients who did not use alcohol and that alcohol consumption was associated with drug-resistant TB (DR-TB)[25].

Another observed aspect is that a large number of patients affected by TB in the municipality of Barra do Garças do not undergo DOT. This data becomes a warning, as the literature refers to DOT as an important tool for reducing treatment abandonment, contributing directly to controlling the disease[5]. In addition to the low level of DOT in the units, flaws were found in the notifications, as many of them did not contain this information.

In addition, it was observed that there is a significant deficiency in relation to the identification of TB/HIV co-infection since no patient was tested during the study period. Attention to populations at risk, such as people living with HIV, is one of the pillars of TB control programs[5]. Detecting cases and properly managing treatment in this vulnerable group is fundamental to achieving a cure, thus reducing mortality rates[26].

One hypothesis that can be raised in relation to the lack of HIV testing of notified TB cases is the poor completion of notification forms with missing and/or incomplete data, which has been configured as a problem that directly affects disease indicators. The lack of information on TB/HIV co-infection found in this study can directly compromise the quality of care, preventing proper follow-up and treatment for these patients[27].

A study that analyzed the quality of records in the medical charts of TB patients found an absence of adequate data, including detailed completion of tests carried out during treatment, such as the anti-HIV test[28]. Evidence also points to the fact that the deficiency and fragility in filling out TB notification forms may be linked to the lack of knowledge and training of health professionals in handling this instrument, as well as the lack of observation in data collection when patients are received at the service[11,28].

With regard to the TB incidence coefficient in Barra do Garças (annual average of 54.62 cases per 100,000 inhabitants), there is another concern, given that it is much higher than the incidence

of the state of Mato Grosso (25.8 cases per 100,000 inhabitants in 2021) and Brazil (32.0 cases per 100,000 inhabitants in 2021)[4]. In Brazil, during the same research period, there were also peaks in 2018 and 2019, with a drop in 2020, the time of the COVID-19 pandemic, which may be related to the decrease in case detection and the reduction in the quality of the segment of people diagnosed[4].

The diagnosis of TB during the COVID-19 pandemic required high clinical suspicion, as the two diseases have similar symptoms, such as fever and respiratory symptoms. In addition, TB and COVID-19 can present simultaneously, as previously demonstrated in the first cohort study of patients with TB and COVID-19[3].

The results obtained with the spatial distribution of notified cases are in line with a study carried out in the municipality of Belém - Pará, which showed that the presence of Primary Health Care (PHC) services in neighborhoods with higher TB rates was not decisive in improving access to health services[28].

In addition to the existence of health services, it is necessary for the health professionals working in these units to provide resolutive care and the welcome needed to strengthen the bond with patients, in order to promote greater adherence to TB treatment[29]. In this context, it is essential to implement training programs for health professionals so that they can provide assertive, qualified care based on technical and scientific attitudes, which also corroborates one of the pillars of the End TB Strategy[5,9].

As for the cases of abandonment in the *Centro* and *Santo Antônio* neighborhoods, the results found are lower than the percentage of 5% established by the WHO as the maximum tolerable, but they still sound a warning sign for immediate and rigorous intervention in TB management in these places4. Abandonment of treatment has been characterized as one of the main obstacles to controlling the disease, which is commonly linked to the actions developed within the scope of PHC[29].

In this sense, health managers need to pay attention to the effectiveness of strategies and care for people with TB and how these units have been established in the municipality's healthcare network.

Studies mention predictive factors that may be related to treatment abandonment, such as low schooling, age, low income, drug use, non-performance of DOT, adverse effects of medication, and symptomatic improvement[30-31].

The results obtained in this study show that some neighborhoods with an FHS or Polyclinics had no cases of abandonment, while some neighborhoods with these services had cases of abandonment. This issue may be related to the way in which TB actions are being carried out, which may not be occurring effectively in all units[32]. The quality of care has been discussed as a strong influence on treatment abandonment. The absence of spaces for listening and proactive attitudes on the part of health teams, as well as practices that go against comprehensive care, reinforce the fragmentation of care in the care network, which can contribute to patient withdrawal and consequent abandonment of treatment[29].

The relationship between health units and other services in the health care network is fundamental to the success of TB treatment, given that the main form of action in this model is based on individualized care plans that are carried out jointly between professionals and users, taking into account risk stratification and the social determinants of health involved33.

Living conditions, poverty, housing situation, and poor nutrition are part of the social determinants of health that are commonly present in the population affected by TB and which should be investigated from the first contact with the patient. These determinants generate a condition of vulnerability that promotes the maintenance of the disease and makes people who fall ill with TB invisible to the health system[34].

Regions with higher levels of social vulnerability are prone to higher incidences of TB, and these places are also marked by the prevalence of TB/HIV co-infection, delayed diagnosis, and lower adherence to treatment[35]. Thus, the municipality of Barra do Garças needs greater investment in research into the social determinants present in its territory, especially in order to propose strategies that are comprehensive and capable of reducing TB cases, starting with the investigation of TB/HIV co-infection cases, which was a serious problem found in the results of this article.

Analysis at the local level to tackle TB can help strengthen control actions in PHC, given that it is in these units that the search for respiratory symptoms, diagnosis, and treatment of cases are primarily carried out. In this context, spatial analysis tools can be very useful for nurses and the entire multidisciplinary team in managing actions, especially with regard to planning, monitoring, and evaluating strategies aimed at eliminating TB[28].

The limitation of this study lies in the fact that it was carried out in a single municipality with limited numbers of participants, a factor that does not allow its results to be generalized. In addition, the neighborhoods do not have official records with more information on these spaces, which prevents the association of reported cases with other factors. However, these results contribute to the municipality's positioning in terms of care and management so that TB containment strategies can be implemented in the most critical areas.

CONCLUSION

The results of this study showed high rates of notified TB cases in the municipality of Barra do Garças, which is concerning. This study showed that men, indigenous people, those with low levels of schooling, and those aged between 15 and 59 are the most affected in the municipality. Weaknesses were found in the diagnosis of the disease through sputum culture, as well as concerning directly observed treatment and HIV testing. Alcohol consumption was also a prominent feature of the investigated population, which had cure rates lower than those recommended by the Ministry of Health. The deficiency and fragility in filling in notification forms could also be seen as an obstacle to tackling TB.

In addition, the study geographically pinpointed priority areas for strategies to tackle the disease.

It was also noted that although the municipality has health units distributed throughout the territory, there is still room for improvement in coverage, which could help make these services more accessible to patients.

Finally, the results obtained in this study can be extremely useful for managing health actions to control TB, mainly because they indicate which neighborhoods are in the most critical situation, with the highest number of TB cases and treatment dropouts. Acting directly in these places can be an advantage in terms of optimizing financial and human resources, as well as the possibility of achieving more effective results in a shorter space of time, especially considering the delays caused by the COVID-19 pandemic and the imminent achievement of the TB elimination targets proposed by the WHO.

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