Cogitare Enfermagem

ORIGINAL ARTICLE

Tuberculosis in the incarcerated population: epidemiology and spatial analysis between 2014 and 2020

HIGHLIGHTS

1. A PDL represented 14% of TB cases between 2014 and 2020 in MT.
2. TB focuses on prisons and nearby locations.
3. It is necessary to implement TB prevention policies in the PDL.
4. TB represents a problem in the PDL of Mato Grosso.

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Abstract

Objective: To describe the epidemiology and spatial distribution of tuberculosis in the incarcerated population in the state of Mato Grosso, from 2014 to 2020. **Method:** Descriptive study, with spatial analysis of the geographical distribution of tuberculosis. The incidences were estimated, evaluating their distributions in the municipalities of Mato Grosso - Brazil through the analysis of spatial clusters Gi*. **Results:** 14.0% (n=1,003) of the 7,201 tuberculosis cases reported between 2014 and 2020 in adults occurred in the incarcerated population. The incidence of tuberculosis in this population decreased from 3,261.1 to 722.3 cases per 100,000 inhabitants between 2014 and 2020. Men aged 18-39, of brown race/color and with incomplete elementary education were associated with a higher occurrence of tuberculosis. **Conclusion:** High-risk clusters were found in the central and southern regions of the state, near municipalities with a higher number of prisons. The study contributes to the formation of public health policies and strategies for controlling Tuberculosis.

Keywords: Tuberculosis; *Mycobacterium tuberculosis*; Incarcerated Population; Prisons; Epidemiological Surveillance.

HOW TO REFERENCE THIS ARTICLE

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INTRODUCTION

Tuberculosis (TB) is the second infectious disease, caused by a single etiological agent, that causes the most deaths worldwide, second only to the disease caused by the new coronavirus[1]. The transmission of TB is directly associated with large population gatherings and poor housing and sanitation conditions, food insecurity, drug abuse, and restricted access to health services[1-2.] Among the most vulnerable populations more susceptible to the development of TB, the population deprived of liberty (PDL) stands out[2-3].

Currently, there are about 9.9 million people incarcerated worldwide and 3.8 million of them are in the American continent[4]. Central and South America, starting from the year 2000, saw a 206% increase in the prison population, with countries like Ecuador and El Salvador showing increases of 367% and 411%, respectively[3,5]. Brazil has the third largest prison population in the world, with 835,643 inmates (0.4% of the total population), corresponding to the country with the highest absolute number of incarcerated people in the Americas[5-6].

In prisons, the risk of developing TB is 28 to 32 times higher than in the general population, due to the physical environment, overcrowding and poor hygiene conditions, prolonged internal confinement, poorly ventilated cells, limited exposure to sunlight, and high rates of HIV infection[2-4,7-8], which worsens the health conditions and prognosis of these individuals.

Between 2011 and 2017, TB cases in the PDL quadrupled in Central America and more than doubled in South America[3]. In Brazil, the number of new TB cases in the PDL ranged from 5,860 in 2015 to 6,773 in 2021, with an increase of 15.6%, with the highest number of cases among vulnerable populations in all years of the period[9]. The incidence of the disease in the PDL is heterogeneous among Brazilian states, with some showing values much higher than the national incidence[4.8,10].

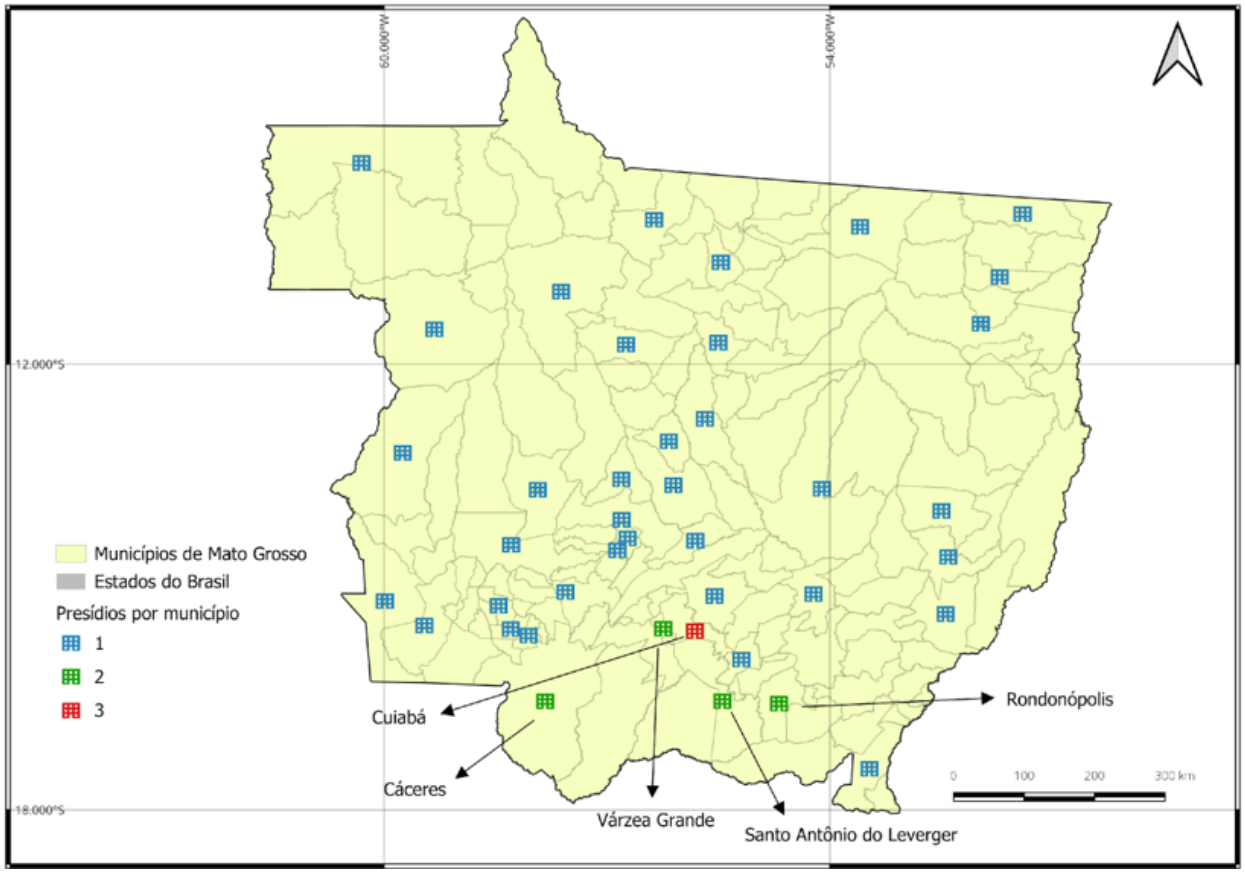
There is a growing number of studies on the incidence and implications of TB in PDL, in Brazil and in some Brazilian states[4,7-8,11-13]. However, no studies were identified in the state of Mato Grosso, despite the disease showing high endemicity in the state[9]. Therefore, this study aimed to describe the epidemiology and spatial distribution of TB in the PDL in the state of Mato Grosso, from 2014 to 2020.

METHOD

This is a descriptive study that sought to describe the incidence and characteristics of TB among the general population and the PDL, from 2014 to 2020. In addition, a spatial analysis was incorporated to examine the geographic distribution of this population in the state.

The state of Mato Grosso, whose capital is Cuiabá, is located in the Central-West region of Brazil, covering an area of 903,207.050 km^2. The estimated population of Mato Grosso in 2020 was 3,526,220 inhabitants, with a population density of 3.36 inhabitants/km^2. The PDL, in December 2020, was 16,972, allocated in 48 penal units, distributed across 41 municipalities (Figure 1). The state has a high Human Development Index (HDI) of 0.736, a GINI index of 0.461, and a per capita income of R$ 1,674.00[6.14].

Figure 1 - Map of the distribution of prisons in the municipalities of Mato Grosso, Brazil, 2020. Cuiabá, MT, Brasil, 2023



Source: Authors (2023)

The study population consisted of TB cases in individuals aged 18 years or older, reported in the Notification Diseases Information System (Sinan), from 2014 to 2020, provided in an Excel® spreadsheet by the Epidemiological Surveillance of the State Health Department of Mato Grosso on November 17, 2021. For this study, only new cases were considered, identified through the categories "new case", "unknown", and "post-mortem", present in variable number 32 of the TB notification form. The individuals marked with the category "diagnosis change", present in variable number 62 of the TB monitoring form, were excluded as they are not TB cases. The general resident population of the state was obtained from the Brazilian Institute of Geography and Statistics[6]. The state PDL, in each year of the study, and the distribution of the number of existing prisons in these locations were obtained from the Information System of the National Penitentiary Department (SISDEPEN)[15].

The variables of interest regarding the sociodemographic information of the cases were: age, sex, race/color, education, Federation Unit (UF), municipality of residence, and special populations - PDL. The variables of interest regarding the clinical information of TB were: date of diagnosis, type of entry, form, associated diseases and conditions, HIV, antiretroviral therapy during TB treatment (for people living with HIV - PLHIV), directly observed treatment (DOT), and closure status. The diagnostic tests, the sputum bacilloscopy, the culture, and the rapid molecular test were grouped into a single variable, so that the performance of any of the three tests was considered sufficient for the laboratory confirmation of TB. For the calculation of incidence, the variable municipality of residence was used for both the general population and the PDL.

For the incidence estimate, the numerator was taken as the number of TB cases reported according to the municipality of residence divided by the resident population and/or PDL

registered in SISPEDEN. Subsequently, the result was multiplied by 100,000. The rates were presented in annual series and calculated for the state of Mato Grosso, as well as for its municipalities. The diagnosis date was used to define the year of the new case.

A descriptive analysis was conducted in order to understand the characteristics of the study population. For the discrete variables, frequencies were calculated and the chi-square test was used to compare them and their respective *p-values*. Continuous variables were described by the mean and median. The statistical analysis of the data was performed in the IBM SPSS *Statistics* 25 program.

The incidence rates were still used for the analysis of spatial clusters Gi* by Getis and Ord (1992)[16], which uses the neighborhood matrix for identifying local association. The analysis of clusters through the Gi* statistic uses the visualization tool of *clusters* "*hot spot*" or hot areas and "*cold spot*" or cold areas in the municipalities of the state of Mato Grosso. In this statistic, the clusters of high values (*hot spot*) represent the presence of high occurrence rates and the clusters of low values (*cold spot*) represent the existence of low rates in the observed locations, both identified through the significant *p-value*[17].

For this study, the method for the neighborhood criterion was the order 1 Queen type model, considering neighboring municipalities those that share common borders with the municipality under observation[18]. The calculation of the spatial statistic Gi* is represented as: i) *Wij* value in the proximity matrix for region *i* with region *j* as a function of distance (d); ii) *xi* and *xj* are the values considered in the areas *i* and *j*; and iii) *d* is the distance between the points.

$$G_i*(d)=\frac{\sum j\, w_{ij}(d)\, x_j}{\sum j\, x_j}$$

Based on the results obtained, maps were created using Qgis version 3.24.3 and Geoda (http://geodacenter.github.io/).

The study was conducted in accordance with national and international ethical guidelines and approved by the Ethics Committee for Research with Human Beings of the Health Area of the Federal University of Mato Grosso (CEP-Saúde/UFMT), opinion no. 4.915.563. The patient's consent was waived as it is a study with secondary data, in the public domain, which does not allow for the identification of the individual.

RESULTS

Between 2014 and 2020, 7,201 cases of TB were reported in the state of Mato Grosso among adults, with an average of 1,028.7 cases per year, of which 6,198 were in the general population (86.0%; average of 885.42 cases per year) and 1,003 (14.0%; average of 143.3 cases per year) cases in the PDL. The incidence of TB in the PDL was higher than in the general population in all years of the analyzed period. In the general population, the incidence of TB decreased from 41.6 to 35.4 cases per 100,000 inhabitants, and in the PDL from 3,261.1 to 722.3 cases per 100,000 PDL between 2014 and 2020, respectively. Both in the general population and in the PDL, the year with the highest incidence was 2014; while the year with the lowest incidence in the general population was 2015, with 31.4 cases per 100,000 inhabitants, and in the PDL, the year was 2020, with 722.3 cases per 100,000 PDL.

In the state of Mato Grosso, between 2014 and 2020, TB predominantly affected i) males 4,987 (69.3%); ii) individuals aged between 18 and 39 years 3,262 (45.6%) (average age of 44.2 years and median of 42.0 years); iii) individuals of mixed race/color 4,205 (59.5%); and iv) those with incomplete elementary education 2,756 (36.4%). Comparing the PDL with the general population, a similar distribution of the previously observed characteristics is noted: i) a higher proportion of cases being male (91.9% vs. 65.6%, $p<0.001$); ii) in the age group between 18 and 39 years (83.8% vs. 39.5%, $p<0.001$) (mean of 31.7 years and median of 29.0 years); iii) of brown race/color (70.3% vs. 57.8%, $p<0.001$) and; iv) with incomplete elementary education (48.1% vs. 47.5%,$p<0.001$) (Table 1).

Table 1 – Sociodemographic characteristics of individuals with tuberculosis in the general population and in the incarcerated population, Mato Grosso, 2014-2020. Cuiabá, MT, Brazil, 2023

Demographic characteristics of individuals	Tuberculosis Cases						P-value
	Total n=7.201		General Population n=6.198		PPL** n=1.003		
	n	%	n	%	n	%	
Sex							
Female	2.214	30,7	2.133	34,4	81	8,1	<0,001
Male	4.987	69,3	4.065	65,6	922	91,9	
Age range (years)							
18 a 39	3.262	45,6	2.428	39,5	834	83,8	
40 a 59	2.459	34,4	2.333	37,9	126	12,7	<0,001
60 e +	1.425	19,9	1.390	22,6	35	3,5	
Average age (years)	**44,2**	**46,2**	**31,7**				
Median age (years)	42,0	45,0	29,0				
Race/Color*							
White	1.443	20,4	1.276	20,9	167	17,3	
Black	852	12,1	738	12,1	114	11,8	
Yellow	63	0,9	61	1,0	2	0,2	<0,001
Brown	4.205	59,5	3.525	57,8	680	70,3	
Indigenous	503	7,1	499	8,2	4	0,4	
Education*							
Illiterate	443	7,6	422	8,4	21	2,6	
Incomplete elementary education	2.756	47,6	2.372	47,5	384	48,1	
Complete elementary education + Incomplete or complete high school	2.107	36,4	1.731	34,7	376	47,1	<0,001
Incomplete or complete higher education	487	8,4	470	9,4	17	2,1	

Note: *The difference to the total number of cases (100%) corresponds to the number of cases ignored and blank. **PDL: Population Deprived of Liberty.

Source: Authors (2023)

Regarding clinical variables, TB predominantly presented in the pulmonary form 6,491 (90.1%), and most evolved to cure 5,408 (75.1%) and 3,207 (60.3%) of cases underwent directly observed treatment (DOT). In 622 (12.7%) cases there was TB-HIV co-infection. The most frequent associated aggravations were tobacco use 1,404 (23.5%) and alcohol use 1,129 (16.7%). Considering all diagnostic tests, laboratory confirmation was obtained in 3,651 (50.7%) of the cases. Compared to the general population, the PDL showed a higher proportion of pulmonary TB cases (95.1% vs. 89.3%, p<0.001), higher percentage of laboratory confirmation (70.4% vs. 47.5, p<0.001), of TDO (80.1% vs. 57.1%, p<0.001) and cure (90.2% vs. 75.2%, p<0.001), with the most frequent issues being tobacco use (45.8% vs. 20.7%, p<0.001) and drugs (41.4% vs. 7.6%, p<0.001). HIV was a more frequent issue in the general population than in the PDL (13.1% vs. 9.6%, p=0.027) (Table 2).

Table 2 – Clinical characteristics of individuals with tuberculosis in the general population and in the incarcerated population, Mato Grosso, 2014-2020. Cuiabá, MT, Brazil, 2023

(continue)

Clinical characteristics of individuals	Tuberculosis Cases						P-value
	Total n=7.201		General Population n=6.198		PPL** n=1.003		
	n	%	n	%	n	%	
Form							
Pulmonar	6.491	90,1	5.537	89,3	954	95,1	<0,001
Extrapulmonar	578	8,0	537	8,7	41	4,1	
Mixed	132	1,8	124	2,0	8	0,8	
Directly Observed Treatment*							
Yes	3.207	60,3	2.612	57,1	595	80,1	<0,001
No	2.109	39,7	1.961	42,9	148	19,9	
Closing Situation*							
Healing	5.408	75,1	4.526	75,2	882	90,2	<0,001
Abandonment	956	13,7	880	14,6	76	7,8	
Death by TB	219	3,1	214	3,6	5	0,5	
Death from Other Causes	413	5,9	398	6,6	15	1,5	
Laboratory confirmation							
Confirmation	3.651	50,7	2.945	47,5	706	70,4	<0,001
No confirmation	3.550	49,3	3.253	52,5	297	29,6	
HIV*							
Positive	622	12,7	574	13,1	48	9,6	0,027
Negative	4.275	87,3	3.822	86,9	453	90,4	
Antiretroviral therapy*							
Yes	431	26,4	402	27,6	29	16,7	0,002
No	1.202	73,6	1.057	72,4	145	83,3	
Alcohol Appeal*							
Yes	1.129	16,7	946	16,1	183	21,2	<0,001
No	5.621	83,3	4.942	83,9	679	78,8	

Table 2 – Clinical characteristics of individuals with tuberculosis in the general population and in the incarcerated population, Mato Grosso, 2014-2020. Cuiabá, MT, Brazil, 2023

(conclusion)

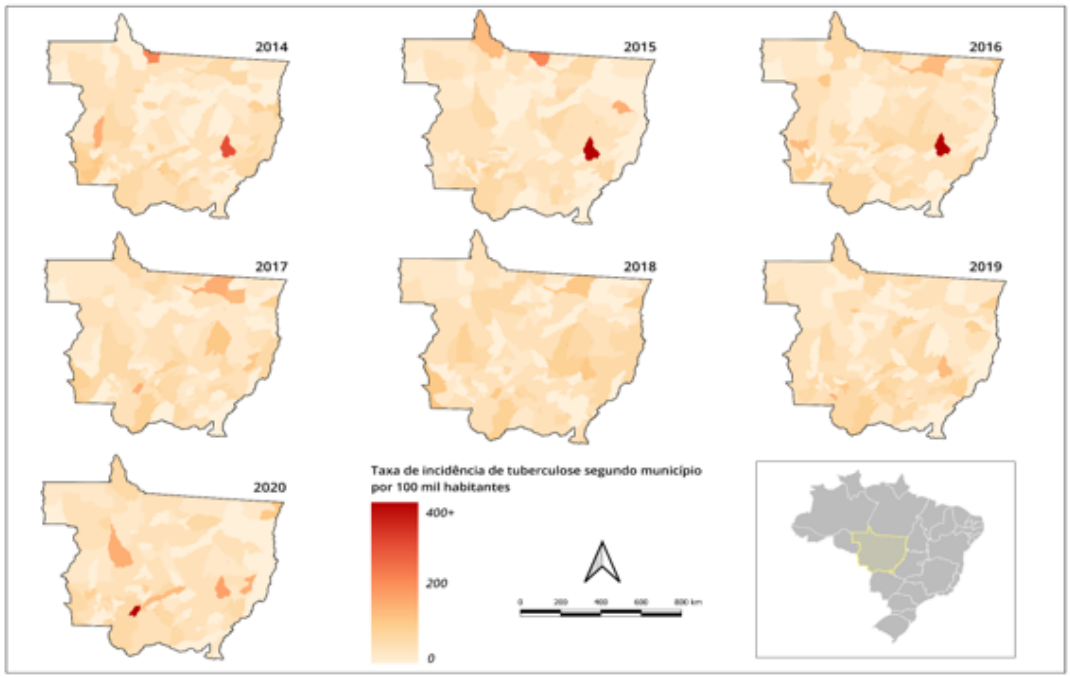
Clinical characteristics of individuals	Tuberculosis Cases						P-value
	Total n=7.201		General Population n=6.198		PPL** n=1.003		
	n	%	n	%	n	%	
Diabetes Aggravation*							
Yes	531	8,0	511	8,7	20	2,5	<0,001
No	6.127	92,0	5.359	91,3	768	97,5	
Mental Illness Appeal*							
Yes	163	2,4	131	2,2	32	3,9	0,004
No	6.504	97,6	5.715	97,8	789	96,1	
Drug Appeal*							
Yes	672	11,3	399	7,6	273	41,4	<0,001
No	5.262	88,7	4.875	92,4	387	58,6	
Tobacco Appeal*							
Yes	1.404	23,5	1.097	20,7	307	45,8	<0,001
No	4.573	76,5	4.209	79,3	364	54,2	

Note: *The difference to the total number of cases (100%) corresponds to the number of cases ignored, blank, or reported with an ongoing examination. **PDL: Population Deprived of Liberty.
Source: Authors (2023)

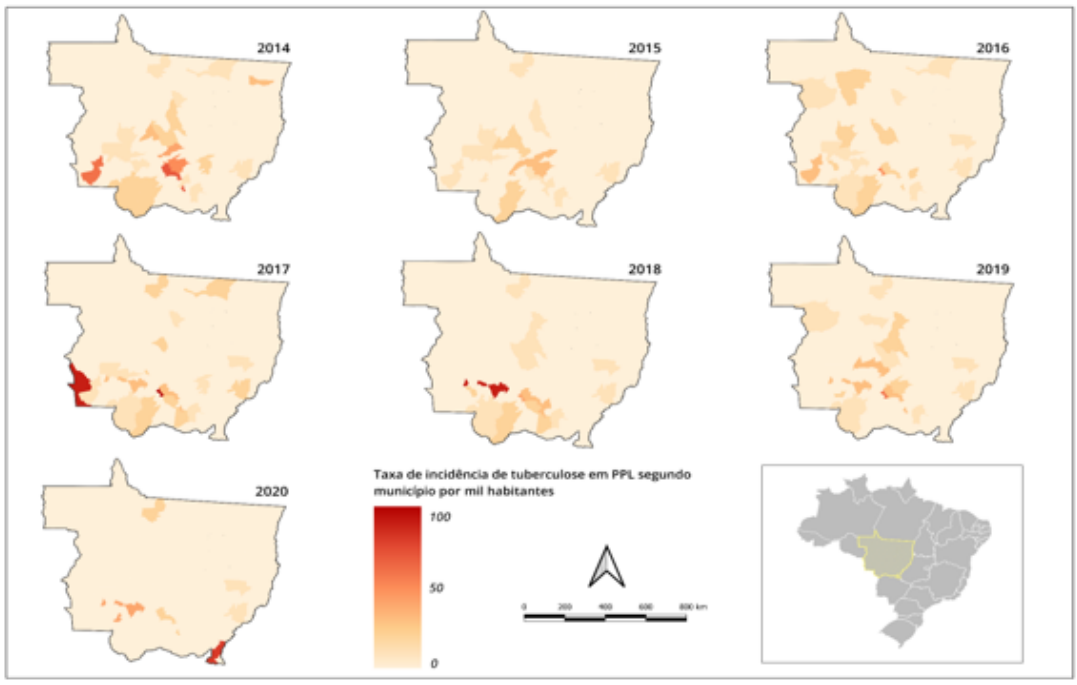
Between 2014 and 2020, specific differences were observed in the spatial distribution of TB incidences in the municipalities of the state of Mato Grosso. With some exceptions, the distribution of cases in the general population was, in a way, random. The municipality of Campinápolis reported rates that reached 1,075.4 cases/100,000 inhabitants in 2015 (population of 15,345 inhabitants in 2015), becoming an important extreme in the region, especially between 2014 and 2016. On average per year, 48 (34%) of the municipalities in Mato Grosso did not report cases of TB during the period, with this condition distributed randomly. In 2020, the municipality of Porto Estrela had high incidence rates (465.0 cases/100,000 inhabitants - population 2,877 inhabitants in 2015), not showing the same pattern in previous years (Figure 2(A)). On the other hand, the distribution of TB cases in the PDL was characteristic of the southern and southwestern regions of the state, mainly near the municipalities with the highest number of prisons, differing from the findings in the general population (Figure 2(B)).

Figure 2 - Map of incidence rates (per 100,000 inhabitants) of tuberculosis in the general population and in the incarcerated population in the municipalities of Mato Grosso, Brazil, between 2014 and 2020. Cuiabá, MT, Brazil, 2023

(A) Map of incidence rates (per 100,000 inhabitants) of tuberculosis in the general population



(B) Map of incidence rates (per 100,000 inhabitants) of tuberculosis in the incarcerated population



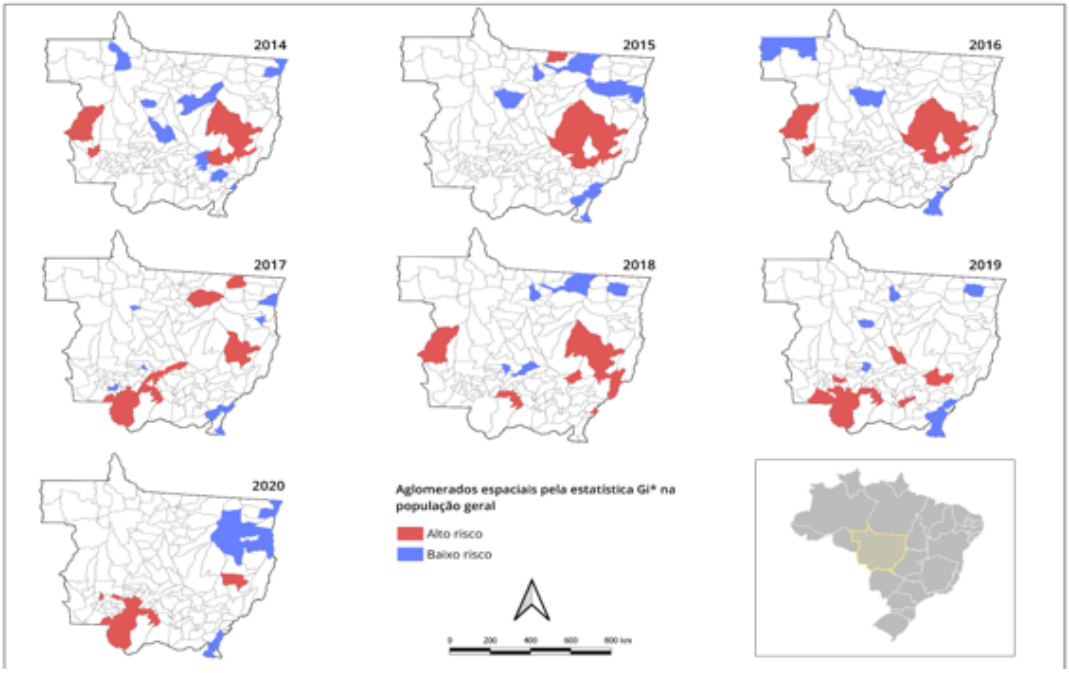
Source: Authors (2023)

The spatial clusters through the Gi* statistic allowed us to observe, in the general population, a more intense presence of high-risk clusters in the eastern regions of the state until 2018, with a slight change in this pattern for the southwest region noted in 2019 and 2020. The low-risk clusters were present in several regions of the state of Mato Grosso (Figure 3(A)). For the PDL, high-risk areas were concentrated near regions

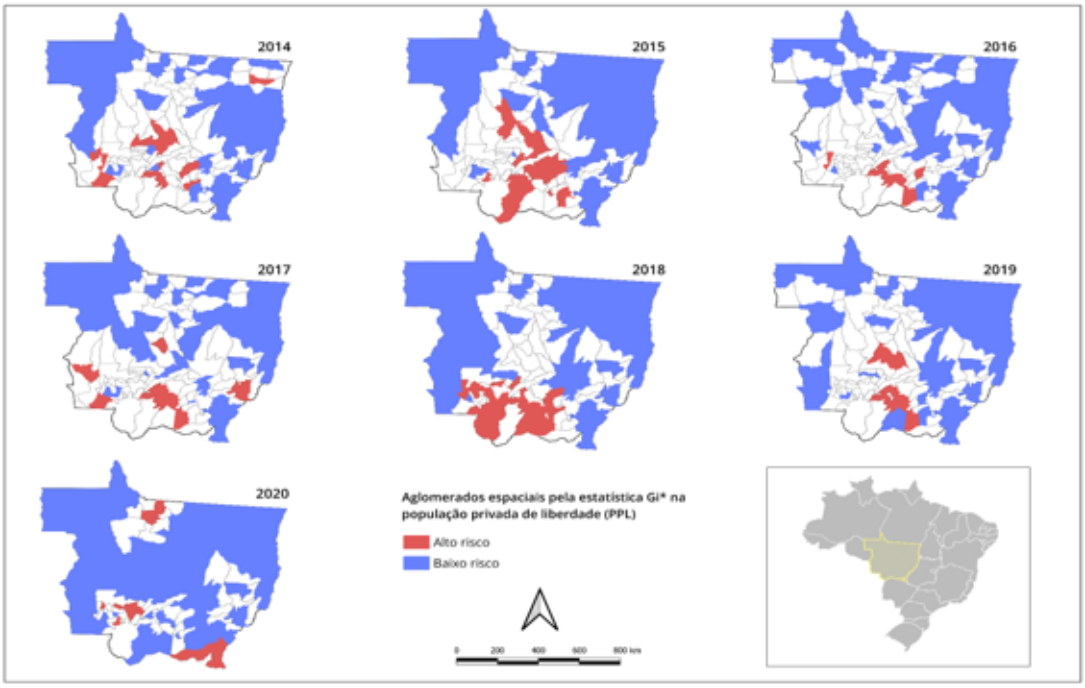
with a higher concentration of active prisons, predominantly in the central and southern regions of the state near the metropolitan area of Cuiabá, the state capital. Low-risk clusters are mainly located in the northwestern and northeastern regions of the state (Figure 3(B)).

Figure 3 - Map of spatial tuberculosis clusters in the general population and the incarcerated population by the Gi* statistic in the municipalities of Mato Grosso, Brazil, between 2014 and 2020. Cuiabá, MT, Brazil, 2023

(A) Map of spatial clusters of tuberculosis in the general population by Gi* statistics



(B) Map of spatial clusters of tuberculosis in the incarcerated population by the Gi* statistics



Source: Authors (2023)

DISCUSSION

This study provided a comprehensive and unprecedented analysis of the epidemiology of TB in the state of Mato Grosso, Brazil, from 2014 to 2020. Significant differences were observed between the general population and the PDL, especially in demographic, clinical, and occurrence regions.

The highest incidence of TB in the PDL compared to the general population suggests that transmission occurs more intensely within the prison environment and reinforces the need for preventive measures directed at the prison system. Furthermore, the proportion of TB cases in the PDL representing the total TB cases is close to the proportion reported worldwide (11%) and is higher than that reported in the country and other states of the federation[2,4,19].

The year 2020 was marked by the COVID-19 pandemic, during which restriction measures were imposed, which may have contributed to reducing TB cases. Studies have indicated a reduction in notifications due to a combination of factors, including reduced attendance at health services, reallocation of health personnel to COVID-19 actions, lower demand from symptomatic individuals for health services, reduction in the execution of laboratory tests, and consequent detection of tuberculosis[20].

The concentration of TB cases in the PDL, especially among young men (economically active age), black/brown individuals, and those with low education, emphasizes the need for specific prevention and treatment interventions in this vulnerable group. The findings regarding age, gender, and education agree with studies conducted in other states, such as Espírito Santo and São Paulo[2,19,21].

The use of tobacco and other drugs was a condition strongly associated with PLP. It is noteworthy that the use of legal or illegal drugs is a risk factor for the effectiveness of treatment, contributing to unfavorable disease outcomes[4,22].

Another condition commonly associated with TB is HIV/AIDS infection. This study found lower TB-HIV co-infection in the incarcerated population compared to the general population. A national study conducted between 2009 and 2014 corroborates the higher prevalence of HIV in the general population compared to the PDL[19]. This fact is related to the characteristics of infection transmission in Brazil, which is predominantly through sexual means[23].

The results of this study indicate that the PDL shows better treatment indicators for TB compared to the general population, such as a higher proportion of laboratory-confirmed cases, directly observed treatment (DOT), and higher cure rates, which may be attributed to closer monitoring and access to treatment within correctional institutions. The TDO is a protective factor for the treatment of TB[2]. The Ministry of Health recommends the DOT for the treatment of TB in the PDL, as it fosters the bond between the user and the health service, allows immediate access and proper management in cases of drug reactions, and prevents situations where the medication is used as a tool for exchange or pressure[24].

The spatial distribution highlighted distinct geographic patterns of TB incidence in the general population and the PDL. While the general population showed a more random distribution of cases, the PDL concentrated in areas near prisons, especially in the south and southeast of the state. It should also be emphasized that some municipalities, such as Campinápolis and Porto Estrela, recorded high rates of TB incidence in the state. This fact can be explained by the occurrence of many cases of TB, compared to

the small population of the municipality, a fact commonly reported in other Brazilian municipalities[25-26]. Thus, small municipalities suffer from the random fluctuation of cases, where one case in a very small population presents a very high rate, which may not be true to the reality of the place. Furthermore, the variability in the incidence of TB may reflect the scope and quality of the local surveillance system25 or specific factors related to access to health services, for example.

The high-risk clusters identified by spatial analysis suggest the existence of "hot spots" of TB, where transmission is more intense. Regarding the distribution of high-risk clusters for TB in the general population, it is possible to see that they are characteristic of small municipalities (between 3,224 and 31,024 inhabitants). Furthermore, the distribution further southwest refers to municipalities that border Bolivia. This fact could be justified by the exchange and population mobility characteristic of border regions, by the search for health services in Brazilian territory. At the same time, the adherence and follow-up of these people become more complex, as reported in a large part of the municipalities in Brazil that border other countries[27-28].

Notoriously, high-risk clusters in the PDL are mainly located near areas with active prisons and close to the metropolitan region of Cuiabá. Similarly, a study conducted in Paraná reported a higher concentration of TB cases in the PDL in the metropolitan region of the state, where there was a higher concentration of prison units or health services aimed at this population[29]. The incipient and incomplete implementation of the National Policy for Comprehensive Health Care for People Deprived of Liberty in the Prison System in all municipalities with active prison units in Mato Grosso contributes to the perpetuation of this scenario[30].

It is important to highlight the significant fragility of the incidence data, as not all municipalities in the state have prisons, allowing the calculation of rates only in municipalities that have prison units and restricting the visualization of the distribution of cases. Furthermore, it is important to acknowledge other limitations of this study. The data used is based on notifications and may be subject to underreporting. Another important point is that the data do not allow us to assess the influence of PDL cases on the general population, as they require further investigations.

CONCLUSION

This study allowed us to observe the differences in incidence and characterize TB in the general population and in PDL between 2014 and 2020 and, based on spatial analysis, identify the geographical distribution and the highest risk areas for TB in the study populations in Mato Grosso. The relevant share that TB cases in the PDL represent in the total number of cases occurring in the state suggests that transmission occurs more intensely within the prison environment, requiring preventive measures directed at the prison system and specific interventions focused on the prevention and treatment of the most vulnerable group, represented by male individuals aged between 18 and 39 years, of black race/color, and with incomplete elementary education. Despite this, the PDL showed higher proportions of laboratory confirmation, TDO, and cure, which highlights the importance of proper follow-up of patients in treatment. Unlike the general population, the spatial distribution of TB in the PDL and in high-risk clusters was characteristic of the southern and southeastern regions, which have a higher number of prisons, emphasizing the trend of concentration of TB cases in the PDL and in areas close to prisons.

These findings have practical implications for the formulation of public health policies and TB control strategies. Once prisons are considered institutional amplifiers or reservoirs of TB, prioritizing specific at-risk groups, such as the incarcerated population, through continuous monitoring of areas identified with high incidence may impact the reduction of the TB burden not only in prisons but also in the general population.

We suggest the development of laboratory studies to investigate the distribution of strains, identifying whether their spread in the community is influenced by the amplification of cases in the prison systems.

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Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work - **de Souza PC, Couto RM, Lacerda AB, Silva PRS, Espinoza OA, Lima JC.** Drafting the work or revising it critically for important intellectual content - **de Souza PC, Couto RM, Lacerda AB, Silva PRS, Espinoza OA, Lima JC.** Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved - **de Souza PC, Couto RM, Lacerda AB, Silva PRS, Espinoza OA, Lima JC.** All authors approved the final version of the text.

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