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Temporal trend of tuberculosis in the population deprived of Liberty in the State of Tocantins

Tendência temporal da tuberculose na população privada de Liberdade no Estado do Tocantins

Tendencia temporal de la tuberculosis en la población privada de Libertad del Estado de Tocantins

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Abstract
*Objective***:** The objective of the study was to analyze the trend of tuberculosis in the people deprived of liberty in the state of Tocantins between 2010 and 2019. *Methods***:** Study time series based on data from the Department of Informatics of the Unified Health System. Analysis of the time trend was performed using the joinpoint regression model. *Results***:** The tuberculosis incidence coefficient in PDL was 40 times higher than in the general population. According to joinpoint analysis, this indicator increased by 29.3% between 2010 and 2019 in the male PDL (APC: 29.3; CI: 13.7 to 47.1) and was stable in the female PDL (APC: 4.6; CI: - 9.1 to 20.5), the black PDL had a significant increase in tuberculosis (79.4%) between 2016 and 2019. The pulmonary clinical tuberculosis form grew 36.3% over the total period (APC: 36.3; CI: 15.6 to 60.6). All risk behaviors were responsible for the significant growth of tuberculosis cases in the PDL in the evaluated period, with smokers 23.1% (APC: 23.1; CI: 2.6 to 47.7), alcoholics 23.7% (APC: 23.7; CI: 16.6 to 31.2) and users of illicit drugs 29.8% (APC: 29.8; CI: 6.9 to 57.6). *Conclusion***:** Although the state of Tocantins has a tuberculosis rate below the national level, the disease is hyper endemic in PDL and of increasing magnitude. This epidemiological pattern reports the need for public policies focused on diagnosis and timely strategies for monitoring cases to interrupt transmission.
Keywords: Tuberculosis; Epidemiology; Time-series studies; Prisoners.

Resumo
*Objetivo***:** Analisar a tendência da tuberculose (TB) na população privada de liberdade (PPL) no estado do Tocantins no período de 2010 a 2019. *Metodologia***:** Estudo de séries temporais baseado em dados provenientes do Departamento de Informática do Sistema Único de Saúde. Análise da tendência temporal foi realizada por meio do modelo de regressão Joinpoint. *Resultados***:** O coeficiente de incidência da TB na PPL foi 40 vezes maior que na população geral. Pela análise por Joinpoint esse indicador aumentou 29,3% (IC95%: 13,7 a 47,1%) entre 2010 e 2019 na PPL masculina, e manteve-se estável na PPL feminina (APC: 4,6; IC95%: - 9,1 a 20,5%), a PPL de cor/raça-autodeclarada preta teve crescimento significativo de 79,4% (IC95%: X-X%) de TB entre 2016 e 2019. A forma clínica pulmonar cresceu 36,3% (IC95%: 15,6 a 60,6%) no período total. Todos os comportamentos de riscos foram responsáveis pelo crescimento significativo de casos de TB na PPL no período avaliado, sendo estes, tabagistas (APC: 23,1; IC95%: 2,6 a 47,7%), alcoolistas (APC: 23,7; IC95%: 16,6 a 31,2%) e usuários de drogas ilícitas (APC: 29,8;

IC95%: 6,9 a 57,6%). *Conclusão***:** Apesar de o estado do Tocantins apresentar uma taxa de tuberculose inferior a nacional, a doença é hiperendêmica na PPL e de magnitude crescente. Esse padrão epidemiológico reporta a necessidade de políticas públicas com foco no diagnóstico e tratamento oportuno com estratégias efetivas no monitoramento de casos para interrupção da transmissão.
Palavras-chave: Tuberculose; Epidemiologia; Estudos de séries temporais; População privada de liberdade.

Resumen
*Objetivo***:** El objetivo del estudio es analizar la tendencia de la tuberculosis en las personas privadas de libertad en el estado de Tocantins entre 2010 y 2019. *Métodos***:** Estudio de series de tiempo con base en datos del Departamento de Informática del Sistema Único de Salud. El análisis de la tendencia temporal se realizó mediante el modelo de regresión joinpoint. *Resultados***:** El coeficiente de incidencia de tuberculosis en PDL fue 40 veces mayor que en la población general. Según el análisis de joinpoint, este indicador aumentó un 29,3% entre 2010 y 2019 en el PDL masculino (APC: 29,3; IC: 13,7 a 47,1) y se mantuvo estable en el PDL femenino (APC: 4,6; IC: - 9,1 a 20,5), el PDL negro tuvo un aumento significativo de tuberculosis (79,4%) entre 2016 y 2019. La forma de tuberculosis clínica pulmonar creció 36,3% durante el período total (PCA: 36,3; IC: 15,6 a 60,6). Todas las conductas de riesgo fueron responsables del crecimiento significativo de casos de tuberculosis en el PDL en el período evaluado, con fumadores 23,1% (PCA: 23,1; IC: 2,6 a 47,7), alcohólicos 23,7% (PCA: 23,7; IC: 16,6 a 31,2) y usuarios de drogas ilícitas 29,8% (APC: 29,8; IC: 6,9 a 57,6). *Conclusión***:** Aunque el estado de Tocantins tiene una tasa de tuberculosis más baja que la nacional, la enfermedad es hiperendémica en PPL y de magnitud creciente. Este patrón epidemiológico reporta la necesidad de políticas públicas con foco en el diagnóstico y tratamiento oportuno con estrategias efectivas en el monitoreo de casos para interrumpir la transmisión.
Palabras clave: Tuberculosis; Epidemiología; Estudios de series de tiempo; Prisioneros.

1. Introduction

Tuberculosis is an infectious disease caused by *Mycobacterium tuberculosis* and is recognized as a major public health problem, especially in the population deprived of liberty (PDL), such as prisoners. In most Brazilian state prisons, the magnitude of tuberculosis is undefined due to inadequate health epidemiological surveillance (Macedo et al., 2020). Tuberculosis is considered one of the most deadly infectious disease in the world, ten million people fell ill with tuberculosis in 2020, with 1.3 million deaths due to complications from the disease (WHO, 2020a). Brazil has one of the highest cases worldwide, and since 2003, the disease is considered a priority on the political agenda of the Ministry of Health (MS). Even though both disease diagnosis and treatment are free of charge by the Unified Health System, barriers to access to health services still exist. In 2019 there were 76,959 new cases and 4,881 registered deaths from tuberculosis in Brazil, with an essential burden in the PDL (Brasil, 2019). The incidence and prognosis of tuberculosis are well associated with immunosuppression, such as human immunodeficiency virus (HIV) infection, health comorbidities, alcohol, and drug use. In light of this, the National Tuberculosis Control Program (PNCT) acknowledged homeless individuals, the PDL, indigenous people, and people living with HIV (PLHIV) as the most vulnerable to *M. tuberculosis* infection (Brasil, 2017; Kyu et al., 2018; Tocantins, 2019; Pelissari & Diaz-Quijano, 2020).

Due to the unhealthy environmental conditions in prisons, the consequences of confinement and the difficulty accessing health services, the PDL has a tuberculosis incidence rate 30 times higher than that of the general population (Soares Filho & Bueno, 2016; Friede, 2019; Pelissari & Diaz-Quijano, 2020; WHO, 2020b). There is an urgent need to monitor disease indicators to support the National Policy for Comprehensive Health Care for Persons Deprived of Liberty in the Prison System (PNAISP) (Brasil, 2014), considering Brazil's regional differences. In this context, this study aims to analyze the trend of tuberculosis amongst the PDL in the state of Tocantins, Brazil, between 2010 to 2019. Despite being one of the least populous states in the country, Tocantins contains a high level of tuberculosis amongst PDL.

2. Methodology

Located in the northern region of Brazil, the state of Tocantins is part of the Brazilian Amazon region and has a predominantly cerrado vegetation. It is the country's newest state, with a territorial extension of 277,622 km^2 and an estimated

population of 1,590,248 million people in 2020 (IBGE, 2020). It comprises 139 municipalities and is divided into eight health regions created by the Bipartite Interagency Commission (CIB) in 2012. There are 22 prison primary care teams within these regions and seven additional groups in place, pending assignment. These teams are multidisciplinary to provide health care to all prisoners (Tocantins, 2012).

We carried out an ecological time-series trend study based on data from the Department of Informatics of the Unified Health System (DATASUS). In this study, we included new tuberculosis incidences amongst PDL in Tocantins between 2010 to 2019. The incidence rates of tuberculosis in Tocantins are compared with the incidence rates of tuberculosis in the general and deprived population in Brazil for elucidating the magnitude of it. This study was based on secondary data from public domain tuberculosis records, available for access on the DATASUS website, whose database does not disclose people's identification. Therefore, it was not necessary to submit the study to the appreciation of an Ethics in Research Committee.

The PDL in Tocantins during the second half of 2019 was 4,481 persons. Of these, 2,237 (%) are in a closed regime, 636 (%) in a semi-open regime, 1,593 (%) in a provisional regime, five (%) in an open regime, nine (%) under security measures, and one (%) under outpatient treatment. The cases notifications of tuberculosis during the period from 2010 to 2019 in PDL was 85 cases (Datasus, 2020). TB cases with diagnostic errors and duplicate notifications are excluded.

The data were collected from the Department of Informatics of the Unified Health System, whose database is in the public domain and accessible through the site http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sinannet/cnv/tubercto.def .This data comes from the compulsory notification forms, consisting of a standardized format with sociodemographic and clinical information filled out by health professionals. Population data obtained from the Brazilian Institute of Geography and Statistics (IBGE) was based on the 2010 demographic censuses, population estimates for inter-census years (2011-2019), and data extracted from the DATASUS website (IBGE, 2020; Datasus, 2020).

The health indicators selected for analysis were based on recommendations by the national tuberculosis assessment and monitoring program. The tuberculosis incidence coefficients in the general population and the tuberculosis incidence coefficients in the PDL were selected as indicators. Of these tuberculosis indicators in the PDL, the following were assessed: incidence coefficient in the male population; incidence coefficient in the female population; incidence coefficient in the caucasian population; incidence coefficient in the black population; incidence coefficient in the yellow population; incidence coefficient in the brown population; incidence coefficient in the indigenous population; percentage of tuberculosis cases in the clinical pulmonary form; percentage of extrapulmonary tuberculosis cases; percentage of pulmonary and extrapulmonary cases; percentage of tuberculosis cases among smokers, alcoholics, and users of illicit drugs; percentage of people living with HIV and tuberculosis; HIV incidence coefficient; percentage of tuberculosis cases tested for HIV; percentage of completion of the 1st microscopy smear; percentage of completion of the 2nd microscopy smear; percentage of rapid HIV testing; percentage of performance in the sensitivity test; percentage of directly observed treatment (DOT); percentage of microscopy smear in the 6th month since diagnosis; percentage of tuberculosis cases with laboratory confirmation (Brasil, 2019).

The indicators were calculated using the Tocantins' state as the geographical unit of analysis. The tuberculosis incidence coefficients were calculated by dividing the number of cases per tuberculosis and the respective PDL populations according to the diagnosis year, with the result multiplied by 100. The descriptive analysis of the data was represented by the averages.

All analysis of the tuberculosis indicators' temporal trends in the PDL for the study period were performed using the Joinpoint regression model (by inflection points) and Poisson regression. The geographical unit for analysis was the state of Tocantins. This statistical technique regulates the adjustment of a series of lines and their inflection points on a logarithmic scale using the annual trend test (Kim et al., 2000). To obtain the best line for each segment, we used the Monte Carlo permutation method as a test for statistical significance. From the definition of the segments, the Annual Percentage Change

(APC) and the Average Annual Percentage Change (AAPC) were calculated, throughout the analyzed time-period (2010-2019), with their respective confidence interval (CI 95%) (Kim et al., 2000; Clegg et al., 2009). All Joinpoint regression analyzes were performed using the Joinpoint Regression Program version 4.1.0 (US National Cancer Institute, Bethesda, MD, USA).

3. Results

The state of Tocantins has 37 prison units in 36 municipalities, which are detailed in Table 1. Between 2010 and 2019, 85 new cases of tuberculosis were diagnosed amongst the PDL among all states.

Table 1: Data from the national prison department on the population deprived of liberty in the state of Tocantins in 2020.

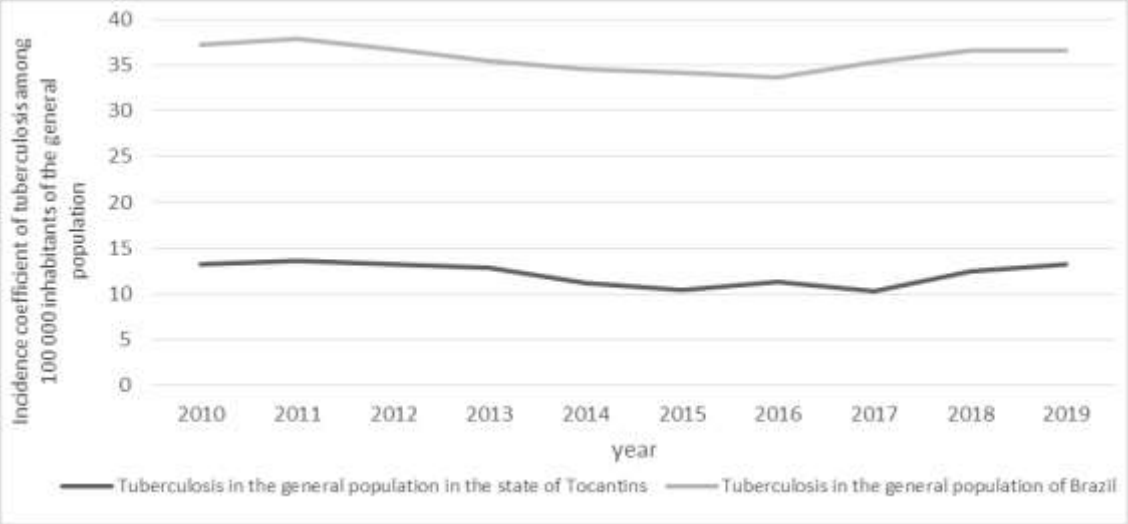
N	Municipality	Closed Regime		Semi-open Regime		Open Regime		Provisional Regime		Total*	
		N	%	N	%	N	%	N	%	N	%
1	Ananás	27	1,21%	-	-	-	-	9	0,56%	36	0,80%
2	Araguacema	28	1,25%	-	-	-	-	11	0,69%	39	0,87%
3	Araguaçu	17	0,76%	7	1,10%	-	-	8	0,50%	32	0,71%
4	Araguaína	404	18,06%	-	-	-	-	327	20,53%	736	16,42%
5	Araguatins	39	1,74%	-	-	-	-	20	1,26%	59	1,32%
6	Arapoema	12	0,54%	-	-	-	-	10	0,63%	22	0,49%
7	Arraias	52	2,32%	-	-	-	-	27	1,69%	79	1,76%
8	Augustinópolis	45	2,01%	-	-	-	-	69	4,33%	114	2,54%
9	Babaçulândia	10	0,45%	-	-	-	-	19	1,19%	29	0,65%
10	Barrolândia	24	1,07%	7	1,10%	-	-	6	0,38%	37	0,83%
11	Bernardo Sayão	19	0,85%	4	0,63%	-	-	2	0,13%	25	0,56%
12	Cariri do Tocantins	314	14,04%	10	1,57%	-	-	2	0,13%	328	7,32%
13	Colinas do Tocantins	22	0,98%	-	-	-	-	70	4,39%	92	2,05%
14	Colmeia	21	0,94%	15	2,36%	-	-	23	1,44%	59	1,32%
15	Cristalândia	38	1,70%	-	-	-	-	20	1,26%	59	1,32%

16	Dianópolis	41	1,83%	-	-	-	-	25	1,57%	66	1,47%
17	Formoso do Araguaia	36	1,61%	5	0,79%	-	-	13	0,82%	54	1,21%
18	Guaraí	88	3,93%	22	3,46%	-	-	49	3,08%	159	3,55%
19	Gurupi	12	0,54%	2	0,31%	-	-	75	4,71%	89	1,99%
20	Lajeado	8	0,36%	-	-	-	-	4	0,25%	12	0,27%
21	Miracema do Tocantins	61	2,73%	-	-	-	-	46	2,89%	107	2,39%
22	Miranorte	23	1,03%	9	1,42%	3	6-	10	0,63%	45	1,00%
23	Natividade	8	0,36%	-	-	-	-	20	1,26%	28	0,62%
24	Novo Alegre	15	0,67%	13	2,04%	-	-	5	0,31%	33	0,74%
25	Palmas	420	18,78%	417	65,57%	2	4-	388	24,36%	1229	27,43%
26	Palmeirópolis	30	1,34%	-	-	-	-	7	0,44%	37	0,83%
27	Paraíso do Tocantins	125	5,59%	51	8,02%	-	-	122	7,66%	298	6,65%
28	Paranã	26	1,16%	-	-	-	-	17	1,07%	43	0,96%
29	Pedro Afonso	17	0,76%	1	0,16%	-	-	22	1,38%	40	0,89%
30	Peixe	21	0,94%	7	1,10%	-	-	19	1,19%	47	1,05%
31	Pium	31	1,39%	6	0,94%	-	-	15	0,94%	52	1,16%
32	Porto Nacional	101	4,51%	39	6,13%	-	-	60	3,77%	200	4,46%
33	Taguatinga	30	1,34%	12	1,89%	-	-	19	1,19%	61	1,36%
34	Talismã	29	1,30%	-	-	-	-	14	0,88%	43	0,96%
35	Tocantinópolis	31	1,39%	-	-	-	-	20	1,26%	51	1,14%
36	Xambioá	12	0,54%	9	1,42%	-	-	20	1,26%	41	0,91%
	Total	**2.237**	**100%**	**636**	**100%**	**5**	**100%**	**1.593**	**100%**	**4.481**	100%

Note: *Without data from the judicial police (federal, district, and state), the police battalions, and military firefighters.
Source: Information System of the National Penitentiary Department (2021).

The average trend of the tuberculosis incidence coefficient in Tocantins' population was 12.2 (± SD) cases per 100,000 inhabitants, and in Brazil, it was 35.8 (± SD) cases per 100,000 inhabitants amongst the general population (Figure 1).

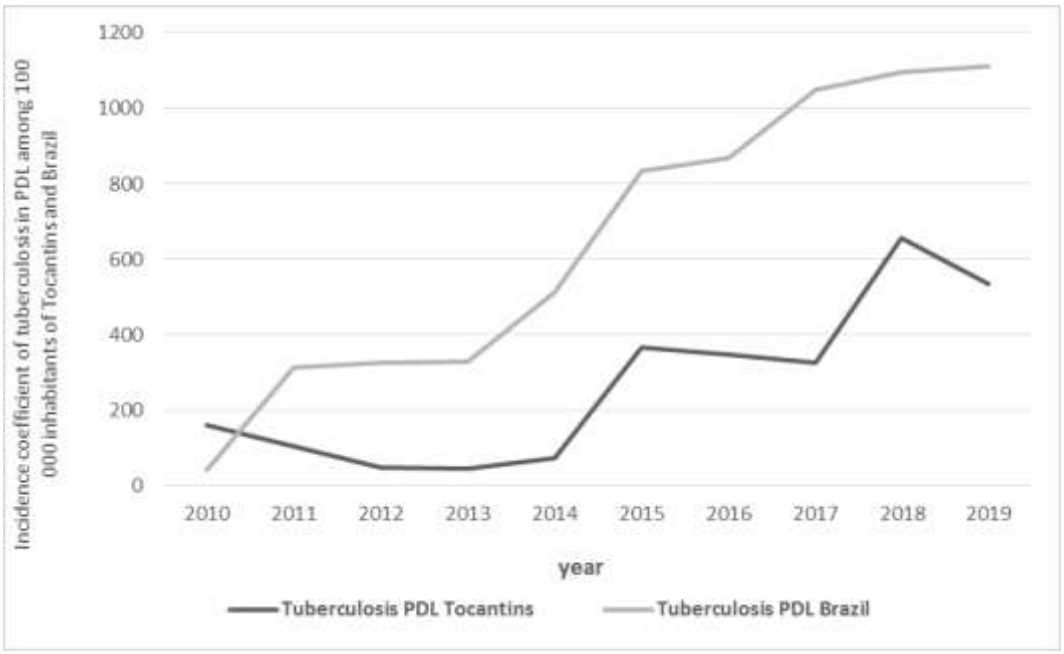
Figure 1: Tuberculosis incidence coefficient in the general population in the state of Tocantins and in Brazil, 2010 to 2019.



Source: Authors.

The average coefficient of tuberculosis incidence of the PDL in Tocantins was 265.2 cases per 100,000 inhabitants. The highest tuberculosis incidence of the Brazilian PDL was in 2018, with 655.46 cases per 100,000 inhabitants. While there was an increased tuberculosis incidence in both Brazil and Tocantins PDL, Tocantins prisons recorded the highest cases with 1112.46 (Figure 2).

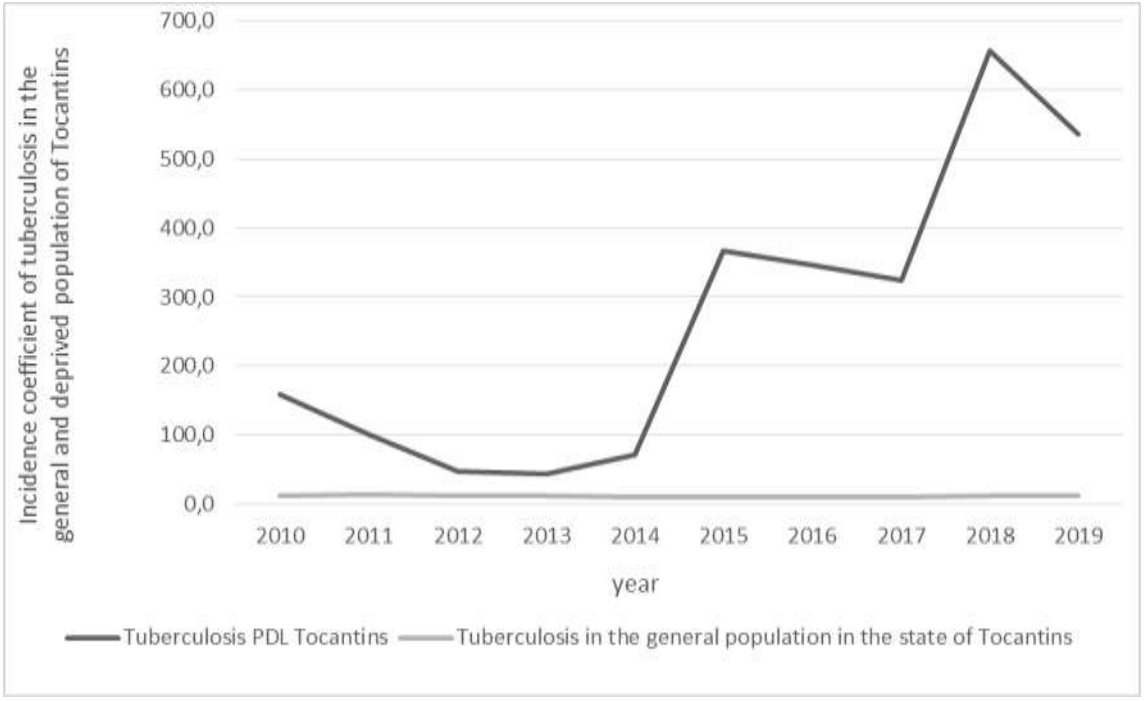
Figure 2: Tuberculosis incidence coefficient per 100 000 inhabitants in the PDL for the state of Tocantins and Brazil, from 2010 to 2019.



Source: Authors.

In 2019, the incidence coefficient of tuberculosis amongst the PDL in Tocantins was 535.6 cases per 100,000 inhabitants, while in the general population, it was 13.3 cases per 100,000 inhabitants. In the total period, the average incidence rate of tuberculosis in the PDL was 265.2 cases, and in the general population, it was 12.2 cases per 100 000 inhabitants (Figure 3).

Figure 3: Tuberculosis incidence coefficient per 100 000 inhabitants in the general population and PDL in the state of Tocantins, 2010 to 2019.



Source: Authors.

From 2010 to 2019, the tuberculosis incidence coefficient amongst the Tocantins PDL significantly increased by 20.9%, as determined by the Joinpoint regression test. In the general population, this trend dropped significantly by 4.1% (95%CI) between 2010 and 2017 (95%CI: -6.7 to -1.4%) and became stable after by 14.2% 2018 (95%CI: -5.8 to 38.4%). Between the genders, the tuberculosis incidence coefficient increased significantly by 29.3% (95%CI: 13.7 to 47.1%) between 2010 and 2019 in the male PDL. The black PDL had a significant increase of 79.4% in tuberculosis between 2016 and 2019. The percentage of the clinical pulmonary form of tuberculosis was responsible for a 36.3% (95%CI: 15.6 to 60.6%) increase in tuberculosis cases among the total period. All risk behaviors were responsible for the significant growth of tuberculosis cases in the PDL in the evaluated period, with smokers by 23.1% (95%CI: 2.6 to 47.7%), alcoholics by 23.7% (95%CI: 16.6 to 31.2%), and users of illicit drugs by 29.8% (95%CI: 6.9 to 57.6%). In the total period, the percentage of TB cases with HIV testing increased significantly by 37.5% (95%CI: 14.0 to 65.8%), as well as the other tests for monitoring cases of tuberculosis and the DOT for PDL (Table 2).

Table 2: The trend of tuberculosis health indicators in PDL according to joinpoint regression analysis in the state of Tocantins, 2010-2019.

Indicators	**Trend 1**			**Trend 2**			**Total Period**	
Tocantins	***Period***	***APC***	***IC[c]***	***Period***	***APC[b]***	***IC[c]***	***AAPC[d]***	***IC[c] 95%[a]***
Coef. incidence of TB[α] in PDL	2010-2019	20.9*	4.7 to 39.6	-	-	-	20.9*	4.7 to 39.6
Coef. incidence of TB[α] General population of Tocantins	2010-2017	-4.1*	-6.7 to -1.4	2017-2019	14.2	-5.8 a 38.4	-0.3	-3.9 to 3.4
Coef. incidence of TB[α] in men deprived of their liberty	2010-2019	29.3*	13.7 to 47.1	-	-	-	29.3*	13.7 to 47.1
Coef. incidence of TB[α] in women deprived of their liberty	2010-2019	4.6	-9.1 to 20.5	-	-	-	4.6	-9.1 to 20.5
Coef. incidence of TB[α] in people of color white PDL	2010-2019	17.2	-2.2 to 40.3	-	-	-	17.2	-2.2 to 40.3
Coef. incidence of TB[α] in the population color b lack PDL	2010-2016	-13.9	-42.9 to 29.8	2016-2019	79.4*	0.4 a 220.7	10.0	-14.8 to 42.0
Coef. incidence of TB[α] in the population colore d yellow PDL	2010-2019	-3.8	-10.5 to 3.5	-	-	-	-3.8	-10.5 to 3.5
Coef. incidence of TB[α] in brown colored PDL	2010-2019	34.0*	16.8 to 53.7	-	-	-	34.0*	16.8 to 53.7
Coef. incidence	2010-2015	45.4*	18.0 to	2015-2019	-	-54.8 a -	-2.0	-14.0 to

of TB[α] in the PDL indigenous population			79.2			40.2*	20.9		11.5	
% of pulmonary TB[α] among cases of TB[α] in PDL	2010-2019	36.3*	15.6	to 60.6	-	-	-	36.3*	15.6	to 60.6
% of extrapulmonary TB[α] among cases of TB[α] in PDL	2010-2019	4.3	-5.4	to 14.9	-	-	-	4.3	-5.4	to 14.9
% of pulmonary and extrapulmonary TB[α] among cases of TB[α] in PDL	2010-2019	5.2*	0.9 to 9.7		-	-	-	5.2*	0.9 to 9.7	
% of smokers diagnosed with TB[α] in PDL	2010-2019	23.1*	2.6	to 47.7	-	-	-	23.1*	2.6	to 47.7
% of alcoholics diagnosed with TB[α] in PDL	2010-2019	23.7*	16.6	to 31.2	-	-	-	23.7*	16.6	to 31.2
% of illicit drug users diagnosed with TB[α] in PDL	2010-2019	29.8*	6.9	to 57.6	-	-	-	29.8*	6.9	to 57.6
% of TB[α] cases in PDL with diagnostic AIDS	2010-2019	4.2	-4.4	to 13.6	-	-	-	4.2	-4.4	to 13.6
Coefficient of HIV incidence in PDL	2010-2019	-0.1	-6.4	to 6.6	-	-	-	-0.1	-6.4	to 6.6
% of people with TB[α] tested	2010-2019	37.5*	14.0	to	-	-	-	37.5*	14.0	to

for HIV in PDL			65.8						65.8		
% of completion of the 1st smear for TBα in PDL	2010-2019	35.1*	13.8	to	-	-	-	35.1*	13.8	to	
			60.4						60.4		
% of completion of the 2nd bacilloscopy for TBα in PDL	2010-2019	34.3*	11.6	to	-	-	-	34.3*	11.6	to	
			61.5						61.5		
% of rapid testing for TBα in PDL	2010-2019	38.5*	17.6	to	-	-	-	38.5*	17.6	to	
			63.1						63.1		
% of sensitivity test for TBα in PDL	2010-2019	20.3*	1.8	to	-	-	-	20.3*	1.8	to	
			42.2						42.2		
% of DOT for TBα in PDL	2010-2019	26.4*	3.2	to	-	-	-	26.4*	3.2	to	
			55.0						55.0		
% of 6th month bacilloscopy for TBα in PDL	2010-2019	39.1*	4.4	to	-	-	-	39.1*	4.4	to	
			85.5						85.5		
% of laboratory confirmation for TBα in PDL	2010-2019	33.7*	11.3	to	-	-	-	33.7*	11.3	to	
			60.7						60.7		

[a] Percentage.
[b] Annual percentage change.
[c] 95% confidence interval.
[d] Average annual percentage change.
* Significantly different from 0 (p <0.005).
[α] Tuberculosis
Source: Authors.

4. Discussion

In Tocantins, the incidence coefficient of TB in the PDL was 40 times higher than in the general population. After applying a joinpoint regression to the coefficient of TB incidence in the PDL, the health indicator trends were significantly increased (above 20%). A significant increase in the PDL who undertook risky behaviors was male and were from an

indigenous background. The data from this study indicate that the incidence of TB in the general population in Tocantins and Brazil is stable, confirmed by the incidence coefficients. This may be associated with improved living conditions and the effect of the TB control programs (Pelissari et al., 2018).

On the other hand, the descriptive results for the indicators evaluated for TB in the PDL within Brazil and Tocantins' state indicate that the country has an increasing TB burden due to the coefficients measured. This reinforces the need to strengthen control strategies through integration and intersectoral efforts. The strategy's main aims would be to enable prevention by gaining access, diagnose early, and provide opportune treatment for populations most vulnerable to the disease and in the PDL (Brasil, 2017; Kritski et al., 2018; WHO, 2020b). In this context, Brazil recently launched the National Plan for the End of TB as a Public Health Problem. This plan established strategies and actions that enable access to diagnosis and adequate treatment for vulnerable populations, such as individuals with TB and HIV co-infection and the PDL (Brasil, 2017). However, the implementation of this plan brings challenges in the face of the TB epidemic in prisons, such as regional differences and the Ministry of Health's political will.

Despite progress in reducing TB morbidity and mortality in the country, this progress is not homogeneous across states. It is insufficient to achieve the global goals agreed to end TB (Kritski et al., 2018). We also verify this statement using a joinpoint regression analysis on the PDL health indicators in Tocantins. The data from this study report a significant increase in trends in the coefficients. We show a 30% increase in males affected with TB, reflecting the country's epidemiological scenario where most cases also occur in men (Brasil, 2019). The high incidence in men can be explained by greater exposure to *M. TB* during work activities and the frequency of risky behaviors undertaken, such as greater alcohol consumption, smoking, and drug use[1,19]. The gender difference observed in the health indicators trend may be explained by males not maintaining good self-care, low desire to access health care, and less adherence and abandonment of treatment (Kyu et al., 2018; Macedo & Maciel, 2020).

A significant increase in TB disease in the PDL is observed within the proportion of people who use drugs, consume alcohol, smoke, and are of indigenous origins. These vulnerabilities aggravate the spread and transmission of TB within the prison environment. Increased transmission is also attributed to these people's living conditions before incarceration, including being young, male, reduced schooling, drug use, comorbidities, prior TB treatment and a history of incarceration. In addition to the factors listed above, bad prison conditions also play an essential role in *M. TB* spread. These include overpopulated jail cells, poor ventilation, little sunlight, confined environment, lack of health information, and difficulty accessing health services (Brasil, 2011; Brasil, 2017; Macedo & Maciel, 2020; WHO, 2020b). Some studies corroborate the findings that new TB cases are attributed to malnutrition, HIV infection, smoking, diabetes, alcohol, and illicit drug use (Brasil, 2011; Imtiaz et al., 2017; Macedo & Maciel,2020; WHO, 2020b).

Although Tocantins, in absolute numbers, has a smaller prison population than in other states, in 2017, the occupancy rate in their prison establishments was 176%, while it was 171.62% in the country. Prisoners without conviction in Brazil was 33.29% and 43.3% in Tocantins. These data reflect prison capacities, subjecting individuals to confined spaces, leading to increased vulnerability of infection. In addition, Tocantins is the state with the most incarcerated youths under 24 (Brasil, 2019). In these prisons, overcrowding, late case detection, inadequate treatment, and non-existent and insufficient implementation of infection control measures are most likely to explain the increase in TB transmission (Baussano et al., 2010; WHO, 2020) It is noteworthy that TB is an eminently social disease, and its persistence stems from inadequate social conditions and health inequities (Bertolozzi et al., 2014; WHO, 2020).

There is an increasing trend towards HIV testing in the PDL who have a diagnosis of TB, and stability in HIV infections has significantly increased as a positive result. This highlights that efforts to control TB in the PDL in the Tocantins have increased. The assessment of HIV infections amongst TB positive inmate is essential not only important withint the

prisons but also of global importance since TB is considered the leading cause of infectious death for people living with HIV and is responsible for about 30% of deaths from AIDS (WHO, 2020a). In addition, HIV infection and associated immunological suppression are important risk factors in the development of active TB in people who acquire new *M. TB* infection or have a latent *M. TB* infection (Escritório das Nações Unidas sobre Drogas e Crime, 2007). Considering that TB and HIV epidemics are closely related, the health services provided for the PDL must align with prison administration. This cooperation will allow for effective management of anti-TB drugs and antiretroviral therapy (O'Grady et al., 2011; Kyu et al., 2018; Macedo & Maciel, 2020).

The incidence of TB in indigenous PDL showed a significant increase in the period from 2010 to 2015. In prisons in Tocantins there is no prison cell distinction for the indigenous population (Brasil, 2019). Research shows marked inequalities between the relation of the epidemiological profile of some ethnic minorities in our country regarding illness and death. For example, indigenous people have a high incidence and mortality from infectious and parasitic diseases, emphasizing respiratory problems (Basta et al., 2012; Castro et al., 2016). Indigenous people in high, medium, or low-income countries have a higher disproportionate TB incidence, but this burden varies widely between groups and regions (Tollefson et al., 2013; Castro et al., 2016). Differences in socioeconomic status lead to an increased risk of TB transmission in indigenous communities, indicating that disease prevention strategies must consider why social factors lead to unequal health outcomes among this population. This is especially important considering 80% of *M. TB* is transmitted through the indigenous community and not within family interactions (Catro et al., 2016; Sacchi et al., 2018).

Notably, the Tocantins Prison Health Program was implemented in prison units with the highest PDL in the state. Even with this program's implementation, frequent prison exchanges between units are common and introduces an important loss in the follow-up of diagnosed and under-treated TB cases. In this scenario, constant communication between health and safety professionals is essential in minimizing instances where treatment is abandoned. In addition, the Ministry of Health states that mobility in the prison system increases the risk of becoming infected with *M. TB* due to the circulation between different prison institutions, health services, and the general community, during and after incarceration (Brasil, 2014; Brasil, 2017; Brasil 2019).

The significant increase in the trends for laboratory diagnostic tests and disease monitoring and the DOT for TB in the PDL is a result of the actions by the prison health teams in Tocantins. The control of TB in the PDL in Tocantins requires expanding all the health service units to reach acceptable health indicators. Laboratory capacity, sufficient diagnostic tools, provision of drug treatments, integration between the TB health services to the prison systems, implementation of the DOT, and priority for health care in prisons at a political level is crucial to decrease TB incidence of TB (Dara et al., 2015; Macedo & Maciel, 2020; Brasil, 2020). The potentially modifiable risk factors for the disease (tobacco, alcohol, drugs, diabetes, and HIV) are important elements to be included in the disease control policy. These factors can increase TB risk by suppressing the immune system, especially cell-mediated immunity (Imtiaz et al., 2017; Macedo & Maciel, 2020). Therefore, efforts to prevent these health-related risk factors will substantially reduce the TB burden in prisons (Kyu et al., 2018).

This study used data from a secondary database, which may provide problems in data consistency and fulfillment, and the possibility of underreporting, which may interfere with the quality and quantity of information. This study is important since it analyzes the 10-year time trend of a deadly disease, being able to collaborate with strategies to monitor control actions and consequently improve the attention to PDL.

In short, TB incidence within PDL is an inevitable consequence of incarceration. Here, TB can be controlled through strategic actions, such as improvements to prison conditions (Brasil, 2014; Brasil, 2017; WHO, 2020b) and focusing on high-risk groups and PDL.

5. Conclusion

Although the state of Tocantins has a tuberculosis rate below the national level, the disease is hyper endemic in PDL and of increasing magnitude. This epidemiological pattern reports the need for public policies focused on diagnosis and timely strategies for monitoring cases to interrupt transmission.

This study reinforces the importance of strengthening TB control and surveillance strategies towards PDL in Tocantins. It is essential to implement the National Policy for Comprehensive Health Care for Persons Deprived of Liberty in the Prison System to improve disease control in Tocantins. For this, it is crucial to integrate prison administration and health to promote intersectoral actions that allow access for prevention control, early diagnosis, and timely and appropriate treatment of TB.

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