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ORIGINAL ARTICLE

Changes in tuberculosis control in the state of Bahia following the onset of Covid-19

Mudanças no controle da tuberculose no estado da Bahia após o início da Covid-19
Cambios en el control de la tuberculosis en el estado de Bahía tras la aparición de la Covid-19

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ABSTRACT

Background and Objectives: The Covid-19 pandemic reversed years of progress in tuberculosis control worldwide, and for the first time in over a decade, tuberculosis-related deaths increased. This study aimed to compare the epidemiological, clinical, and laboratory variables of pulmonary tuberculosis before and after the onset of Covid-19 in two territories in southern Bahia, Brazil. **Methods:** This ecological study utilized data from the Notifiable Diseases Information System (Sinan) and the Hospital Information System of the Unified Health System (SIH/SUS). The data included new pulmonary tuberculosis cases reported between 2017 and 2022, which were compared across the pre-pandemic period (2017–2019) and the post-pandemic onset period (2020–2022) in the *Costa do Descobrimento* and *Extremo Sul* territories of Bahia. **Results:** Between January 2017 and December 2022, 1,682 new pulmonary tuberculosis cases were reported, with an annual mean incidence rate of 33.5 cases per 100,000 population, and a mean mortality rate of 1.1 deaths per 100,000 population. Following the onset of Covid-19, a 3.3% increase in incidence and a 20.5% increase in mortality were observed, along with a 5.7% decrease in cure rates and a 38.6% reduction in hospital case fatality rates. Notifications of tuberculosis-HIV/Aids co-infection and cases among individuals with more than eight years of schooling increased during the pandemic. **Conclusion:** Diagnostic and treatment

gaps caused by Covid-19 may have contributed to the increased incidence and mortality of tuberculosis in southern Bahia.

Keywords: *Pulmonary Tuberculosis. Epidemiological Monitoring. Communicable Disease Control. Ecological Studies*.

RESUMO

Justificativa e Objetivos: A pandemia de Covid-19 reverteu anos de progresso no controle da tuberculose no mundo e, pela primeira vez em mais de uma década, as mortes relacionadas com a tuberculose aumentaram. Este estudo teve como objetivo comparar as variáveis epidemiológicas, clínicas e laboratoriais da tuberculose pulmonar antes e após o início da Covid-19 em dois territórios do sul da Bahia, Brasil. **Métodos:** Estudo ecológico utilizando dados do Sistema de Informação de Agravos de Notificação (Sinan) e do Sistema de Informação Hospitalar do Sistema Único de Saúde (SIH/SUS). Os dados incluíram casos novos de tuberculose pulmonar notificados entre 2017-2022, que foram comparados entre o período pré-pandemia (2017–2019) e o pós-pandemia (2020–2022) nos territórios da Costa do Descobrimento e Extremo Sul da Bahia. **Resultados:** Entre janeiro de 2017 e dezembro de 2022 foram notificados 1.682 casos novos de tuberculose pulmonar, com taxa de incidência média anual de 33,5 casos por 100 mil habitantes e taxa de mortalidade média de 1,1 óbitos por 100 mil habitantes. Após o início da Covid-19 observou-se aumento de 3,3% na incidência e de 20,5% na mortalidade, juntamente com redução de 5,7% na taxa de cura e de 38,6% na taxa de letalidade hospitalar. As notificações de coinfecção tuberculose-HIV/Aids e de casos entre indivíduos com mais de oito anos de escolaridade aumentaram durante a pandemia. **Conclusões:** As lacunas de diagnóstico e tratamento causadas pela Covid-19 podem ter contribuído para o aumento da incidência e mortalidade por tuberculose no sul da Bahia.

Descritores: *Tuberculose Pulmonar. Monitoramento Epidemiológico. Controle de Doenças Transmissíveis. Estudos Ecológicos*.

RESUMEN

Justificación y Objetivos: La Covid-19 revirtió años de progreso en el control de la tuberculosis en el mundo y, por primera vez en más de una década, aumentaron las muertes relacionadas con la tuberculosis. Este estudio tuvo como objetivo comparar las variables epidemiológicas, clínicas y de laboratorio de la tuberculosis pulmonar antes y después de la aparición de la Covid-19 en dos territorios de Bahía, Brasil. **Métodos:** Estudio ecológico utilizando datos del Sistema de Información de Enfermedades de Declaración Obligatoria (Sinan) y del Sistema de Información Hospitalaria del Sistema Único de Salud (SIH/SUS). Los datos incluyeron nuevos casos de tuberculosis pulmonar notificados entre 2017-2022, comparados entre el período prepandemia (2017-2019) y el período pospandemia (2020-2022) en la *Costa do Descobrimento* y *Extremo Sul* de Bahía. **Resultados:** Entre enero de 2017 y diciembre de 2022 se notificaron 1.682 nuevos casos de tuberculosis pulmonar, con una tasa de incidencia promedio anual de 33,5 casos por 100 mil habitantes y de mortalidad promedio de 1,1 muertes por 100 mil habitantes. Tras la aparición de la Covid-19, hubo un aumento del 3,3% en la incidencia y del 20,5% en la mortalidad, junto con una reducción del 5,7% en la curación y del 38,6% en la letalidad hospitalaria. Durante la pandemia aumentaron las notificaciones de coinfección

tuberculosis-VIH/Sida y los casos entre personas con más de ocho años de educación. **Conclusión:** Las brechas de diagnóstico y tratamiento causadas por la Covid-19 pueden haber contribuido al aumento de la incidencia y la mortalidad por tuberculosis en Bahía.

Palabras Clave: *Tuberculosis Pulmonar. Monitoreo Epidemiológico. Control De Enfermedades Transmisibles. Estudios Ecológicos*.

INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by bacteria from the *Mycobacterium tuberculosis* complex and is transmitted via airborne droplets expelled through coughing, speaking, or sneezing by individuals with untreated active pulmonary TB.[1,2] The pulmonary form is the most prevalent and is responsible for sustaining the disease's transmission chain.[1,3] The extrapulmonary form, which affects other organs and tissues, primarily occurs in individuals infected with the Human Immunodeficiency Virus (HIV).[1,3]

Considered a severe public health problem, TB has reemerged as the leading global cause of death from a single infectious agent.[4] Estimates for 2022 indicate that TB affected 10.6 million people worldwide, representing a 4.5% increase compared to 2021, and caused 1.1 million deaths.[2] Brazil accounts for one-third of TB cases in the Americas, reporting 78,000 new cases and 4,500 deaths in 2022.[2,5]

The Northeast is the region in Brazil with the second-highest number of new pulmonary TB cases, with an incidence rate of 34.9 cases per 100,000 population.[5] In the state of Bahia, where the incidence rate is 27 cases per 100,000 population, the disease predominantly affects males aged 30–49 years, individuals with brown skin color/race, low educational attainment, and negative HIV serology.[5-7] Within the state, clusters of new TB cases are concentrated in municipalities with incidence rates exceeding 40 cases per 100,000 population.[8]

Currently, research on the epidemiological profile of TB in Bahia primarily focuses on the capital, Salvador, and larger cities,[6,7,9,10] making it challenging to assess the disease's status in other territories. It is also known that TB programs worldwide faced challenges in providing essential diagnostic and treatment services during the Covid-19 pandemic.[11,12] Therefore, epidemiological monitoring of pulmonary TB in southern Bahia before and after the onset of Covid-19 is crucial for understanding the pandemic's impact on TB control in the state's socially vulnerable areas.

This study aimed to compare the epidemiological, clinical, and laboratory variables of pulmonary TB before and after the onset of Covid-19 in two territories in southern Bahia, Brazil.

METHODS

This study is an ecological analysis utilizing data from the Notifiable Diseases Information System (*Sistema de Informação de Agravos de Notificação* - Sinan) and the Hospital Information System (*Sistema de Informações Hospitalares* - SIH) of the Unified Health System (*Sistema Único de Saúde* – SUS), accessed via the online portal of the Department of Informatics of SUS. These data included new pulmonary TB cases reported among residents of municipalities within the *Costa do Descobrimento* and *Extremo Sul* territories of Bahia from 2017 to 2022. New cases of extrapulmonary tuberculosis were excluded.

Costa do Descobrimento and *Extremo Sul* are territories located in the southern region of Bahia state, comprising 21 municipalities with an estimated population of 853,039 inhabitants.[13] *Costa do Descobrimento* includes eight municipalities: Belmonte, Eunápolis, Guaratinga, Itabela, Itagimirim, Itapebi, Porto Seguro and Santa Cruz Cabrália. *Extremo Sul* consists of 13 municipalities: Alcobaça, Caravelas, Ibirapuã, Itamaraju, Itanhém, Jucuruçu, Lajedão, Medeiros Neto, Mucuri, Nova Viçosa, Prado, Teixeira de Freitas and Vereda.

Sociodemographic (age, sex, race/skin color, education level), clinical (person with Aids), and laboratory (sputum smear microscopy, culture, rapid molecular test for TB, histopathology, drug susceptibility test, HIV test) data on pulmonary TB were compared between the pre-pandemic period (2017–2019) and the post-pandemic period (2020–2022). Population estimates from 2017 to 2021, and the 2022 Population Census were used to calculate incidence and mortality rates. Hospitalizations and hospital deaths due to pulmonary TB were identified using codes A15.0 to A15.3 from the International Classification of Diseases (ICD-10).[14] The hospital case fatality rate for pulmonary TB was calculated by dividing the number of hospital deaths by the number of hospitalizations for the disease, with the result multiplied by 100.[15] The spatial distribution of pulmonary TB incidence and mortality rates was analyzed using QGIS software version 3.32.3.

Data were presented as measures of central tendency and dispersion for quantitative variables and as absolute and relative frequencies for qualitative variables. To compare the number of new cases, cured cases, deaths among new cases, and hospital deaths before and after the onset of Covid-19, the Shapiro-Wilk test was used to assess data distribution. Upon confirming normality, Student's *t*-test was applied. Pearson's Chi-square test and Fisher's Exact test were used to evaluate associations between sociodemographic, clinical, and laboratory variables across the two periods. Statistical analyses were conducted using the RStudio programming language version 2023.06.0 (RStudio Team, 250 Northern Ave, Boston, MA, USA), with a significance level of $p \leq 0.05$.

The use of secondary databases exempts this study from approval by a Research Ethics Committee, in accordance with Resolutions No. 466/2012 and No. 510/2016 of the Brazilian National Health Council.

RESULTS

From 2017 to 2022, 2,169 cases of pulmonary TB were reported, of which 1,682 (77.5%) were new cases, 166 (7.7%) were transfers, 161 (7.4%) were reentries after abandonment, 126 (5.8%) were relapses, 17 (0.8%) were postmortem entries, and the remaining 17 (0.8%) did not have their entry type specified.

The new pulmonary TB cases annual mean was 280 (±42.7). In the period before Covid-19, the mean was 274.3 (±47.3), while after its onset, it rose to 286.3 (±47.3) (Table 1). *Costa do Descobrimento* reported 862 new cases, with 438 (50.8%) occurring before the pandemic and 424 (49.2%) afterward. *Extremo Sul* da Bahia reported 820 new cases, with 385 (46.9%) reported before Covid-19 and 435 (53.1%) after the pandemic began.

Table 1. Comparison of the mean number of new pulmonary tuberculosis cases, cured cases, deaths, and hospital deaths before (2017–2019) and after the onset of the novel coronavirus disease (Covid-19) (2020–2022) in *Costa do Descobrimento* and *Extremo Sul*, Bahia, Brazil.

Variables	Mean	SD	CV (%)	p-value
New cases				
2017-2019	274.3	47.3	17.3	0.772
2020-2022	286.3	47.3	16.5	
Cured cases				
2017-2019	188.0	33.9	18.0	0.663
2020-2022	177.3	18.2	10.3	
Deaths				
2017-2019	7.7	2.1	27.1	0.234
2020-2022	10.0	2.0	20.0	
Hospital deaths				
2017-2019	5.00	1.00	20.0	**0.021**

2020-2022	2.00	1.00	50.0	

Abbreviation: CV: Coefficient of Variation. SD: Standard Deviation.

The mean incidence of new pulmonary TB cases was 33.5 (±5.4) cases per 100,000 population. *Costa do Descobrimento* recorded a mean incidence of 34.7 (±8.2) cases per 100,000 population, while Extremo Sul had a mean of 26.5 (±5.9) cases per 100,000 population (figure 1A). After the onset of Covid-19, the mean incidence of new pulmonary TB cases in the evaluated territories increased by 3.3% compared to the pre-pandemic period. In *Costa do Descobrimento*, the incidence decreased by 19.6%, whereas in *Extremo Sul*, it increased by 29.8% (table 2). The largest increases in incidence occurred in the municipalities of Itanhém, Lajedão, and Ibirapuã, while the largest decreases were observed in Itagimirim, Guaratinga, and Itapebi (table 2 and figure 2).

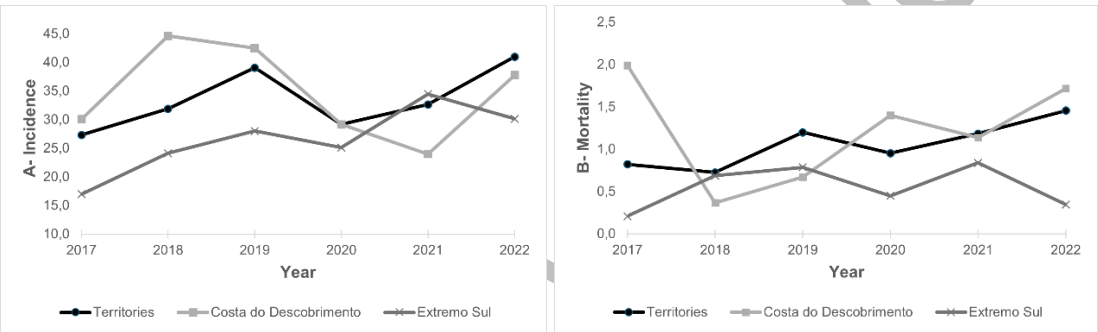

Figure 1. Distribution of pulmonary tuberculosis incidence (A) and mortality (B) rates reported in *Costa do Descobrimento* and *Extremo Sul*, Bahia, Brazil – 2017 to 2022 (*N* = 1,682).

Table 2. Comparison of pulmonary tuberculosis incidence, mortality, and hospital case fatality rates before (2017–2019) and after the onset (2020–2022) of the novel coronavirus disease (Covid-19) in *Costa do Descobrimento* and *Extremo Sul*, Bahia, Brazil.

	Incidence		Mortality		Hospital case fatality rate	
Location	**2017-2019**	**2020-2022**	**2017-2019**	**2020-2022**	**2017-2019**	**2020-2022**
Alcobaça	39.5	41.6	3.0	0.0	-	0.0
Belmonte	36.7	36.0	0.0	4.5	0.0	-
Caravelas	40.6	47.7	0.0	0.0	0.0	0.0
Eunápolis	38.8	29.8	1.2	0.0	27.1	19.8
Guaratinga	21.8	8.3	0.0	0.0	-	0.0
Ibirapuã	11.6	30.4	0.0	0.0	-	0.0
Itabela	46.6	44.0	0.0	2.7	0.0	16.7
Itagimirim	57.4	14.6	4.6	0.0	0.0	0.0
Itamaraju	36.1	34.3	0.5	0.5	10.0	0.0
Itanhém	5.1	18.0	0.0	1.7	-	0.0
Itapebi	25.6	20.7	0.0	0.0	0.0	-
Jucuruçu	17.8	29.3	0.0	0.0	0.0	-
Lajedão	8.4	25.1	0.0	0.0	-	-
Medeiros Neto	23.2	19.2	0.0	1.5	11.1	0.0
Mucuri	20.0	19.9	0.0	0.0	-	0.0
Nova Viçosa	22.3	20.9	0.0	0.8	16.7	0.0
Porto Seguro	36.4	43.6	1.1	3.5	11.1	4.2
Prado	27.0	37.7	2.4	2.4	0.0	0.0
Santa Cruz Cabrália	49.0	45.5	1.2	1.1	0.0	0.0
Teixeira de Freitas	31.6	37.9	1.4	0.2	29.6	11.1

Vereda	16.1	27.5	0.0	0.0	-	-
Costa do Descobrimento	***40.3***	***32.4***	***1.0***	***1.4***	***4.8***	***5.1***
Extremo Sul	***23.0***	***29.9***	***0.6***	***0.5***	***5.2***	***0.8***
Territories of Bahia	**29.1**	**30.1**	**0.7**	**0.9**	**13.8**	**8.4**

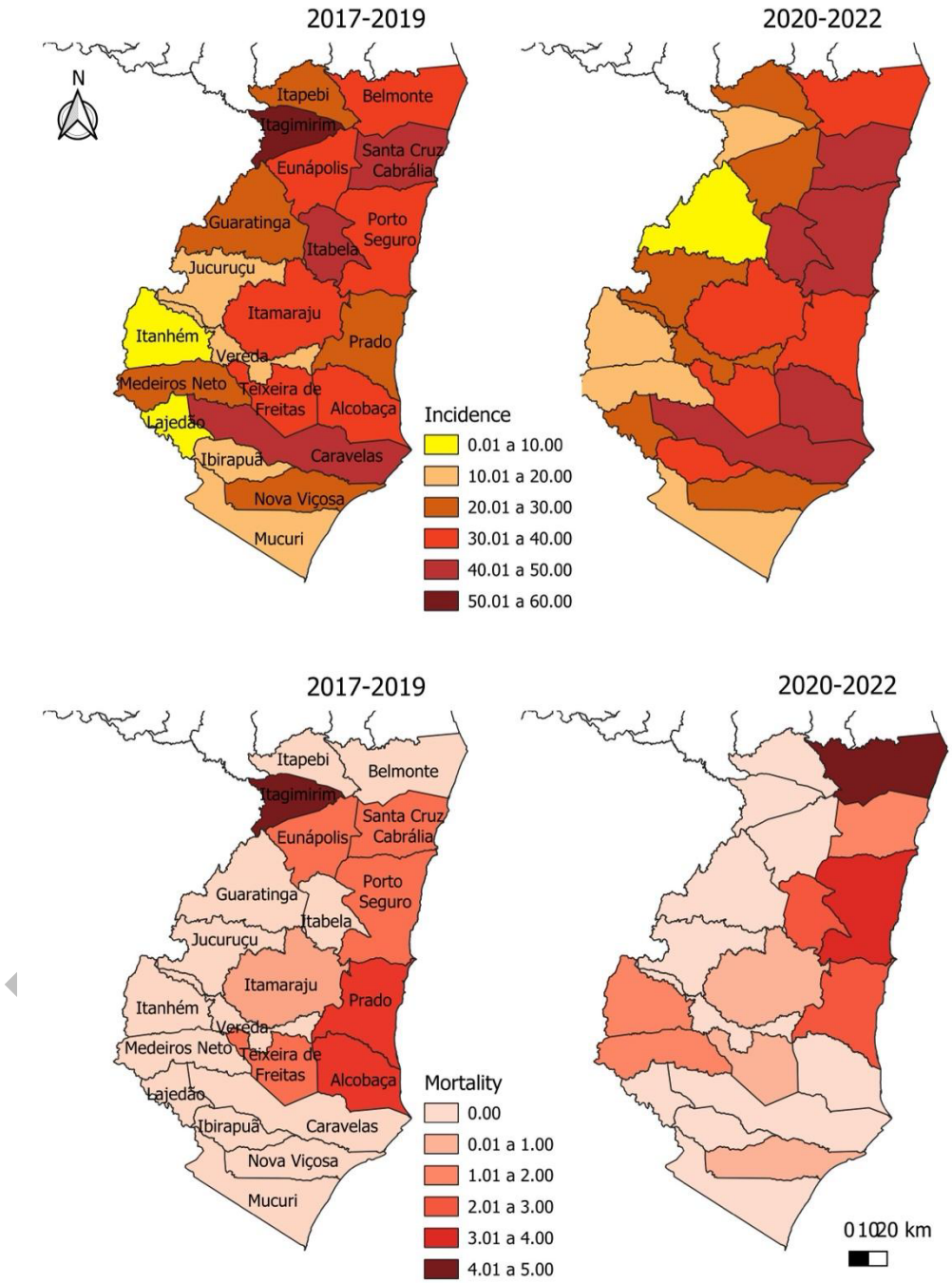

Figure 2. Comparison of incidence and mortality rates of new pulmonary tuberculosis cases in the municipalities of *Costa do Descobrimento* and *Extremo Sul*, Bahia, Brazil – 2017–2019 and 2020–2022.

Regarding sociodemographic characteristics, the majority of cases occurred among men (69.1%; n=1,163), individuals aged 20–59 years (75.7%; n=1,274), individuals of Black or mixed race (71.7%; n=793), and those with low educational attainment (71.7%; n=793).

In the analysis of associated comorbidities, 314 (18.7%) individuals reported alcoholism, 310 (18.4%) tobacco use, 148 (8.8%) illicit drug use, 145 (8.6%) diabetes, 107 (6.4%) acquired immunodeficiency syndrome (Aids), and 60 (3.6%) mental illness. After the onset of Covid-19, a 65.7% increase in TB-HIV/Aids coinfection was observed ($p = 0.026$), along with a 10.1% increase in individuals with low educational attainment ($p = 0.005$) (table 3). Although not statistically significant, there were increases of 43.9% in individuals with mental illness, 36.4% with diabetes, 15.2% among tobacco users, 7.3% among individuals with alcoholism, and 3.7% among illicit drug users.

Table 3. Comparison of sociodemographic, clinical, and laboratory characteristics of new pulmonary tuberculosis cases before (2017–2019) and after (2020–2022) the onset of the novel coronavirus disease (Covid-19) in *Costa do Descobrimento* and *Extremo Sul*, Bahia, Brazil (N = 1,682).

Variables	2017-2019 N (%)	2020-2022 N (%)	p-value
Age			
Up to 19 years	76 (9.2)	74 (8.6)	0.127
20 to 39 years	367 (44.6)	347 (40.4)	
40 to 59 years	269 (32.7)	291 (33.9)	
60 years or older	111 (13.5)	147 (17.1)	
Sex			
Male	565 (68.7)	598 (69.6)	0.707
Female	258 (31.3)	261 (30.4)	
Race/skin color			
Brown/Black	708 (88.7)	717 (87.2)	0.396
Other	90 (11.3)	105 (12.8)	
Unknown or blank*	25	37	
Education level			
≤ 8 years	455 (76.7)	338 (69.0)	**0.005**
8 years	138 (23.3)	152 (31.0)	
Unknown or blank*	218	359	
Not applicable**	12	10	
Aids			
Yes	39 (5.4)	68 (8.5)	**0.026**
No	681 (94.6)	734 (91.5)	
Unknown or blank*	103	57	
Sputum Smear Microscopy			
Positive	508 (63.8)	465 (55.7)	0.550
Negative	147 (18.4)	147 (17.6)	
Performed	655 (82.2)	612 (73.4)	**<0.001**
Not performed	142 (17.8)	222 (26.6)	
Unknown or blank*	26	25	
Culture			
Positive	109 (13.2)	143 (6.6)	1.000
Negative	42 (5.1)	55 (6.4)	
Performed/in progress	163 (19.8)	220 (26.6)	**0.005**
Not performed	660 (80.2)	639 (74.4)	
RMT-TB			
Detectable	63 (8.7)	256 (32.7)	**0.001**

Non-detectable/Inconclusive	34 (4.8)	52 (6.6)	
Performed/in progress	97 (13.3)	308 (39.4)	**<0.001**
Not performed	630 (86.7)	474 (60.6)	
Unknown or blank*	96	77	
Histopathology			
Positive	146 (19.0)	118 (15.0)	0.635
Suggestive	48 (6.2)	33 (4.2)	
Not suggestive	8 (1.0)	4 (0.5)	
Performed/in progress	241 (31.3)	206 (26.1)	**0.027**
Not performed	529 (68.7)	583 (73.9)	
Unknown or blank*	53	70	
Drug Susceptibility Test			
Resistant	4 (1.3)	4 (1.2)	0.719
Susceptible	76 (24.0)	110 (31.8)	
Performed/in progress	105 (33.2)	149 (43.1)	**0.012**
Not performed	211 (66.8)	197 (56.9)	
Unknown or blank*	507	513	
HIV Test			
Positive	44 (5.3)	71 (8.3)	0.065
Negative	634 (77.0)	696 (81.0)	
Performed/in progress	683 (83.0)	775 (90.2)	**<0.001**
Not performed	140 (17.0)	84 (9.8)	

Abbreviation: *Not included in the statistical analysis. **Individuals not of school age. HIV: Human Immunodeficiency Virus. Aids: Acquired Immunodeficiency Syndrome. RMT-TB: Rapid Molecular Test for Tuberculosis.

In the territories of *Costa do Descobrimento* and *Extremo Sul*, TB-HIV/Aids coinfection notifications increased by 50% and 100%, respectively.

Regarding laboratory findings, most individuals had negative HIV serology (79%) and positive sputum smear microscopy (59.7%). Sputum culture, histopathology, and rapid molecular testing for tuberculosis (RMT-TB) were positive in 72.2%, 73.9%, and 78.8% of the cases analyzed, respectively. After the onset of Covid-19, both the utilization of RMT-TB and the detection of mycobacteria through this method significantly increased ($p < 0.001$) (table 3). In *Costa do Descobrimento*, there was a 36% increase in HIV positivity and a significant reduction in sputum smear microscopy ($p = 0.003$) and RMT-TB performance ($p = 0.002$). In *Extremo Sul*, a significant decrease was observed in sputum smear microscopy ($p = 0.003$) and histopathological examinations ($p < 0.001$), alongside an increase in HIV testing ($p < 0.001$). Notably, there was a 1,592.9% increase in RMT-TB positivity ($p = 0.001$) in *Extremo Sul*.

Regarding case closure outcomes for new pulmonary TB cases, 1,096 (65.2%) resulted in cure, 199 (11.8%) were lost to follow-up, 106 (6.3%) were transferred, 71 (4.2%) resulted in death from other causes, 53 (3.2%) resulted in death from pulmonary TB, 39 (2.3%) had a change in diagnosis, 10 (0.6%) were primary abandonments, nine (0.5%) had a change in treatment regimen, six (0.4%) had drug-resistant TB, and four

(0.2%) were due to treatment failure. Additionally, 89 (5.3%) cases had an unspecified closure type.

The annual mean number of cured cases was 182.7 (±25.0), with 564 (51.5%) reported before Covid-19 and 532 (48.5%) after its onset. The annual mean number of deaths from pulmonary TB was 8.8 (±2.2) across both territories, with 23 (43.4%) deaths reported before the pandemic and 30 (56.6%) afterward. During the study, 180 hospitalizations for pulmonary TB were recorded, of which 109 (60.6%) occurred before Covid-19 and 71 (39.4%) afterward. Twenty-one hospital deaths from pulmonary TB were reported, with 15 (71.4%) occurring before and six (28.6%) after the pandemic began. The mean number of hospital deaths was significantly higher before the pandemic ($p = 0.021$) (table 1).

The mean mortality rate in the territories was 1.1 (±0.3) deaths from new cases per 100,000 population (figure 1B). *Costa do Descobrimento* recorded a mean mortality rate of 1.2 (±0.6) deaths per 100,000 population, while *Extremo Sul* recorded a mean of 0.5 (±0.2) deaths per 100,000 population. The mortality rate increased from 0.7 deaths per 100,000 population before the pandemic to 0.9 deaths per 100,000 population afterward, representing a 22.2% increase. During this period, the mortality rate increased by 40.6% in *Costa do Descobrimento* and decreased by 3.6% in *Extremo Sul*. The largest increases in mortality were observed in the municipalities of Itabela, Porto Seguro, and Belmonte, while the largest decreases were in Itagimirim, Alcobaça, and Eunápolis (table 2 and figure 2).

The hospital case fatality rate was 11.7%. After the onset of Covid-19, the hospital fatality rate decreased by 38.6% across both territories, increased by 6.3% in *Costa do Descobrimento*, and fell by 83.6% in *Extremo Sul*. The largest decreases in the hospital fatality rate were observed in the municipalities of Nova Viçosa, Medeiros Neto, and Itamaraju (table 2).

DISCUSSION

To expand the understanding of the sociodemographic and clinical-laboratory characteristics of pulmonary TB before and after the onset of the Covid-19 pandemic in two endemic territories in southern Bahia, this study identified an increase in incidence and mortality rates, along with a reduction in cured cases during the pandemic period.

Despite TB being a disease with universal and free diagnosis and treatment provided by the Unified Health System (SUS), barriers to healthcare access persist, with 280 new cases and 8.8 deaths reported annually in *Costa do Descobrimento* and *Extremo Sul* da Bahia.

The emergence of Covid-19 reversed years of progress in TB control worldwide.[2] Globally, during the first year of the pandemic, the reallocation of human and financial resources to address Covid-19 reduced TB control and reporting efforts, as healthcare systems focused on responding to the emergency.[11,12,16] This study aimed to identify the effects of Covid-19 in the investigated territories to inform strategies for improving coverage and access to public policies provided by SUS.

From 2017 to 2019, TB incidence rates in Brazil increased by 3.6%, contrary to the declining trend observed since 2012. In 2020, pulmonary TB incidence decreased by 9% compared to the previous year due to the pandemic. However, in 2021 and 2022, with the partial recovery of the TB care network, pulmonary TB rates increased by 14.2%, rising from 28 to 32 cases per 100,000 population.[5] Contrary to the global and Brazilian trends of increasing TB incidence,[2] a 19.6% decrease was observed in the *Costa do Descobrimento* territory. Additionally, in 2022, pulmonary TB incidence in the two evaluated territories reached 41 cases per 100,000 population, exceeding the rates calculated for the state of Bahia (23.6) and Brazil (32).[5] This high incidence may be related to an increase in undiagnosed and untreated cases during the pandemic, potentially resulting in greater community transmission.[4] Regional inequalities in healthcare access and social vulnerabilities likely contribute to the disparity between the territories' incidence rates and national data.[8,17]

The SUS provides free access to TB diagnosis and treatment throughout the country, but these actions occur unequally. Since access to health services is related to the social and residential conditions of the population, individuals living in areas with lower socioeconomic development and greater income vulnerability may face greater difficulties in accessing health care, especially in pandemic situations.[4,5] Furthermore, TB imposes an economic burden on families of patients with expenses related to indirect costs of treatment or incapacity to work, demonstrating the catastrophic costs of the disease. This economic burden can be even more damaging for individuals with precarious living conditions.[8,9]

The sociodemographic characteristics of the studied population align with observations in other parts of Bahia,[6,7] with a predominance of individuals aged 20 to 39 years (42.5%), male (69.1%), self-identified as Black or mixed race (88%), and with low educational attainment (71.7%). Low educational attainment increases vulnerability to infection as it hinders understanding of disease transmission and adherence to treatment[8,9]. However, after the onset of Covid-19, a significant increase in new pulmonary TB cases was observed among individuals with more than eight years of schooling, likely due to the interruption of healthcare services across the system, regardless of education level or income.[18]

During this period, there was also an increase in new cases among individuals aged 60 years or older, potentially related to immunosenescence and the aging population in Bahia, as the proportion of individuals in this age group has increased by nearly 50% over the past 12 years.[13] In this segment of the population, surveillance actions in primary healthcare are recommended for the early identification of respiratory symptoms, as TB's incubation period can be shortened depending on the degree of immunosuppression.[17]

People living with HIV are up to 20 times more likely to develop active TB and exhibit lower therapeutic success rates, making them a priority group for surveillance and treatment.[2] Contrary to the decreasing trend in TB/HIV coinfection observed nationally during the pandemic,[19] this study found an increase in coinfection in the *Costa do Descobrimento* and *Extremo Sul* regions of Bahia. This increase may be linked to low social development indices, as areas with inadequate socioeconomic, housing, and sanitation conditions tend to show a greater overlap of these issues.[9,18,21] The rise in coinfection cases after the onset of Covid-19 may also have resulted from expanded HIV testing coverage and the incorporation of RMT-TB in these regions, which could lead to increased dual reporting.[5]

From 2020 to 2022, diagnostic methods for TB underwent changes in the territories of interest. Despite reduced access to TB diagnostic tools during the pandemic,[11,12,16] an increase in RMT-TB usage was observed in *Extremo Sul*. This shift may have contributed to the detection of new cases after a decline during the first year of the pandemic, as RMT-TB is more sensitive in identifying mycobacteria and can also detect resistance to rifampin, the primary drug used in TB treatment regimens.[3] The reduction in histopathological testing may be attributed to difficulties in obtaining tissue

samples. When RMT-TB is available, it often becomes the preferred diagnostic method.[3] Despite the increased use of RMT-TB, sputum smear microscopy remains the most widely used diagnostic method in both territories, as it is the fastest and most cost-effective test. However, its sensitivity is lower and depends on the extent of lesions.[3]

The diagnostic and treatment gaps caused by Covid-19 led to an additional 1.5 million TB-related deaths worldwide.[2,4] Compared to 2017, Brazil's TB mortality rate increased by 22.5% in 2022, reversing years of progress achieved prior to the pandemic. In both territories, a 5.7% decrease in the number of cured new cases was observed, aligning with national and state trends.[12,21]

The 40.6% increase in the mortality rate in *Costa do Descobrimento* may have been influenced by a higher proportion of treatment abandonment and the subsequent reduction in cured cases observed in Brazil and Bahia since 2020.[12,21] Conversely, the 3.6% decrease in the mortality rate in *Extremo Sul* may have resulted from technical challenges faced by healthcare professionals in accurately classifying TB-related deaths during the pandemic, as Covid-19 was prioritized.[12]

The clinical presentation of pulmonary TB includes signs and symptoms that resemble those of Covid-19, which can interfere with proper management and accurate reporting of hospital deaths caused by TB.[3,22] During the pandemic, there was a significant reduction in the number of hospital deaths from TB in both evaluated territories, resulting in a 38.6% decrease in the hospital case fatality rate. It is worth noting that in Brazil, as in other countries, the increase in Covid-19-related hospitalizations, combined with the decline in TB-related hospitalizations, may have contributed to the reduced hospital case fatality rate for TB, even as the overall TB mortality rate increased.[23] Furthermore, active or latent TB has been identified as a risk factor for fatal outcomes in patients with Covid-19. As a result, even when TB was the underlying cause of hospital death, the death coding may have been attributed to Covid-19.[24]

The *Extremo Sul* region of Bahia demonstrated better performance in hospital case fatality and mortality rates after the onset of Covid-19. This improvement may reflect a higher number of pulmonary TB notifications with associated comorbidities, enabling a more individualized approach to patient care and, consequently, better treatment outcomes. Additionally, this region exhibited greater testing coverage and higher

positivity rates for pulmonary TB, with a significant increase in RMT-TB usage starting in 2020, which may have facilitated an improved management of close contacts.

The contribution of this study lies in identifying changes in the incidence, mortality, and hospital case fatality rates of pulmonary TB in two territories characterized by socially vulnerable populations and significant tourist activity. Although the observed changes occurred after the onset of the pandemic, the use of aggregated data does not allow for establishing Covid-19 as the direct cause or for controlling confounding variables.

Among the limitations of this study is the ecological fallacy, as the results, based on aggregated data, cannot be extrapolated to the individual level. The research analyzed notifications of new pulmonary TB cases obtained from the Sinan database, which may contain incomplete entries originating from Basic Health Units, potentially contributing to underreporting. However, Sinan distinguishes deaths from new pulmonary TB cases from other types of entries, which is not the case for notifications in the Mortality Information System.[25] Underreporting also occurs in the records of hospitalizations and hospital deaths obtained from the SUS Hospital Information System, as it only includes users admitted to public SUS facilities.

After the emergence of Covid-19, an increase was observed in the proportion of new cases among individuals with more than eight years of schooling and those with Aids, as well as greater use of RMT-TB at the expense of sputum smear microscopy and histopathological testing. TB is a significant cause of death among individuals living with HIV, and the increased detection of TB/HIV coinfection during the pandemic underscores the importance of monitoring and preventive treatment in these individuals.[19] At the municipal level, discrepancies in these measures were observed when comparing the pre- and post-Covid-19 periods. These differences may be attributed to the performance of primary healthcare in case detection and management, as well as to socio-spatial and economic inequalities. In light of these findings, this study conducted a comprehensive epidemiological evaluation of TB after the emergence of Covid-19 to assist in adapting strategies and goals for prevention, diagnosis, and treatment to combat the disease. Brazil, like other countries, has committed to eradicating TB in accordance with the targets set by the United Nations' Sustainable Development Goals and the World Health Organization's End TB Strategy.[2,5] In this context, the study identified increased use of

RMT-TB and HIV detection testing after 2020, which has contributed to greater disease detection and may support Brazil's efforts to reduce TB incidence and mortality.

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