



Temporal Trend of Tuberculosis Incidence in Brazilian Adults from 2001 to 2021

Tendência temporal da incidência de tuberculose em adultos brasileiros, no período de 2001 a 2021
Tendencia temporal de la incidencia de tuberculosis en adultos brasileños, durante el periodo de 2001 a 2021

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ABSTRACT

Background and Objectives: Tuberculosis is a communicable disease and a serious public health problem, with Brazil ranking among the countries with the highest burden of the disease. For epidemiological surveillance and tuberculosis control, time-series studies are important to investigate temporal patterns in disease occurrence. The aim of this study was to analyze temporal trends in tuberculosis incidence among Brazilian adults over a 21-year period. **Methods:** We conducted an ecological epidemiological study of tuberculosis notification data for the Brazilian adult population (age 20-59 years) between 2001 and 2021, obtained from the Notifiable Diseases Information System (SINAN). We calculated overall incidence and specific rates by sex, age group, and clinical form. Temporal trends were analyzed using the Prais-Winsten regression model, and Annual Percent Change (APC) was estimated. **Results:** A total of 1,446,499 adult cases of tuberculosis were reported in Brazil, and a decreasing trend was observed for overall incidence ($\beta = -0.005$; $p < 0.001$; APC = -1.3%). Regarding age group, sex, and clinical form, all strata showed a decreasing trend, except for the 20-29-year age group, which showed a stationary trend ($\beta = 0.001$; $p = 0.643$; APC = 0.2%). **Conclusion:** Notwithstanding the stationery trend in the 20-29-year age group, there was a decreasing trend in the overall incidence rate of tuberculosis in Brazilian adults, although this remains far from global targets for disease control. The findings highlight that Brazil still faces major challenges for tuberculosis prevention and control.

Keywords: Ecological Studies. Epidemiology. Tuberculosis. Health Indicators. Public Health.

RESUMO

Justificativa e Objetivos: a tuberculose é uma doença infectocontagiosa, considerada um grave problema de saúde pública, e o Brasil se encontra entre os países com maior carga da doença. Considerando a vigilância epidemiológica e controle da tuberculose, os estudos de séries temporais são importantes para investigar os padrões de variação da doença. Assim, este estudo objetivou analisar a tendência temporal da incidência de tuberculose em adultos brasileiros, em um período de 21 anos. **Métodos:** estudo epidemiológico do tipo ecológico, cujos dados de notificação da tuberculose na população adulta brasileira (20 a 59 anos), no período de 2001 a 2021, foram extraídos do Sistema de Informação de Agravos de Notificação. Foram calculadas as taxas de incidência geral, específica por sexo, faixa etária e forma clínica. Para análise de tendência, utilizou-se o modelo de Prais-Winsten e foi calculada a Taxa de Incremento Anual (TIA). **Resultados:** foram notificados no Brasil, 1.446.499 casos de tuberculose em adultos, identificou-se tendência decrescente da incidência geral ($\beta = -0.005$; $p = <0.001$; TIA = -1,3%). Com relação à faixa etária, ao sexo e à forma clínica, todos os estratos apresentaram tendência decrescente, exceto a faixa etária de 20 a 29 anos, que apresentou tendência estacionária ($\beta = 0.001$; $p = 0.643$; TIA = 0,2%). **Conclusão:** conclui-se que, apesar da faixa etária de 20 a 29 anos manter-se estacionária, observou-se uma tendência decrescente na taxa de incidência geral de tuberculose em adultos no Brasil, estando ainda distante das metas globais de controle da doença. Ficou evidente que o Brasil possui grandes desafios para a prevenção e controle da tuberculose. **Descritores:** Estudos Ecológicos. Epidemiologia. Tuberculose. Indicadores de Saúde. Saúde Pública.

RESUMEN

Justificación y Objetivos: La tuberculosis es una enfermedad transmisible y un problema de salud pública, y Brasil se encuentra entre los países con mayor carga. En el contexto de la vigilancia y del control, los estudios de series temporales son importantes para investigar patrones de variación. Este estudio tuvo como objetivo analizar la tendencia temporal de la incidencia de tuberculosis en adultos brasileños durante un período de 21 años. **Métodos:** Se realizó un estudio epidemiológico de tipo ecológico con datos de notificación de tuberculosis en adultos brasileños (20-59 años) durante el período 2001-2021, extraídos del Sistema de Información de Agravos de Notificación (SINAN). Se calcularon tasas de incidencia globales y específicas por sexo, grupo de edad y forma clínica. La tendencia se analizó mediante el modelo de Prais-Winsten y se estimó la Tasa de Cambio Anual (TCA). **Resultados:** Se notificaron 1.446.499 casos de tuberculosis y se observó una tendencia descendente en la incidencia global ($\beta = -0.005$; $p < 0.001$; TCA = -1,3%). Por grupo de edad, sexo y forma clínica, todos los estratos presentaron una tendencia descendente, excepto el grupo de 20-29 años, que presentó una tendencia estacionaria ($\beta = 0.001$; $p = 0.643$; TCA = 0,2%). **Conclusiones:** Aunque el grupo de 20-29 años presentó una tendencia estacionaria, se observó tendencia descendente en la tasa de incidencia global de tuberculosis en Brasil, aún distante de las metas mundiales de control. Los resultados muestran que el país enfrenta grandes desafíos para la prevención y el control de la enfermedad.

Palabras Clave: Estudios Ecológicos. Epidemiología. Tuberculosis. Indicadores de Salud. Salud Pública.

INTRODUCTION

Tuberculosis is an infectious disease considered a major global public health problem. It primarily affects the lungs; however, it is important to note that the disease can also affect other organs, such as the bones, kidneys, meninges, skin, and lymph nodes, constituting the extrapulmonary form of the disease.¹

Advances in tuberculosis control over the past decades worldwide have contributed to a reduction in its incidence and mortality. However, it remains one of the deadliest infectious diseases.² In 2019, tuberculosis was the most common cause of death attributable to a single infectious pathogen. Globally, an estimated 10 million people developed tuberculosis disease in 2019, with an estimated 1.2 million deaths from tuberculosis among HIV-negative individuals and an additional 208,000 deaths among people living with HIV.¹

In 2024, there was an increase in the global incidence of tuberculosis, with an estimated 10.7 million people developing the disease, 1.08 million deaths among HIV-negative individuals, and 150,000 deaths among people living with HIV, resulting in a combined total of 1.23 million tuberculosis-related deaths.³ This increase in the number of cases once again made tuberculosis the leading cause of death from an infectious disease.⁴ The impact of tuberculosis on morbidity and mortality rates is directly related to the socioeconomic profile of countries, being higher in low- and middle-income countries, which account for 95% of deaths caused by the disease.⁵

Brazil is among the countries with the highest tuberculosis incidence rates. Social, economic, and demographic determinants, institutional factors related to public health services, and lifestyle factors contribute to this scenario, which has been the subject of ongoing discussions among health authorities, with the aim of reducing disease transmission.^{6,7} The End TB Strategy is an initiative of the World Health Organization (WHO) that integrates international efforts to achieve the Sustainable Development Goals (SDGs), guiding strategies for their implementation at the regional and national levels.^{7,8} From this perspective, the WHO established three targets to be achieved by 2035: to reduce the tuberculosis incidence rate by 90% and the number of deaths from the disease by 95% compared with 2015 levels, as well as to eliminate the number of people affected by catastrophic costs resulting from tuberculosis.^{8,9}

In this context, although data on the decreasing trend in tuberculosis incidence rates in Brazil are available in the literature,¹⁰⁻¹² the time series are short,^{11,13} restricted to certain regions of the country¹³⁻¹⁵ and/or have gaps in stratification or in specific population groups.^{10,14,16} Therefore, studies that update this information, particularly considering recent epidemiological changes,

are essential, as time-series analysis is especially relevant for supporting health management in the formulation or reformulation of existing public health policies and the development of prevention strategies. Such analyses can assist health managers in decision-making, planning, and the implementation of new policies and programs aimed at reducing the incidence and mortality of diseases such as tuberculosis.¹⁷

In view of the above, with the aim of informing specific public health policies regarding the temporal trend of tuberculosis among the economically active Brazilian population, this study aimed to analyze the temporal trend in tuberculosis incidence among Brazilian adults over a 21-year period.

METHODS

Study Design

This was an ecological, analytical epidemiological time-series study that analyzed trends in the incidence of tuberculosis among Brazilian adults reported between 2001 and 2021. The study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (STROBE).¹⁸

Study Period and Setting

Cases reported in all Brazilian Federative Units and the Federal District were investigated from January 2001 to December 2021.

Brazil is located in the central part of South America, predominantly in the Southern Hemisphere and entirely in the Western Hemisphere, occupying nearly half of the continent (approximately 47%). It is the largest country in South America and the fifth-largest country in the world in terms of territorial area. According to the Brazilian Institute of Geography and Statistics (IBGE), Brazil is a Federative Republic that is politically and administratively organized into states, municipalities, and districts. It currently comprises 26 states and the Federal District, which together constitute the Federative Republic of Brazil; for this reason, the states are referred to as Federative Units.¹⁸ In the most recent census, conducted in 2022, Brazil's resident population was 203,080,756, of whom 116,425,264 were adults. This group represents the largest share of the national population, accounting for 57.33% of the total.¹⁹

Population, Sample, Inclusion and Exclusion Criteria

In this study, individuals aged 20 to 59 years were considered adults.²⁰ Only new and confirmed cases of tuberculosis among adults were included, based on the place of occurrence. The Ministry of Health recommends that individuals with tuberculosis be considered new cases when registered under the

following options: “new case,” “unknown,” and “post-mortem.” These categories refer to the different patient entry classifications in the health conditions notification system. “New case” refers to a patient who has never undergone tuberculosis chemotherapy; “post-mortem” refers to a case in which death due to the disease was reported; and “unknown” indicates that information regarding the patient’s status was not recorded or was incomplete.^{21,22}

The following inclusion criteria were applied: new and confirmed cases of pulmonary and extrapulmonary tuberculosis among individuals aged ≥ 20 and < 60 years. Cases with missing information on age, sex, or clinical form of tuberculosis were excluded.

Data Collection

Data were extracted from the Ministry of Health’s Notifiable Diseases Information System (SINAN) and the Brazilian Institute of Geography and Statistics (IBGE) between April and May 2024, using TabNet, available on the website of the Department of Informatics of the Brazilian Unified Health System (DATASUS). SINAN is the official system for the notification and investigation of cases of diseases and health conditions included in the national list of notifiable diseases.²³ For the extraction of data on reported tuberculosis cases from TabNet, the years, Federative Units, and the Federal District were selected. For the rows, the years were selected; for the columns, the Federative Units and the Federal District were selected; and the content consisted of confirmed cases, as described in the tutorial developed by DATASUS for generating information from the databases of the Brazilian Unified Health System (SUS).²³

Study Variables

The selected variables were: year of notification (2001 to 2021); sex (male; female); age group (in years: 20–29; 30–39; 40–49; 50–59); and clinical form of tuberculosis (pulmonary; extrapulmonary; pulmonary and extrapulmonary). Tuberculosis incidence rates were calculated annually, using the absolute number of new cases as the numerator and the estimated population aged 20 to 59 years, according to IBGE, for the same period as the denominator, expressed per 100,000 population.²¹

Data Analysis and Interpretation

The temporal trend in tuberculosis incidence in Brazil was calculated using the Prais–Winsten linear regression model. For the purposes of the analysis, the year was considered the independent variable, and the incidence rates were considered the dependent variables. This statistical method allows for the identification and quantification of trends in temporal data, such as increases or decreases in disease cases over time. Initially, a logarithmic transformation of the

variables of interest was performed, followed by the application of the Prais–Winsten autoregressive model, from which the β coefficient of the overall tuberculosis incidence rates and those stratified by sex, age group, and clinical form was obtained, corresponding to the slope of the regression line. The time series may reveal an increasing trend (p -value < 0.05 and positive β), a decreasing trend (p -value < 0.05 and negative β), or a stationary trend (p -value > 0.05 , regardless of the β value).¹⁷

Additionally, the Annual Percentage Change (APC) was calculated using the following equation:

$$APC = (-1 + 10^\beta) * 100$$

Where β is the value of the slope coefficient obtained from the linear regression.

The 95% confidence interval (95%CI) for the study measures was also calculated using the following formula:

$$95\%CI = (-1 + 10^{(\beta \pm t * SE)}) * 100$$

Where t is the value corresponding to the Student’s t -distribution with 20 degrees of freedom at a two-tailed 95% confidence level, and SE is the standard error of the estimate of β , obtained from the regression analysis. Results with p -values < 0.05 were considered statistically significant.

Ethical Considerations

The data used in this study are secondary data from publicly available sources and are unrestrictedly accessible, with no possibility of nominal identification. Therefore, submission to and review by a Research Ethics Committee involving human participants was not required.

RESULTS

Between 2001 and 2021, 1,446,499 cases of tuberculosis were reported in Brazil. However, to meet the proposed exclusion criteria, 252 cases (0.017%) were excluded, leaving 1,446,247 cases for analysis. Throughout the study period, variation was observed in the tuberculosis incidence rate among the adult population, with the lowest rate of 55.43 per 100,000 population recorded in 2020 and the highest rate of 76.77 per 100,000 population recorded in 2002. When the tuberculosis incidence rate was calculated by sex, the highest rate recorded among men was 103.77 per 100,000 population, while among women it was 50.88 per 100,000 population, both in 2002 (Table 1, Figure 1).

When the tuberculosis incidence rate was calculated by age group, the results showed that the 40–49 and 50–59-year age groups had the highest rates up to 2013 (Table 1, Figure 2). Regarding the clinical form, the highest incidence rates were observed for pulmonary tuberculosis. In the first year of the series, the incidence

rate for this clinical form was 61.54 per 100,000 population, while in the final year, the rate was 50.06 per 100,000 population. The highest rate recorded

throughout the study period occurred in 2002 (63.68 per 100,000 population) (Table 1, Figure 3).

Table 1. Tuberculosis incidence rate among adults (per 100,000 population), overall and stratified by sex, age group (years), and clinical form, Brazil, 2001–2021.

Year	Tuberculosis Incidence Rate Among Adults									
	General	By Sex		By Age Group (years)				Clinical Form		
		Male	Female	20-29	30-39	40-49	50-59	Pulmonary	Extrapulmonary	Pulmonary + Extrapulmonary
2001	73.76	99.54	48.97	62.66	76.54	84.04	78.70	61.54	9.58	2.44
2002	76.77	103.77	50.88	65.72	79.32	87.42	81.32	63.68	10.21	2.65
2003	76.05	102.79	50.51	65.88	78.38	86.64	78.77	62.94	10.16	2.62
2004	74.01	100.70	48.55	65.31	75.63	82.58	77.87	61.23	9.98	2.58
2005	71.77	98.08	46.64	64.02	72.54	80.10	75.15	59.55	9.56	2.44
2006	65.34	89.57	42.23	58.53	65.13	72.40	69.79	54.54	8.61	2.17
2007	63.72	87.98	40.63	58.28	63.57	69.64	66.88	53.03	8.48	2.23
2008	64.72	90.16	40.51	59.91	64.72	69.57	67.53	53.88	8.53	2.32
2009	63.32	88.38	39.48	60.00	63.12	66.37	65.92	52.90	8.20	2.21
2010	61.72	86.60	38.04	57.94	62.14	64.70	64.30	51.63	7.85	2.24
2011	62.10	87.88	37.44	58.31	62.46	64.81	64.72	51.66	8.05	2.15
2012	60.30	85.58	36.21	57.18	60.89	61.93	62.81	50.19	7.87	2.22
2013	59.25	84.09	35.53	56.62	59.74	60.60	61.24	49.54	7.60	2.01
2014	57.94	82.79	34.33	56.16	58.51	58.75	59.16	48.78	7.21	1.95
2015	57.28	83.03	32.74	57.85	57.10	55.86	58.41	48.84	6.71	1.89
2016	56.86	82.66	32.24	59.03	57.27	54.52	55.86	48.12	6.88	1.76
2017	59.02	87.03	32.19	64.57	58.77	54.53	56.51	50.26	6.96	1.78
2018	61.32	90.40	33.45	69.14	60.02	56.95	56.99	52.15	7.27	1.91
2019	61.36	90.43	33.46	70.19	59.83	56.67	56.34	52.13	7.43	1.79
2020	55.43	81.86	30.05	64.17	54.31	51.42	49.42	47.35	6.30	1.76
2021	58.03	85.71	31.46	66.38	56.74	54.54	52.58	50.06	6.15	1.83

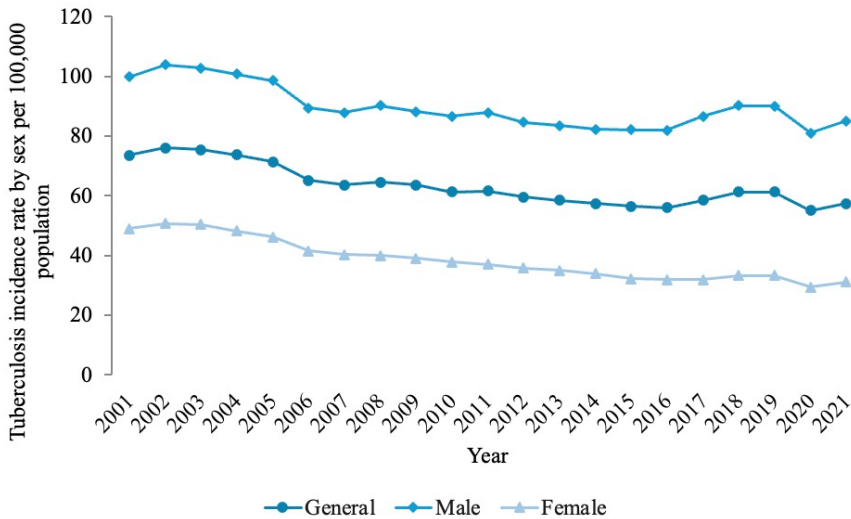


Figure 1. Overall and sex-specific tuberculosis incidence rates among adults (per 100,000 inhabitants) in Brazil from 2001 to 2021.

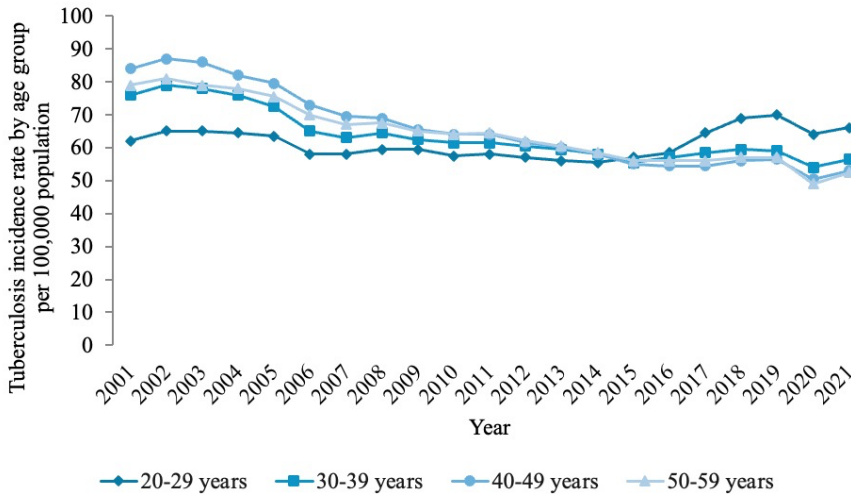


Figure 2. Tuberculosis incidence rate in adults (per 100,000 inhabitants) by age group in Brazil from 2001 to 2021.

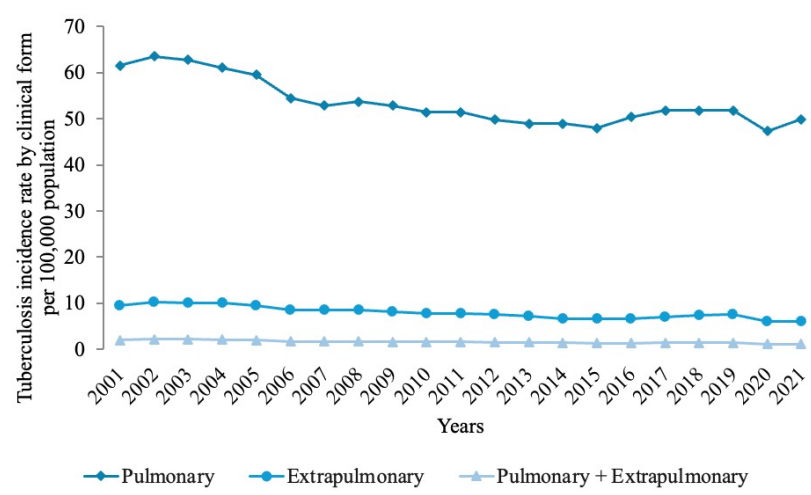


Figure 3. Tuberculosis incidence rate in adults (per 100,000 inhabitants) by clinical form of the disease in Brazil from 2001 to 2021.

It was observed that the temporal trend in the overall incidence of tuberculosis in Brazil was decreasing ($\beta = -0.005$; $p < 0.001$; APC = -1.3%), with a 1.3% annual reduction. When analyzing the trend in incidence rates according to sex, a decreasing trend was observed among males ($\beta = -0.003$; $p = 0.014$; APC = -0.8%) and females ($\beta = -0.010$; $p < 0.001$; APC = -2.4%), with a greater reduction in the temporal trend observed among females, based on the annual rate of change in this population group, compared with males. Regarding age group, among individuals aged 20–29 years, the temporal trend was stationary ($\beta = 0.001$; $p = 0.643$; APC = 0.2%), as there was no statistically significant change in the tuberculosis incidence rate over the years analyzed. For the 30–39-year age group ($\beta = -0.006$; $p < 0.001$; APC = -1.6%), 40–49-year age group ($\beta = -0.010$; $p < 0.001$; APC = -2.4%), and 50–59-year age group ($\beta = -0.009$; $p < 0.001$; APC = -2.2%), a decreasing temporal trend in tuberculosis incidence was observed. Regarding the temporal trend in tuberculosis incidence by clinical form, pulmonary ($\beta = -0.005$; $p = 0.003$; APC = -1.1%), extrapulmonary ($\beta = -0.010$; $p < 0.001$; APC = -2.3%), and pulmonary + extrapulmonary tuberculosis ($\beta = -0.008$; $p < 0.001$; APC = -2.0%) all showed a decreasing trend (Table 2).

Table 2. Temporal analysis of tuberculosis incidence rates among Brazilian adults, overall and stratified by sex, age group, and clinical form, from 2001 to 2021.

Variable	Prais-Winsten					Annual Percentage Change (APC%)			
	β	95%CI		p -value*	R^2	APC%	95%CI		Trend
		Lowest	Highest				Lowest	Highest	
General	-0.005	-0.008	-0.002	<0.001	0.992	-1.3	-2.0	-0.7	Decreasing
By sex									
Male	-0.003	-0.006	-0.000	0.014	0.992	-0.8	-1.5	-0.2	Decreasing
Female	-0.010	-0.013	-0.008	<0.001	0.991	-2.4	-3.0	1.9	Decreasing
By age group (years)									
20 - 29	0.001	-0.003	0.005	0.643	0.986	0.2	-0.8	1.3	Stationary
30 - 39	-0.006	-0.009	-0.004	<0.001	0.992	-1.6	-2.2	-0.9	Decreasing
40 - 49	-0.010	-0.013	-0.008	<0.001	0.992	-2.4	-3.0	-1.8	Decreasing
50 - 59	-0.009	-0.010	-0.008	<0.001	0.972	-2.2	-2.5	-2.0	Decreasing
Clinical form									
Pulmonary	-0.005	-0.008	-0.001	0.003	0.991	-1.1	-1.8	0.5	Decreasing
Extrapulmonary	-0.010	-0.012	-0.007	<0.001	0.952	-2.3	-6.9	2.6	Decreasing
Pulmonary + Extrapulmonary	-0.008	-0.010	-0.006	<0.001	0.865	-2.0	-2.4	-1.6	Decreasing

Abbreviation: 95%CI: Confidence interval; R²: coefficient of determination; APC: Annual Percentage Change; * Significance level: $p < 0.05$.

DISCUSSION

The tuberculosis incidence rate in Brazil showed a decreasing trend between 2001 and 2021, consistent with findings reported in the scientific literature.^{11,24} One study found that the overall tuberculosis incidence among individuals aged 20 to 59 years in Brazil showed a decreasing trend throughout the study period, from 2001 to 2017. The incidence rate decreased from 73.0 per 100,000 population in 2001 to 55.2 per 100,000 population in 2017, reflecting a continuous decline in the disease.¹¹ Another study using secondary data from 209 countries demonstrated a decline in the global tuberculosis incidence rate between 2000 and 2021, from 184 cases per 100,000 population in 2000 to 134 cases per 100,000 population in 2021. This decreasing trend was observed in several countries, including Brazil, with variations in the magnitude of the decline across different geographical areas.²⁴

The reduction in the tuberculosis incidence rate in Brazil is the result of a combination of global and national efforts aimed at addressing the disease. Starting in 1990, the implementation of the Stop TB Strategy, followed by the End TB Strategy endorsed by the World Health Organization (WHO) in 2014, brought about significant changes in the approach to tuberculosis control.⁹ This new strategy aims to end tuberculosis as a public health problem by 2035, with a 90% reduction in cases and a 95% reduction in deaths, while also minimizing the economic impact on affected families.^{3,8,9} The End TB Strategy is structured around three fundamental pillars: patient-centered care and prevention, bold policies and supportive systems, and intensified innovation and research.²⁵ These pillars aim to ensure universal access to diagnosis, treatment, and prevention without catastrophic costs for patients. The integration of these actions is essential for detecting and treating active tuberculosis, preventing new cases, and ensuring a multisectoral response to the disease.⁹

In Brazil, effective public policies, such as the Brazilian Unified Health System (SUS) and the Bolsa Família Program (PBF), have contributed to effective tuberculosis control in the country.⁵ Universal health coverage, free access to tuberculosis diagnosis and treatment through the SUS, and high BCG vaccination coverage are key factors contributing to this achievement. Additionally, the Family Health Strategy (FHS) and directly observed treatment (DOT) have contributed to reducing the incidence of the disease.²⁶

Although progress has been made in tuberculosis control, the disease continues to disproportionately affect vulnerable populations, such as people experiencing homelessness, incarcerated individuals, Indigenous communities, and people living with

HIV/AIDS.⁶ To address these challenges, it is essential to invest in intersectoral coordination and the development of public policies that address the social determinants of tuberculosis through integrated and multisectoral actions.⁵ Such initiatives should ensure equitable access to prevention, early diagnosis, and appropriate treatment, with particular attention to vulnerable populations.²⁷

In this study, when the trend in tuberculosis incidence rates was analyzed by sex, a decreasing trend was observed for both sexes, although the incidence rates were considerably higher among males. The results observed are consistent with those reported in the scientific literature, which consistently indicates higher tuberculosis incidence and mortality among men in various regions of Brazil.^{28,29} In a time-series study conducted in Santa Catarina from 2010 to 2019, the highest tuberculosis incidence rate was observed among males (68.5%) in every year of the study period.²⁸ Another study conducted in Brazil reported a total of 144,804 hospitalizations due to tuberculosis in the country, with a higher prevalence among men (72.3%) during the period from 2013 to 2022.²⁹

Several hypotheses have been proposed to explain this gender difference in tuberculosis, involving biological, social, behavioral, and healthcare access factors. From a biological perspective, men may be more susceptible to infection and disease progression due to hormonal, immunological, and genetic factors.³⁰ The literature has demonstrated increased male susceptibility to *M. tuberculosis* infection due to the formation of smaller B-cell follicles in men, a factor that contributes to a less effective immune response.³⁰

From a social perspective, research indicates that men may be more exposed to risk factors for tuberculosis, such as poverty, malnutrition, smoking, alcohol use, illicit drug use, HIV infection, diabetes, silicosis, and other chronic pulmonary diseases.^{28,29,31} These factors may impair immunity and the body's resistance to *M. tuberculosis*, thereby favoring the development of the disease.³² Another aspect that deserves attention is social contact. Evidence suggests that men tend to have more social contacts outside the home than women, which may increase their exposure to and transmission of tuberculosis, particularly in workplaces and public spaces.³² Additionally, men may be less likely to seek healthcare services and may experience greater difficulty adhering to treatment, which may contribute to sustaining the chain of tuberculosis transmission.³³

When tuberculosis incidence was analyzed by age group, the population aged 20–29 years was the only group that showed a stationary trend, with an average annual variation of 0.2%, whereas the other age groups showed a decreasing trend, with average annual reductions ranging from 1.6% to 2.4%. This

phenomenon may be related to factors that influence both exposure to and susceptibility to *M. tuberculosis*. One such factor is the greater social mobility of young adults, who may move more frequently between different settings, such as schools, workplaces, and recreational venues, increasing their contact with infected individuals or people with active disease. In addition, they may spend more time in enclosed and crowded environments, such as bars, parties, and public transportation, thereby facilitating airborne transmission of the bacillus.³⁴ An additional factor that may influence the stationary trend in tuberculosis incidence among young adults is the increased susceptibility to tuberculosis–HIV coinfection in this population group.⁶

A third factor that may be associated with the stationary tuberculosis incidence rate among individuals aged 20–29 years is the harmful use of alcohol and other drugs in this population group.³⁵ Alcohol and drugs can impair the body's immune response, facilitating infection and reactivation of *M. tuberculosis*. In addition, alcohol and drug use may interfere with adherence to tuberculosis treatment, increasing the risk of treatment discontinuation, relapse, and drug resistance.³¹ The use of alcohol and other drugs may also be associated with unfavorable social and economic conditions, such as poverty, violence, and marginalization, which may hinder access to healthcare services and tuberculosis prevention.^{31,35}

Regarding the clinical form of the disease, the present study demonstrates a decreasing trend in the incidence rate across all clinical forms. This finding is comparable to that of a study that analyzed the temporal distribution of tuberculosis cases in Fortaleza, Ceará, from 2012 to 2021, which demonstrated a decrease in the incidence of pulmonary and extrapulmonary tuberculosis, but an increase in cases with both pulmonary and extrapulmonary involvement.³⁶

Despite the decreasing trend across clinical forms, this study observed a predominance of pulmonary tuberculosis, accounting for 83.98% of cases, while extrapulmonary tuberculosis and pulmonary tuberculosis associated with extrapulmonary involvement accounted for 12.59% and 3.34% of cases, respectively. This finding is consistent with the literature, which also identifies pulmonary tuberculosis as the most common form and the most relevant to public health, as it is primarily responsible for disease transmission.³⁷

The clinical form of tuberculosis depends on the interaction between the etiological agent, the host, and the environment. *M. tuberculosis* has a predilection for pulmonary tissue, particularly the upper lobes, where there is a higher oxygen concentration and lower partial pressure of carbon dioxide, favoring its growth and multiplication.³⁷ The host, in turn, may exhibit varying degrees of immunity and resistance to the bacillus,

which can influence the dissemination and localization of the disease. For example, individuals with impaired cellular immunity, such as those living with HIV, are at increased risk of developing extrapulmonary forms of tuberculosis, including meningeal, lymph node, bone, renal, and cutaneous tuberculosis, among others.⁶ The environment may also influence the clinical form of tuberculosis through factors such as population density, ventilation, lighting, hygiene, and nutrition, which can affect exposure to and the host response to the bacillus.³⁸

It should be noted that, given the nature of the study, the results obtained represent general patterns in the populations studied and should not be extrapolated to specific individuals. It is important to note that case notification rates may be influenced by behavioral factors related to healthcare-seeking behavior, as well as by the systemic issue of underreporting. These factors should be taken into account when interpreting the results. For example, the Covid-19 pandemic led to a reduction in both the demand for and provision of healthcare services, particularly in primary care, which serves as the gateway to tuberculosis diagnosis and treatment. This contributed to the underreporting of tuberculosis cases in Brazil, particularly in 2020, when the Covid-19 pandemic reached its peak.³⁹

Regarding the limitations of the study, the use of a database obtained from DATASUS should be highlighted, as it may contain incomplete data entry and/or underreporting of the disease. However, a strength of the study is the use of SINAN, a high-quality national surveillance database. It is a database widely used in Brazil for health monitoring and is an essential tool that enables the continuous consolidation of data, as well as the evaluation and monitoring of actions related to disease control in the country. It includes a large and robust study population, as well as a 21-year historical time series. Therefore, the findings of the present study not only reinforce the importance of the results, which may support health policymakers in the development and/or revision of public health policies and strategies, but also highlight their potential to serve as a reference for future research in the field.

It can be concluded that, during the period analyzed from 2001 to 2021, tuberculosis incidence rates in Brazil showed a decreasing trend, except among individuals aged 20–29 years, who showed a stationary trend. The clinical forms of tuberculosis also showed a declining pattern in incidence rates, with pulmonary tuberculosis being the most common form. This study demonstrated that Brazil remains far from achieving the global targets for tuberculosis control and faces major challenges in the prevention and control of the disease. Furthermore, the importance of data on the temporal trends in tuberculosis incidence rates was evident, playing an important role in understanding the disease

and developing control strategies to reduce its occurrence.

REFERENCES

- Chakaya J, Khan M, Ntoumi F, Aklillu E, Fatima R, Mwaba P, et al. Global Tuberculosis Report 2020 – Reflections on the Global TB burden, treatment and prevention efforts. *International Journal of Infectious Diseases*. 2021;113(1):S7–S12. <https://doi.org/10.1016/j.ijid.2021.02.107>
- World Health Organization. Global tuberculosis report 2021 [Internet]. Geneva: WHO; 2021. Disponível em: <https://www.who.int/publications/i/item/9789240037021>
- World Health Organization. Global tuberculosis report 2025 [Internet]. Geneva: WHO; 2025. Disponível em: <https://www.who.int/teams/global-programme-on-tuberculosis-and-lung-health/tb-reports/global-tuberculosis-report-2025>
- Organização Pan-Americana da Saúde, Organização Mundial da Saúde. Tuberculose ressurgiu como a principal causa de morte por doença infecciosa. Geneva: OPAS/OMS; 2024. Disponível em: <https://www.paho.org/pt/noticias/1-11-2024-tuberculose-ressurgiu-como-principal-causa-morte-por-doenca-infecciosa>
- Moreira ASR, Kritski AL, Carvalho ACC. Social determinants of health and catastrophic costs associated with the diagnosis and treatment of tuberculosis. *J Bras Pneumol*. 2020;46(5):e20200015. <https://dx.doi.org/10.36416/1806-3756/e20200015>
- Santos BA, Ribeiro CJN, Santos AD, Sousa AFL, Siqueira TS, Andrade LA, et al. Surveillance of TB-HIV coinfection in Brazil: a space-time approach. *Rev Bras Epidemiol*. 2024; 27: e240037. <https://doi.org/10.1590/1980-549720240037.2>
- Cortez AO, Melo AC, Neves LO, Resende KA, Camargos P. Tuberculosis in Brazil: one country, multiple realities. *J Bras Pneumol*. 2021;47(2):e20200119. <https://dx.doi.org/10.36416/1806-3756/e20200119>
- World Health Organization. Global tuberculosis report 2022 [Internet]. Geneva: WHO; 2022. Disponível em: <https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022>
- Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância das Doenças Transmissíveis. Brasil Livre da Tuberculose: Plano Nacional pelo Fim da Tuberculose como Problema de Saúde Pública. Brasília: Ministério da Saúde, 2017. Disponível em: https://bvsmms.saude.gov.br/bvs/publicacoes/brasil_livre_tuberculose_plano_nacional.pdf
- Silva MT, Galvão TF. Tuberculosis incidence in Brazil: time series analysis between 2001 and 2021 and projection until 2030. *Rev Bras Epidemiol*. 2024; 27: e240027. <https://doi.org/10.1590/1980-549720240027.2>
- Melo MC, Barros H, Donalisio MR. Temporal trend of tuberculosis in Brazil. *Cad. Saúde Pública* 2020; 36(6):e00081319. <https://doi.org/10.1590/0102-311X00081319>
- Guimarães RM, Lobo AP, Siqueira EA, Borges TFF, Melo SCC. Tuberculosis, HIV, and poverty: temporal trends in Brazil, the Americas, and worldwide. *J Bras Pneumol*. 2012;38(4):511–517. <https://doi.org/10.1590/S1806-37132012000400014>
- Araújo MC, Passinho RS, Pereira RS, Mora DJ. Temporal trends in incidence and mortality from pulmonary tuberculosis: time series study, Sul da Bahia, 2010–2023. *Epidemiol Serv Saúde*. 2025;34:e20240778. <https://doi.org/10.1590/S2237-96222025v34e20240778.pt>
- Traebert J, Ferrer GCN, Nazário NO, Schneider IJC, Silva RM. Temporal trends in tuberculosis-related morbidity and mortality in the state of Santa Catarina, Brazil, between 2002 and 2009. *J Bras Pneumol*. 2012;38(6):771–775. <https://doi.org/10.1590/S1806-37132012000600014>
- Giacomet CL, Santos MS, Berra TZ, Alves YM, Alves LS, Costa FBP, et al. Temporal trend of tuberculosis incidence and its spatial distribution in Macapá – Amapá. *Rev Saude Publica*. 2021;55:96. <https://doi.org/10.11606/s1518-8787.2021055003431>
- Seabra DBMH, Silva EO, Lacerda FKDFC, Goulart LS, Lessa AC, Freitas RF. Temporal trends in tuberculosis incidence among older adults in Brazil: annual analysis from 2004 to 2023. *Rev. Bras. Geriatr. Gerontol*. 2025;28:e250151. <https://doi.org/10.1590/1981-22562025028.250151.pt>
- Antunes JLF, Cardoso MRA. Uso da análise de séries temporais em estudos epidemiológicos. *Epidemiol. Serv. Saude* 2015; 24(3):565–576. <https://doi.org/10.5123/S1679-49742015000300024>
- Malta M, Cardoso LO, Bastos FI, Magnanini MMF, Silva CMFP. STROBE initiative: guidelines on reporting observational studies. *Rev Saude Pública*. 2010;44(3):559–65. <https://doi.org/10.1590/S0034-89102010000300021>
- Instituto Brasileiro de Geografia e Estatística (IBGE). Divisão Territorial. Disponível em: <https://educa.ibge.gov.br/criancas/brasil/2850-nosso-territorio/19637-divisao-territorial.html>
- Instituto Brasileiro de Geografia e Estatística (IBGE). População Brasil. Disponível em: <https://censo2022.ibge.gov.br/panorama/?localidade=BR>
- Brasil. Ministério da Saúde. Boletim Epidemiológico. Tuberculose 2024. Brasília: MS; 2024 (Número Especial) [Internet]. Disponível em: <https://www.gov.br/aidas/pt-br/central-de-conteudo/boletins-epidemiologicos/2024/boletim-epidemiologico-tuberculose-2024/@display-file/file>
- Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância das Doenças Transmissíveis. Vigilância epidemiológica da tuberculose: análise de indicadores operacionais e epidemiológicos a partir da base de dados do Sinan versão 5.0. Brasília: MS; 2016. [Internet]. Disponível em: https://portalsinan.saude.gov.br/images/documentos/Agravos/Tuberculose/Apostila_Curso_Sinan_2016.pdf
- Brasil. Ministério da Saúde. Datasus. Tecnologia da Informação a Serviço do SUS. Sistema de Informação de Agravos de Notificação (SINAN). Informações de Saúde. Doenças de Notificação – Brasil. Disponível em: <https://datasus.saude.gov.br/acesso-a-informacao/casos-de-tuberculose-desde-2001-sinan/>
- Bai W, Ameyaw EK. Global, regional and national trends in tuberculosis incidence and main risk factors: a study using data from 2000 to 2021. *BMC Public Health* 2024;24(12). <https://doi.org/10.1186/s12889-023-17495-6>
- Floyd K, Glaziou P, Zumla A, Raviglione M. The global tuberculosis epidemic and progress in care, prevention, and research: an overview in year 3 of the End TB era. *Lancet Respir Med* 2018;6(4):299–314. [https://doi.org/10.1016/s2213-2600\(18\)30057-2](https://doi.org/10.1016/s2213-2600(18)30057-2)
- Almeida MCM, Moura GVT, Cavalcante HTM, Maia KS, Castro TL, Abreu ADP, et al. Avaliação das estratégias de prevenção e controle da tuberculose no contexto da Atenção Primária à Saúde. *Revista Aracê*. 2025; 7(5): 26166–26179. <https://doi.org/10.56238/arev7n5-299>
- Macedo LR, Maciel ELN, Struchiner CJ. Vulnerable populations and tuberculosis treatment outcomes in Brazil. *Ciênc. saúde coletiva* 2021;26(10):4749–4759. <https://doi.org/10.1590/1413-812320212610.24132020>
- Pereira A, Hillesheim D, Silva FM, Valim RCS, Hallal ALC. Tuberculosis incidence rate time series in the state of Santa Catarina, Brazil: analysis of a decade, 2010–2019. *Epidemiol Serv Saúde* 2022;31(3):e20211067. <https://doi.org/10.1590/S2237-96222022000300002>
- Villas Boas FP, Silva RR, Silva NTV, Figueiredo RG. Perfil das internações por tuberculose entre os anos de 2013 e 2022 no Brasil. *Braz J Infect Dis*. 2023; 27(S1):102812. <https://doi.org/10.1016/j.bjid.2023.103647>
- Hertz D, Schneider B. Sex differences in tuberculosis. *Semin Immunopathol* 2019;41(2):225–237. <https://doi.org/10.1007/s00281-018-0725-6>
- Dlatu N, Faye LM, Apalata T. Outcomes of Treating Tuberculosis Patients with Drug-Resistant Tuberculosis, Human Immunodeficiency

Virus, and Nutritional Status: The Combined Impact of Triple Challenges in Rural Eastern Cape. *Int. J. Environ. Res. Public Health* 2025, 22(3), 319. <https://doi.org/10.3390/ijerph22030319>

32. Horton KC, Hoey AL, Béraud G, Corbett EL, White RG. Systematic Review and Meta-Analysis of Sex Differences in Social Contact Patterns and Implications for Tuberculosis Transmission and Control. *Emerg Infect Dis.* 2020; 26(5):910–919. <https://doi.org/10.3201%2Feid2605.190574>

33. Chenciner L, Annerstedt KS, Pescarini JM, Wingfield T. Social and health factors associated with unfavourable treatment outcome in adolescents and young adults with tuberculosis in Brazil: a national retrospective cohort study. *The Lancet Global Health* 2021; 9(10):e1380–e1390. [https://doi.org/10.1016/s2214-109x\(21\)00300-4](https://doi.org/10.1016/s2214-109x(21)00300-4)

34. Laycock KM, Enane LA, Steenhoff A. Tuberculosis in Adolescents and Young Adults: Emerging Data on TB Transmission and Prevention among Vulnerable Young People. *Trop. Med. Infect. Dis.* 2021; 6(3): 148. <https://doi.org/10.3390/tropicalmed6030148>

35. Sharma SK, Mohan A, Kohli, M. Extrapulmonary tuberculosis. *Expert Review of Respiratory Medicine*, 2020; 15 (7), 931–948. <https://doi.org/10.1080/17476348.2021.1927718>

36. Sabóia CAD, Silva CJ. Distribuição temporal da tuberculose em Fortaleza-Ceará no período de 2012 a 2021. *Recisatec - Revista Científica Saúde e Tecnologia* 2022; 2(11):e211222. <https://doi.org/10.53612/recisatec.v2i11.222>

37. Smith I. Mycobacterium tuberculosis Pathogenesis and Molecular Determinants of Virulence. *Clin Microbiol Rev.* 2003; 16(3):463–496. <https://doi.org/10.1128%2FCMR.16.3.463-496.2003>

38. Macedo Júnior AMM, Silva CDD, Araújo EM, Silva JD, Gomes JT, Granjeiro JSC, et al. Perfil epidemiológico e fatores determinantes na saúde ambiental da tuberculose no Brasil. *Revista Ibero-Americana de Ciências Ambientais* 2020; 11(7):243–252. <https://doi.org/10.6008/CBPC2179-6858.2020.007.0022>

39. Souza MR, Paz WS, Sales VBS, Jesus GFH, Tavares DS, Lima SVM, et al. Impact of the COVID-19 Pandemic on the Diagnosis of Tuberculosis in Brazil: Is the WHO End TB Strategy at Risk? *Front Pharmacol* 2022;13:891711. <https://doi.org/10.3389/fphar.2022.891711>

AUTHORS' CONTRIBUTIONS

Daniel Brendon Melo Henriques Seabra contributed to the literature review, drafting of the abstract, introduction, methodology, discussion, interpretation and description of results, preparation of tables, conclusions, and revision. **Aline Magalhães de Oliveira** contributed to the literature review, drafting of the abstract, introduction, methodology, interpretation of results, conclusions, and revision. **Eliezer de Oliveira Silva** contributed to the literature review, drafting of the abstract, introduction, methodology, interpretation of results, conclusions, and revision. **Renata Spener Gomes Cordeiro dos Santos** contributed to the literature review, drafting of the abstract, introduction, methodology, interpretation of results, conclusions, and revision. **Angelina do Carmo Lessa** contributed to drafting the introduction, methodology, discussion, interpretation and description of results, conclusions, revision, and statistical analysis. **Ronilson Ferreira Freitas** contributed to project administration, literature review, drafting of the abstract, introduction, methodology, discussion, interpretation and description of results, conclusions, revision, and statistical analysis.

All authors approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.

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