Temporal trends in tuberculosis incidence among older adults in Brazil: annual analysis from 2004 to 2023

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Abstract

Objective: To analyze the annual temporal trend of the tuberculosis incidence rate in older adults in Brazil, from 2004 to 2023. *Methods:* An epidemiological study with an ecological, descriptive, analytical design was conducted. Annual data were obtained from the Brazilian Notifiable Diseases Information System (SINAN). The general incidence rates of tuberculosis were calculated by sex, age group, and clinical form. The Prais-Winsten model and Annual Percentage Change (APC) were used to analyze the trend in the incidence rate. *Results:* For the period studied, 92,850 cases of tuberculosis were registered in the older population in Brazil. The general incidence rate of tuberculosis fluctuated, reaching a maximum in 2004 (70.10) and a minimum in 2020 (41.74), with a decreasing trend (β = -0.007; p = 0.003; APC = -1.8%). Analysis of the incidence rates of tuberculosis by sex revealed a decreasing trend for both genders, with higher rates among men throughout the historical series. Regarding age, there was a downward trend in incidence rates across all age groups. Analysis of the temporal trend by clinical form showed a stable trend for the combined pulmonary + extrapulmonary form, and a decreasing trend for the separate pulmonary and extrapulmonary forms. *Conclusion:* The study results showed a decrease in tuberculosis incidence rates among older adults. However, specific analysis of the clinical forms revealed that the incidence of the pulmonary + extrapulmonary form of tuberculosis remained stable, indicating specific challenges in diagnosing and managing these clinical presentations.

Keywords: Time Series Studies. Epidemiology. Incidence. Tuberculosis. Geriatric Health.

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INTRODUCTION

Tuberculosis (TB) is a chronic infection caused by the intracellular bacillus *Mycobacterium tuberculosis,* predominantly transmitted through the airborne route, that mainly affects the lungs[1]. According to the World Health Organization (WHO) estimates, one third of the global population is infected by *M. tuberculosis*[2].

Although a disease with well-defined treatment and high probability of cure, TB remains a challenge for health managers worldwide. In 2023, approximately 8.2 million people were diagnosed with TB, the highest number recorded since global monitoring began in 1995. This significant rise in cases, relative to the 7.5 million reported in 2022, ranked TB as the leading cause of death from infectious disease in 2023, ahead of COVID-19[3].

Another factor impacting society in the 21st century is population aging. Older adults represent a high-risk group for developing TB and, in Brazil, account for 10% of all notified cases of the disease[4,5]. This group is more vulnerable to developing TB due to reduced immune system efficacy, age-related functional limitations, and changes in both mucociliary clearance and lung function as a result of the aging processs[6].

In this context, time-series analysis constitutes a valuable tool for epidemiological surveillance and control of TB, revealing changes in patterns of disease over time. This information is vital for planning and management of health services and policies, enabling the needs and demands of the population to be identified, and more effective actions to be implemented for the prevention and control of diseases[7].

In view of this situation, understanding the epidemiological scenario of TB in the Brazilian older population is important. Therefore, the objective of the present study was to analyze the annual temporal trend of the incidence rate of tuberculosis among Brazilian older adults for the period spanning from 2004 to 2023.

METHODS

An epidemiological study with an ecological, descriptive, analytical design analyzing notified cases of TB in the Brazilian older population between 2004 and 2023 was conducted.

For the present study, older adults were defined as individuals aged ≥60 years. Only new confirmed cases of TB in the older population, by place of occurrence, were included. The Ministry of Health defines new cases as individuals with TB recorded under the following options: new case; don´t know; and post-death, referring to the different categories of patient entry into the Notifiable Diseases Information System (SINAN). "New case" denotes patients never undergoing chemotherapy for TB, "post-death" are notified cases of death from the disease, and "don´t know" indicates that information on patient status was either not recorded or incomplete[8,9]. Records not containing information on age and sex were excluded from the analysis. During the period spanning from 2004 to 2023, a total of 248,207 new cases of TB in older adults were registered in Brazil. After applying the study exclusion criteria, 26 cases were subsequently excluded, giving a final total of 248,181 cases for analysis.

The new TB cases were extracted from the SINAN on the 10th of October 2024. The system (DATASUS) is run by the Informatics Department of the Brazilian National Health System (SUS)[10]. The number of older adult residents for calculating incidence rates was obtained from the website of the Brazilian Institute of Geography and Statistics (IBGE)[11].

In order to characterize the sociodemographic and clinical profile of the population, the following variables were selected: year of notification (2004-2023), sex (male; female), age group in years (60-69; 70-79; ≥80), race/color (white; black; yellow; brown; indigenous; ignored), education in years of formal study (illiterate; 1-3; 4-7; ≥8; ignored), and clinical form (pulmonary; extrapulmonary; pulmonary + extrapulmonary).

General and specific incidence rates were calculating by dividing the number of new cases in

the study population (totals, by sex, age group, and clinical form) by the number of resident Brazilian older adults, as estimated by the IBGE[11], multiplied by 100,000 inhabitants.

Absolute and relative distributions, the TB incidence rate indicator, and decimal logarithm values, were calculated.

The time-trend of the TB rate was analyzed using Prais-Winsten linear regression, which takes into account serial autocorrelation[7]. To this end, regression analysis was performed of the decimal logarithm (log of base 10) for each indicator (dependent variable – Y) according to year of TB notification (independent variable – X), adopting the formula:

$$\text{Log } (Yt) = \beta)0 + \beta 1x,$$

where: Log(Yt): value of decimal logarithm of indicator Y in year t; β0: constant or intercept; β1: coefficient of linear trend; x: year of registration of TB.

The percentage change was interpreted as follows[7]:

- Increasing trend: when the β1 coefficient was positive and model statistically significant (*p*-value <0.05 on Prais-Winsten linear regression model);
- Decreasing trend: when the β1 coefficient was negative and model statistically significant (*p*-value <0.05 on Prais-Winsten linear regression model);
- Stable trend: statistically non-significant model (p-value>0.05 on Prais-Winsten linear regression model), irrespective of value of β1 coefficient.

The following formula was used for Annual Percentage Change (APC): $APC=(-1+10^{\beta})*100$, where β value denotes the coefficient of slope of the straight line formed on regression.

The formula below was used for calculating confidence interval (CI) of the measures of the study: $CI_{95\%} = (-1+10^{(\beta \pm t*SE)})*100$, where *t* is the value at which Student´s *t* distribution attains 19 degrees of freedom and a two-tailed 95%CI; and *SE* is the standard error of the estimate of β, furnished by the regression analysis.

The data used in this study are freely available in the public domain and carry no personal identifying information, pursuant to Resolution nos. 466/2012[12] and no. 510/2016[13], of the National Board of Health (CNS), and to Law no.12.527/2011[14].

DATA AVAILABILITY

The complete dataset underpinning the results of the present study is available upon request from the corresponding author Ronilson Ferreira Freitas. The data can also be accessed on the Notifiable Diseases Information System (SINAN).

RESULTS

During the time-series studied (2004 to 2023), a total of 248,181 cases of TB were registered in the older population. The sociodemographic characteristics and clinical forms in the population studied are presented in Table 1.

Table 1. Characteristics of tuberculosis cases in older population. Brazil, 2004-2023 (n=248,181).

Variable	n (%)
Sex	
Male	164,598 (66.29)
Female	83,583 (33.71)
Age group (years)	
60 – 69	145,881 (58.78)
70 – 79	73,063 (29.44)
≥ 80	29,237 (11.78)
Color	
White	89,362 (36.00)
Black	27,078 (10.91)
Yellow	2,674 (1.08)
Brown	101,016 (40.69)
Indigenous	2,798 (1.13)
Ignored	25,253 (10.17)
Education (years)	
Illiterate	52,143 (21.01)
1 – 3	50,334 (20.28)
4 – 7	45,221 (18.22)
≥8	50,218 (20.24)
Not applicable	7,029 (2.83)
Ignored	43,236 (17.42)
Clinical Form	
Pulmonary	210,312 (84.71)
Extrapulmonary	31,138 (12.54)
Pulmonary + Extrapulmonary	6,514 (2.63)
Ignored	217 (0.09)

Source: Notifiable Diseases Information System (SINAN)[10]

There was a decline in TB incidence rate over the period investigated. The highest rate registered in the time-series occurred in 2004 (70.10/100,000 inhabitants) and the lowest in 2020 (41.74/100,000) (Table 2, Figure 1A). The incidence rates were higher among males, where the highest rate registered for this gender was 103.00/100,000 inhabitants in 2004. The highest rate in females was 43.52/100,000 inhabitants, also peaking in 2004 (Table 2, Figure 1A).

Analysis by age group showed a decline in incidence rates with increasing age. with the highest rates observed in the group aged 60-69 years (Table 2, Figure 1B). With regard to clinical form, the highest incidence rates involved the pulmonary form, with the highest rate of 59.33/100,000 inhabitants registered in 2004 (Table 2, Figure 1C).

Analysis of TB incidence rates among Brazilian older adults for the time-series studied showed a decreasing trend (β=-0.007; p=0.003; APC=-1.8%) a pattern repeated on analysis by sex and age group. For clinical form, the TB incidence showed a stable trend for the pulmonary + extrapulmonary form and a decreasing trend for the other forms (Table 2).

Table 2. General and specific tuberculosis incidence rates in older population (per 100,000 inhabitants) by sex, age group, and clinical form. Brazil, 2004-2023 (n=248,181)

Year	General	Sex		Age Group (years)			Clinical Form		
		Male	Female	60-69	70-79	≥ 80	Pulmonary	Extrapulmonary	Pulmonary + Extrapulmonary
2004	70.10	103.0	43.52	72.64	67.44	65.61	59.33	8.79	1.70
2005	67.53	99.42	41.82	69.81	66.13	61.18	57.27	8.53	1.59
2006	60.60	89.07	37.68	61.45	59.84	58.79	51.66	7.32	1.57
2007	58.38	87.16	35.20	60.03	57.80	52.89	49.43	7.34	1.59
2008	56.10	82.93	34.51	58.21	55.37	49.24	47.31	7.40	1.35
2009	53.92	80.12	32.89	56.91	52.21	45.91	45.31	7.27	1.30
2010	52.83	78.59	32.20	54.34	54.10	44.23	45.14	6.46	1.20
2011	53.80	79.45	33.29	55.43	53.95	47.12	45.58	6.83	1.33
2012	50.30	75.08	30.53	52.76	50.01	41.35	42.43	6.32	1.51
2013	49.48	73.76	30.13	51.90	48.55	41.97	41.61	6.52	1.21
2014	47.99	72.75	28.30	51.01	46.98	38.34	40.87	5.84	1.22
2015	47.67	73.06	27.53	50.43	47.26	37.80	40.54	5.92	1.19
2016	47.63	72.43	27.97	51.28	43.91	41.08	40.37	5.90	1.34
2017	48.64	73.54	28.93	51.96	46.73	39.76	41.26	6.19	1.17
2018	48.27	72.33	29.24	51.56	46.77	38.76	40.65	6.27	1.36
2019	48.38	72.26	29.50	52.36	45.85	38.39	40.64	6.42	1.30
2020	41.74	63.56	24.51	45.71	39.84	30.62	35.23	5.28	1.20
2021	44.36	67.23	26.33	48.19	42.31	34.20	37.52	5.52	1.29
2022	49.99	74.37	30.77	55.19	45.86	39.10	42.87	5.74	1.36
2023	50.04	75.32	30.13	54.48	47.52	38.81	42.73	5.87	1.40

Source: Notifiable Diseases Information System (SINAN)[10]

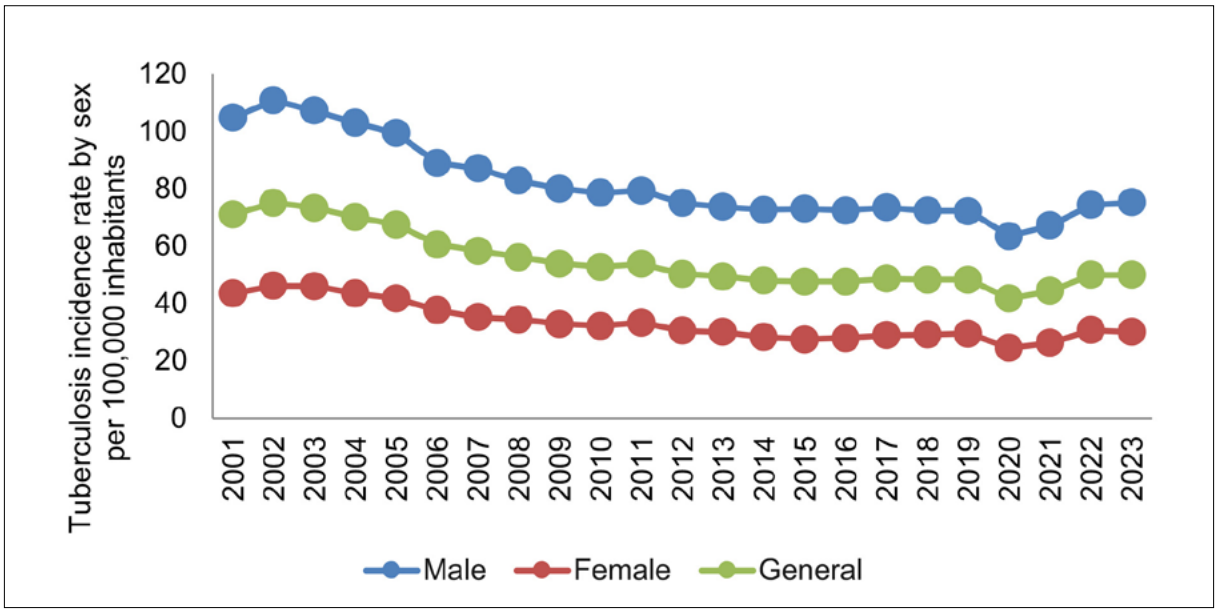

Figure 1A. Specific tuberculosis incidence rate in older population by sex. Brazil, 2004-2023.

Source: Notifiable Diseases Information System (SINAN)[10].

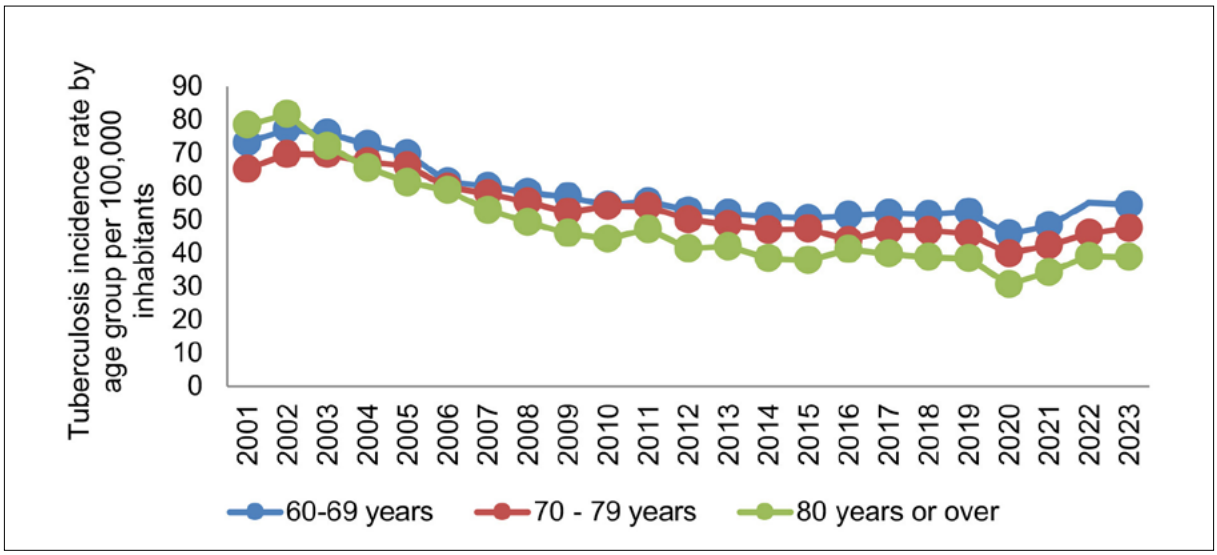

Figure 1B. Specific tuberculosis incidence rate in older population by age group, Brazil, 2004-2023.

Source: Notifiable Diseases Information System (SINAN)[10].

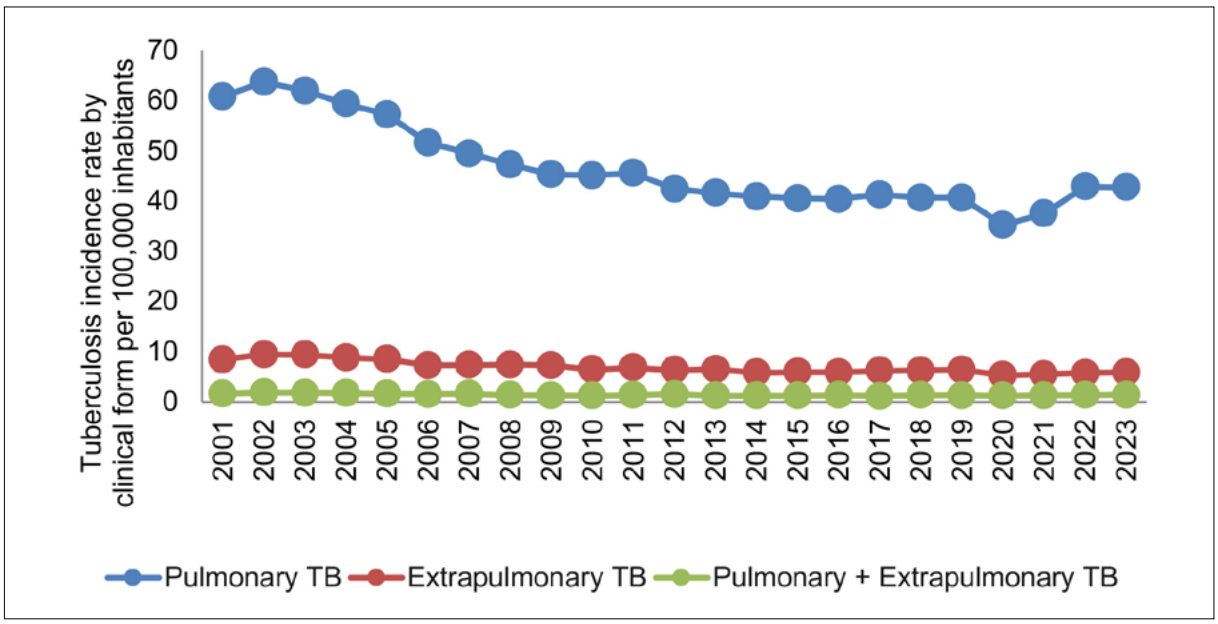

Figure 1C. Specific tuberculosis incidence rate in older population by clinical form. Brazil, 2004-2023.

Source: Notifiable Diseases Information System (SINAN)[10].

Table 3. General and specific trends in tuberculosis incidence rate among older adults in Brazil, by sex and age group, 2004-2023.

Variable	Prais-Winsten					Annual Percentage Change (APC%)			
	β	$CI_{95\%}$		p-value*	R^2	APC%	$CI_{95\%}$		Trend
		Lower	Upper				Lower	Upper	
General	-0.007	-0.012	-0.003	0.003	0.982	-1.8	-2.9	-0.7	Decreasing
By gender									
Male	-0.007	-0.011	-0.002	0.003	0.987	-1.7	-2.7	-0.6	Decreasing
Female	-0.008	-0.013	-0.003	0.002	0.967	-2.0	-3.1	-0.8	Decreasing
Age group (years)									
60 – 69	-0.006	-0.011	-0.001	0.011	0.981	-1.5	-2.6	-0.4	Decreasing
70 – 79	-0.008	-0.012	-0.004	<0.001	0.982	-2.0	-2.9	-1.1	Decreasing
≥ 80	-0.012	-0.017	-0.007	<0.001	0.962	-2.8	-4.0	-1.7	Decreasing
Pulmonary	-0.007	-0.012	-0.002	0.004	0.980	-1.8	-2.9	-0.6	Decreasing
Extrapulmonary	-0.008	-0.011	-0.005	<0.001	0.893	-2.0	-2.7	-1.4	Decreasing
Pulmonary + Extrapulmonary	-0.004	-0.009	0.000	0.055	0.326	-1.0	-2.1	0.0	Stable

$CI_{95\%}$: 95% confidence interval; R^2: coefficient of determination; APC: Annual Percentage Change; *Significance level p<0.05.

DISCUSSION

This study analyzed the temporal trend in TB incidence rate among older adults in Brazil during the period spanning from 2004 to 2023. Results showed a general decreasing trend in TB over the time-series assessed, with highest incidence in 2004 and lowest in 2020. Analysis of TB incidence rate by sex revealed higher rates among men throughout the time-series, but a decreasing trend for both genders. Regarding age group, there was a decreasing incidence trend across all age groups. On the analysis of time-series trends by clinical form, the Pulmonary + Extrapulmonary form was stable, although β values were negative and borderline statistically significant (p=0.055). The separate pulmonary and extrapulmonary forms exhibited a decreasing trend.

For general incidence of TB, results showed a high rate in Brazilian older adults, and that targets proposed by the World Health Organization (WHO) were far from being met. The target was to reduce overall incidence to under 10 cases per 100,000 inhabitants[15], with a forecast reduction to 18.5 cases in more vulnerable groups such as older adults, which remains above WHO targets[16].

The general incidence of TB in older adults remained high in this population, with peak rate registered in 2023, revealing ongoing challenges in controlling the disease. Factors such as changes in vaccine coverage, impact of the COVID-19 pandemic in screening of cases, and difficulties accessing health services, might be associated with the high rate of TB incidence observed in this population[17].

Another relevant factor underlying the high rates of TB in the older population is immunosenescence, characterized by progressive deterioration of the immune system with advancing age. This phenomenon compromises the body´s immune response, rendering older individuals more prone to reactivation of latent infection by *M. tuberculosis*[18]. Moreover, the high prevalence of comorbidities in this age group, such as diabetes mellitus and cardiovascular diseases, not only increases vulnerability to TB, but can also reduce the efficacy of treatment and increase mortality rates[19,20]. This group of factors underscores the need for TB control strategies that take into account the impact of aging and chronic diseases on the course of the infection.

The results of the analysis of TB incidence by sex revealed higher rates in male older adults. In 2004, the TB incidence rate among males was 103.00 cases per 100,000 inhabitants, more than double the rate registered among women for the same year (43.52 cases per 100,000 inhabitants), a pattern that persists throughout the period assessed. This disparity can be explained by several factors, including men´s greater exposure to environments conducive to transmission of the disease, such as poorly ventilated workplaces and correctional facilities. Other factors include risky behaviors such as tabaco and alcohol use, which compromise immune response[21]. Also, men tend to seek health services less, potentially delaying diagnosis and increasing the risk of community transmission, perpetuating the incidence of disease in this population group[22].

The analysis of the incidence of TB by age group revealed a specific pattern within the older population. The data show that the highest incidence rate was registered among individuals aged 60-69 years, with successively lower rates in older age groups. These findings are consistent with previous studies, showing that most cases of tuberculosis in the group of older individuals occur in young older adults[19,23]. A study conducted in Belém, Pará state, found that 64.6% of infected older adults were aged between 60 and 69 years[19]. Similarly, a study conducted in São Paulo state reported highest TB incidence in population aged 60-64 years, suggesting a consistent epidemiological pattern in different regions of Brazil[23].

This lower incidence rate with advancing age might be explained by the fact that oldest-old tend to present fewer specific symptoms, hampering diagnosis and leading to under-notification of cases: the presence of comorbidities and progressive functional decline might mask the classic signs of TB, resulting in lower detection of the disease in this population[24].

The analysis of the clinical form of TB in Brazilian older adults for the period studied reveals that the pulmonary form heavily predominated. These findings are in agreement with studies carried out in different regions of Brazil, confirming pulmonary TB as the most common presentation of the disease across a range of different age groups[25,26].

A study conducted between 2011 and 2015 in Belém, Pará state, showed that 86.95% of TB cases in older adults were of the pulmonary form[25]. Another study, performed in Santa Catarina from 2010 to 2019, found a similar result, where 78.8% of cases notified in individuals aged 60 or older were the pulmonary clinical form[26]. This predominance might be related to the fact that transmission of the disease occurs mainly via the airborne route, making the pulmonary form responsible for much of the dissemination of the bacillus in the community[27].

On the specific analysis of clinical forms, the incidence of TB in the pulmonary + extrapulmonary form remained stable. These data suggest that, while there was an overall reduction in incidence of the disease, the combined forms remained constant, pointing to specific challenges in the diagnosis and management of these clinical presentations[28]. These findings highlight the need to adopt public health strategies aimed not only at general reduction in incidence, but also at effective management of clinically combined forms of the disease.

Despite the scenario of a decreasing trend in TB incidence in Brazilian older adults, it is also important to note the rate of this fall. The rate of decrease in TB showed an annual fall of 1.8%. Although the analysis included the general Brazilian population, Guimarães et al.[29] found almost double the rate of annual reduction compared to that observed in the present study for the years 1990 to 2010 (cumulated decrease of 48.8%). This finding lends credence to the notion that the scenario of TB control has lost impetus in the past decade.

The present study has some limitations, including the source of the data analyzed, given that studies based on data derived from the DATASUS are subject to incorrectly completed forms, missing or skipped data, and under-notification of the disease, especially during the COVID-19 pandemic. Moreover, the analysis was based on TB cases by place of occurrence, but an individual may have reported the case in one place while living in another, introducing bias. Another limitation which may have

impacted results lies in the method, which used general trend in the data, without assessing possible changes in the pattern of the curve over time.

However, strengths of the study include the use of a quality national registry that included a large robust final population and time-series spanning 20 years. Furthermore, previous studies describing the profile of tuberculosis cases and analyzing the temporal trend in disease incidence in the Brazilian state of Santa Catarina concluded the data were adequate to guide actions for disease prevention and control[26,30], enabling monitoring and assessment of public policies for TB diagnosis, as well as informing planning for public health actions, particularly in this specific population.

CONCLUSION

This study reported the incidence rate of tuberculosis in Brazil and its evolution over two decades among older adults. The profile of cases was predominantly in individuals who were male, aged 60-69 years, non-white, and with low education. The most common clinical form of tuberculosis was pulmonary. Over the two decades assessed, there was a significant decline in the incidence rates of tuberculosis in the population group studied. However, the assessment of temporal trends for the clinical forms showed that the pulmonary + extrapulmonary form remained stable, highlighting specific challenges in the diagnosis and management of these clinical presentations.

In this context, there is a clear need for devising actions for health promotion and tuberculosis prevention in older adults, through mass vaccination, guaranteed access to quality health services and specialized follow-up for older individuals with comorbidities, early detection of cases with investigation of respiratory symptoms, and promotion of favorable social and environmental conditions, including adequate housing and nutrition. Educational and awareness-raising actions, along with preventive treatment and strategies for improving treatment adherence and completion, are important to help meet the targets proposed by the World Health Organization.

AUTHORSHIP

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- Ronilson Ferreira Freitas - Project Administration, Formal Analysis, Conception, Data Curation, Writing – Review and Editing, Methodology, Funding Acquisition, Resources, Oversight, Validation and Visualization.

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