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Tuberculosis among Older Adults in Brazil: Recent Changes in Incidence

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Abstract

Background

Tuberculosis (TB) remains a major public health concern, particularly among older adults, who are more vulnerable to severe disease and adverse outcomes. Although recent studies have described temporal trends in TB incidence among older adults in Brazil, important gaps remain regarding recent changes, regional differences, and the municipal distribution of the disease. This study examined temporal and spatial patterns of TB incidence among older adults in Brazil and compared incidence rates between older adults and adults.

Methods

We conducted an ecological study using TB notifications from the Brazilian Notifiable Diseases Information System (Sinan) and population estimates from the Brazilian Institute of Geography and Statistics (IBGE) for 2012–2024. Newly notified pulmonary TB cases, including cases with concurrent extrapulmonary involvement, were selected among older adults (≥ 65 years) and adults (15–64 years). Crude incidence rates and incidence rate ratios (IRRs; older adults/adults) were calculated. Rates were projected to 2030 using Holt's double exponential smoothing. Municipal maps were produced in R using the sf and tmap packages.

Results

A total of 84,880 TB cases were recorded among older adults in Brazil between 2012 and 2024, corresponding to an annual average of 6,529 cases. Projections indicate increasing incidence rates in all five regions by 2030. The North is projected to retain the highest rate (89.75 per 100,000 older adults; 95% CI: 87.84–91.66), whereas the South is expected to have the lowest (27.08; 95% CI: 24.54–29.62). The Southeast is projected to experience the largest increase, reaching 44.59 per 100,000 older adults (95% CI: 40.53–48.66). IRRs varied substantially across regions: they remained above 1.0 in the North and Central-West, were close to 1.0 in the Northeast, and remained below 1.0 in the South and Southeast. Municipal maps showed marked spatial heterogeneity, particularly in the North and parts of the Northeast.

Conclusions

TB incidence among older adults in Brazil varies substantially over time and across regions and municipalities. The projected increase by 2030, together with the geographic differences identified, underscores the need to strengthen surveillance, promote timely diagnosis, and tailor prevention and control strategies to local epidemiological conditions while taking population aging into account.

1. INTRODUCTION

Tuberculosis (TB) is an airborne infectious disease caused by Mycobacterium tuberculosis that primarily affects the lungs. It remains a major cause of morbidity and mortality worldwide, despite the availability of effective diagnostic, treatment, and prevention strategies for decades (1). Approximately one-quarter of the world's population is estimated to be infected with M. tuberculosis, representing a large reservoir from which active TB disease may develop (2).

Despite progress in TB control in Brazil, the country has not yet achieved the incidence-reduction targets established by the World Health Organization (WHO) End TB Strategy for 2030 (3). The estimated incidence rate in 2023 was 39.8 cases per 100,000 population, above the 2015 reference rate of 34.3 per 100,000, indicating that further progress is needed to meet the established targets (4).

Population aging is one of the major demographic transformations of the 21st century and has important implications for the distribution of disease(5). Worldwide, approximately one in ten people is currently aged 60 years or older; this proportion is expected to reach one in five by 2050 [6].

For analytical purposes, this study defined older adults as people aged 65 years or older. This operational definition was adopted to facilitate comparison with international studies using the same age threshold and should not be understood as a universal definition. In Brazil, the legal definition of an older person includes individuals aged 60 years or older. The proportion of the Brazilian population aged 60 years or older increased from 11% in 2010 to 15% in 2022, reflecting the ongoing demographic transition [7].

In recent years, older adults accounted for approximately 15% of TB cases in Brazil and 40% of TB-related deaths. TB incidence is high in this population and increases with advancing age [7]. Mortality data also point to a disproportionate burden: in 2022, the overall TB mortality rate in Brazilian capital cities was 3.6 deaths per 100,000 population, compared with 9.5 per 100,000 among older adults [8].

The burden of TB among older adults has also been examined in international and national studies. A global analysis comparing TB incidence among people aged 65 years or older with that among adults reported that the incidence rate ratio declined between 2000 and 2023, reaching 2.2 in the final year studied [9]. In Brazil, studies have investigated national TB incidence trends and projected the potential effects of control strategies through 2030 [4, 7]. Other research has examined socioeconomic and healthcare-related factors associated with TB mortality among older adults in Brazilian capital cities and the Federal District, but did not include all municipalities in the country [8]. National analyses of temporal trends among older adults have also reported declining incidence over earlier periods, while highlighting the possibility that aggregated linear analyses may not capture changes in trend [5, 7].

Despite these contributions, evidence remains limited on recent temporal changes and the municipal distribution of TB incidence among older adults across Brazil. In addition, the incidence rate ratio between older adults and adults has not been comprehensively assessed across the country. This study

therefore aimed to: (i) describe temporal trends in TB incidence among older adults in Brazil and project rates through 2030; (ii) examine temporal changes in incidence rate ratios between older adults and adults; and (iii) describe the municipal distribution of both indicators across Brazil from 2012 to 2024.

2. METHODS

This ecological study used TB notification records and population data for Brazil from 2012 to 2024. TB data were obtained from the Brazilian Notifiable Diseases Information System (Sistema de Informação de Agravos de Notificação – Sinan), and population estimates were obtained from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE). Cases were selected according to the clinical classification of pulmonary TB or pulmonary TB with concurrent extrapulmonary involvement and the "type of entry" variable, categorized as "new case" or "unknown."

Crude TB incidence rates were calculated annually for older adults (≥ 65 years) and adults (15–64 years) to describe temporal patterns. Incidence rate ratios (IRRs) were calculated by dividing the rate among older adults by the rate among adults in each of Brazil's five regions.

The time series were examined retrospectively, from the most recent observation to the earliest, to identify potential structural changes. If a statistically significant breakpoint was identified at the 5% significance level, the projection was based on the series from that point onward; otherwise, the full historical series was retained.

Projections were generated using Holt's double exponential smoothing method, which models the level and trend components of a time series [11]. The smoothing parameters (α and β) were selected using the Mean Absolute Scaled Error (MASE) criterion. A nonparametric Gaussian-kernel smoothing procedure was first applied to reduce short-term fluctuations. Holt's method was then applied to the smoothed series, and the variability of the resulting residuals was used to estimate 95% confidence intervals. The forecasting approach was implemented in R using the forecast package [12].

The IRR was calculated as the incidence rate among older adults divided by the incidence rate among adults. This measure is consistent with the age-group comparisons discussed in the WHO Global Tuberculosis Report [13] and allows the relative incidence burden in the two populations to be assessed. For the municipal maps of TB incidence, rates were classified into the following categories: <10, 10–49.9, 50–99.9, 100–149.9, and ≥ 150 cases per 100,000 older adults. IRRs were classified as < 0.5, 0.5–<1, 1, > 1–2, and > 2.

Data processing, statistical analyses, and graphical outputs were performed using R (version 4.5.3) and RStudio. The tidyverse, janitor, stringr, lubridate, readxl, rio, foreign, and read.dbc packages were used for data importation and management; ggplot2, patchwork, scales, and RColorBrewer were used to produce graphs; and sf and tmap were used to prepare thematic maps. The here package was used to organize project files [22].

3. RESULTS

A total of 84,880 TB cases were recorded among older adults in Brazil between 2012 and 2024, corresponding to an annual average of 6,529 cases. Incidence rates varied across the five regions over the study period (Fig. 1). The North consistently had the highest rates, exceeding 75 cases per 100,000 older adults throughout the series. Rates declined around 2015 and subsequently increased, reaching approximately 90 per 100,000 in 2022 and remaining at a similarly high level in 2024.

The Northeast had the second-highest regional incidence levels. Its municipal maps showed substantial spatial heterogeneity, with areas of higher incidence persisting over time, particularly in western Bahia (Supplementary Fig. 7).

In the Southeast, rates were relatively stable through 2018, declined in 2019–2020, and then recovered to approximately 30 cases per 100,000 older adults in 2024. In the South, rates were lower than those in the North and Northeast, fluctuating between approximately 23 and 28 cases per 100,000, with a decline in 2020 followed by recovery. In the Central-West, rates fell to approximately 27 per 100,000 in 2020 and increased to approximately 32 in 2024. Overall, the historical series revealed distinct regional levels and temporal patterns.

Projections for 2025–2030 indicate increasing incidence rates in all five regions, although the magnitude of the projected increases differs. The North is expected to retain the highest rate, reaching 89.75 cases per 100,000 older adults in 2030 (95% CI: 87.84–91.66). The Northeast and Southeast are projected to reach similar levels: 44.72 (95% CI: 43.50–45.94) and 44.59 (95% CI: 40.53–48.66), respectively. The Central-West is projected to reach 41.76 (95% CI: 40.64–42.88), while the South is expected to have the lowest rate, at 27.08 (95% CI: 24.54–29.62). The Southeast shows the largest projected increase over the period.

Regional IRRs (older adults/adults) varied across the country (Fig. 2). Ratios remained above 1.0 in the North and Central-West, indicating higher incidence rates among older adults in these regions. In the Northeast, ratios were close to 1.0, suggesting similar incidence rates in the two age groups. In the Southeast and South, ratios remained below 1.0, indicating higher incidence rates among adults aged 15–64 years. Municipal maps of the IRRs are presented in Supplementary Figs. 10–14. These ratios compare incidence rates between age groups and should not be interpreted as direct measures of transmissibility.

The municipal incidence maps (Fig. 3) revealed marked spatial heterogeneity from 2012 to 2024. Municipalities with higher rates were concentrated mainly in the North, where elevated levels persisted throughout the study period (Supplementary Fig. 6). Higher rates were also observed in western Bahia (Supplementary Fig. 7), southern Mato Grosso, and northern Mato Grosso do Sul (Supplementary Fig. 5). Many municipalities in the Southeast and South had lower or intermediate rates (Supplementary Figs. 8 and 9).

In the early years of the study period, extensive areas with high rates were visible in the North, particularly in the Amazon region, as well as in some municipalities in the Northeast. From 2017 onward, municipalities with higher incidence appeared across a wider range of locations, including parts of the Central-West and Northeast. Between 2022 and 2024, elevated rates persisted in the North and in scattered municipalities elsewhere in Brazil.

Municipalities with very low or zero recorded rates were also observed, particularly in parts of the South, Southeast, and Central-West (Supplementary Figs. 5, 8, and 9). These findings should be interpreted cautiously because rates may be unstable in municipalities with small older populations and few reported cases.

The municipal distribution of IRRs also showed substantial heterogeneity (Fig. 4). Many municipalities had ratios below 1.0, indicating higher incidence rates among adults, while ratios above 1.0 indicated higher rates among older adults. Ratios above 2.0 were more frequent in the North and Central-West (Supplementary Figs. 10 and 11), particularly during the earlier years of the series and up to 2020. Municipalities with ratios above 1.0 were nevertheless observed throughout the study period and across different parts of the country.

The spatial distribution of IRRs varied over time, with no consistent nationwide pattern of increase or decrease. The persistence of municipalities with high ratios indicates that older adults experienced higher relative TB incidence in some local settings, whereas ratios below 1.0 in other municipalities point to substantial geographic variation in the age distribution of TB incidence.

4. DISCUSSION

This study identified marked temporal, regional, and spatial differences in TB incidence among older adults in Brazil. Between 2012 and 2024, incidence patterns varied across regions, with the North consistently recording the highest rates. Projections suggest that rates may increase in all five regions between 2025 and 2030, although the expected magnitude of change differs by region.

The historical series fluctuated over the study period. A decline was observed in 2020, followed by a recovery in subsequent years, particularly from 2022 onward. The projected upward trends should be interpreted as estimates based on the historical behavior of the series, not as deterministic predictions of future TB occurrence.

The decline in recorded incidence in 2020 coincided with the COVID-19 pandemic. It should not necessarily be interpreted as a true reduction in TB occurrence, because the pandemic disrupted access to health services, care-seeking behavior, diagnosis, and epidemiological surveillance [5, 7]. These disruptions may have affected the number and timing of notifications.

A national study of TB notifications found that reduced access to health services was associated with a higher proportion of cases notified only after death, a particularly concerning finding in the North [14].

Against this background, the recovery in notification rates observed from 2022 onward may partly reflect the resumption of case detection and the identification of cases that had previously gone undiagnosed [14].

The North had the highest TB incidence rates among older adults throughout the study period. This finding is consistent with a previous analysis of TB among older adults in Brazil from 2011 to 2021, which reported a declining trend but also identified the highest rates in the North and high-risk spatial clusters [7]. The persistence of high rates in the present study suggests that substantial territorial inequalities remain.

These differences may be associated with structural inequities and limitations in the organization of and access to Primary Health Care (PHC) in the North [10]. Among older adults, barriers to care may intersect with biological vulnerability related to immunosenescence and possible reactivation of latent TB infection [15]. Atypical clinical presentations, including dyspnea, asthenia, and weight loss, may also complicate recognition of TB in older patients, particularly when classic symptoms such as fever and hemoptysis are absent [16]. Difficulties accessing PHC may lead patients to seek care directly in hospitals, potentially delaying diagnosis and treatment and prolonging the period during which transmission can occur [17].

Evidence from the South also illustrates the persistence of TB among older adults in settings with different socioeconomic characteristics. A descriptive study in Rio Grande do Sul reported that notifications were concentrated among people aged 60–69 years and predominantly among men, with a concentration in the Porto Alegre metropolitan area. The study also reported TB–HIV coinfection proportions of 20%–30%, above the national average [18].

Previous studies have associated socioeconomic disadvantage with unfavorable TB outcomes among older adults and have highlighted this population's vulnerability to delayed diagnosis, treatment discontinuation, and post-mortem notification [8, 14, 19]. Such factors may contribute to geographic differences in the burden of disease. However, the ecological design of the present study does not allow causal relationships between socioeconomic conditions and the observed incidence rates to be established.

The distribution of TB in Brazil must also be considered in light of the country's demographic and territorial heterogeneity, including differences in population density, living conditions, and access to health services. Population concentration in large urban and metropolitan areas may shape opportunities for exposure and transmission. The Southeast, for example, has higher incidence rates among adults aged 15–64 years than the other regions, according to the national data considered in the WHO report [13].

A study of TB mortality among older adults in Brazilian capital cities used the Gini index to characterize socioeconomic inequalities and examined their relationship with mortality alongside comorbidities and TB–HIV coinfection [8]. Other studies have also described post-mortem notification and treatment

discontinuation among socially vulnerable people with TB [14, 19]. These findings reinforce the importance of considering social and health-system conditions when interpreting regional differences.

A national study of 70,833 TB cases among older adults in Brazil between 2015 and 2019 found that people aged 80 years or older had a 2.66-fold higher risk of death from TB. The authors emphasized the relevance of social vulnerabilities, including homelessness, race/skin color, and mental disorders, as well as programmatic measures such as directly observed treatment [20]. These findings suggest that improving outcomes requires more than pharmacological treatment alone; it also depends on accessible, continuous, and socially responsive care.

International evidence further supports the importance of examining TB among older adults separately from trends in the general population. A global analysis of people aged 65 years or older across different regions from 2000 to 2023 found increasing TB occurrence in this age group, including in settings where overall incidence declined [9]. This reinforces the need to incorporate population aging into TB surveillance and control strategies.

Research from Mexico has likewise emphasized the high burden of TB among older adults, diagnostic challenges, and unfavorable clinical outcomes in this population [21]. Although findings from different countries cannot be directly extrapolated to Brazil, they highlight issues that are relevant to health systems facing population aging.

Differences between the trends reported in previous Brazilian studies and those observed here may partly reflect the periods analyzed. For example, the study by do Nascimento et al. examined trends through 2021 [7], whereas the present analysis includes 2022–2024, when notification rates recovered after the decline recorded in 2020. Differences in study design and analytical methods should also be considered. The increase observed from 2022 onward may reflect changes in disease occurrence, the recovery of diagnostic and surveillance activities, or both. Continued monitoring is therefore essential to distinguish these processes.

The projections for 2025–2030 suggest that regional differences in TB incidence among older adults may persist. The North is projected to retain the highest rate and the South the lowest. The Southeast shows the largest projected increase, reaching a level similar to that of the Northeast by 2030, while the Central-West is also expected to experience an increase. These projections describe possible trajectories based on the historical series and should not be interpreted as certain outcomes.

The comparison between age groups adds an important dimension to these findings. IRRs were above 1.0 in the North and Central-West, close to 1.0 in the Northeast, and below 1.0 in the South and Southeast. Thus, the relative incidence burden among older adults differs across regions and should be interpreted in relation to the rates observed among adults.

The municipal analyses further demonstrated that regional averages conceal substantial local variation. Municipalities with high incidence rates and IRRs were unevenly distributed, with elevated incidence

particularly evident in the North and parts of the Northeast. These patterns support the use of territorially tailored surveillance and control strategies rather than relying exclusively on state- or region-level indicators.

5. CONCLUSION

This study combined temporal, comparative, and spatial analyses to characterize TB incidence among older adults in Brazil. The findings show substantial variation across regions and municipalities, as well as differences in incidence between older adults and adults that are not captured by a single national indicator.

Incidence rates fluctuated between 2012 and 2024, including a decline in 2020 followed by recovery in subsequent years. Projections indicate a possible increase in all five regions by 2030. The North is expected to retain the highest rate and the South the lowest, while the Southeast is projected to show the largest increase and to reach a level similar to that of the Northeast.

The comparison between age groups revealed higher relative incidence among older adults in the North and Central-West, similar rates in the Northeast, and higher incidence among adults in the South and Southeast. These differences underscore the importance of interpreting the burden of TB among older adults in relation to the epidemiological context of each region.

Municipal maps showed persistent geographic heterogeneity in both incidence rates and IRRs. Higher incidence was particularly evident in the North and parts of the Northeast, while the distribution of IRRs varied across municipalities and over time. These findings highlight the value of local-level information for planning surveillance and TB control.

Strengthening TB surveillance among older adults requires active case finding, timely diagnosis, and appropriate treatment and follow-up, particularly in areas with higher incidence. Prevention and control policies should also account for population aging, regional inequalities, and the specific healthcare needs of older people.

The study's main contribution is its integrated assessment of temporal trends, differences between age groups, and municipal patterns of TB incidence among older adults in Brazil. By identifying geographic and age-related inequalities, the findings can inform more targeted and equitable surveillance, prevention, and healthcare strategies.

Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable. This study was based exclusively on publicly available, anonymized secondary data obtained from the Brazilian Notifiable Diseases Information System (Sinan), accessed through DATASUS, and population data provided by the Brazilian Institute of Geography and Statistics (IBGE). No identifiable

personal information was accessed or analyzed, and no direct contact with human participants was involved.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The datasets analyzed in this study are publicly available from the Brazilian Notifiable Diseases Information System (Sinan), through DATASUS (https://datasus.saude.gov.br/), and from the Brazilian Institute of Geography and Statistics (IBGE) (https://www.ibge.gov.br/).

COMPETING INTERESTS

The authors declare that they have no competing interests.

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AUTHORS' CONTRIBUTIONS

GFP contributed to the conceptualization, methodology, data curation, formal analysis, visualization, and drafting of the manuscript. JUB contributed to the study methodology, supervision, interpretation of results, and critical revision of the manuscript. Both authors read and approved the final manuscript.

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Figures

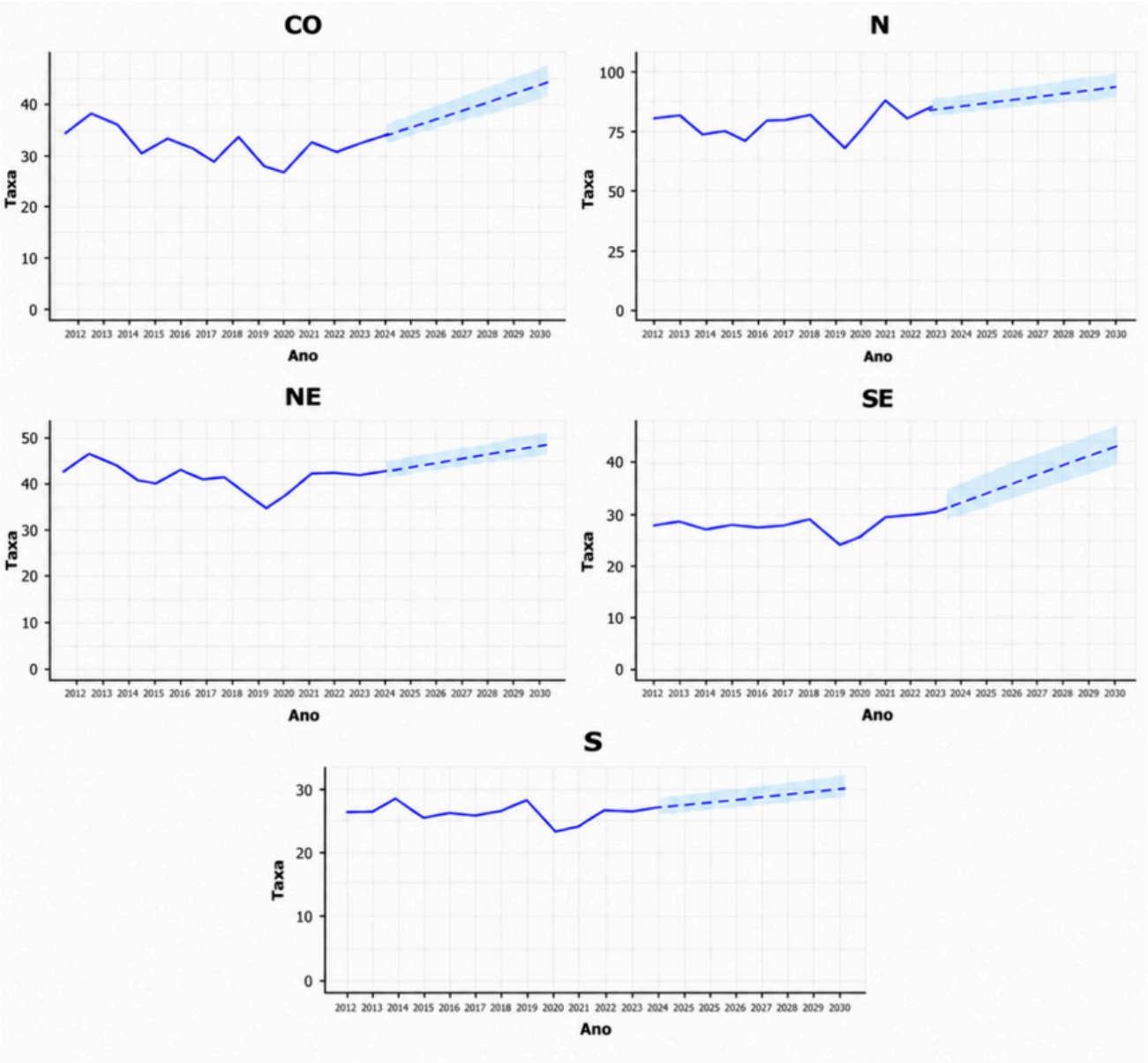


Figure 1

Observed tuberculosis incidence rates among older adults in the five Brazilian regions, 2012–2024, and projected rates for 2025–2030.

Note: CW, Central-West; N, North; NE, Northeast; SE, Southeast; S, South.

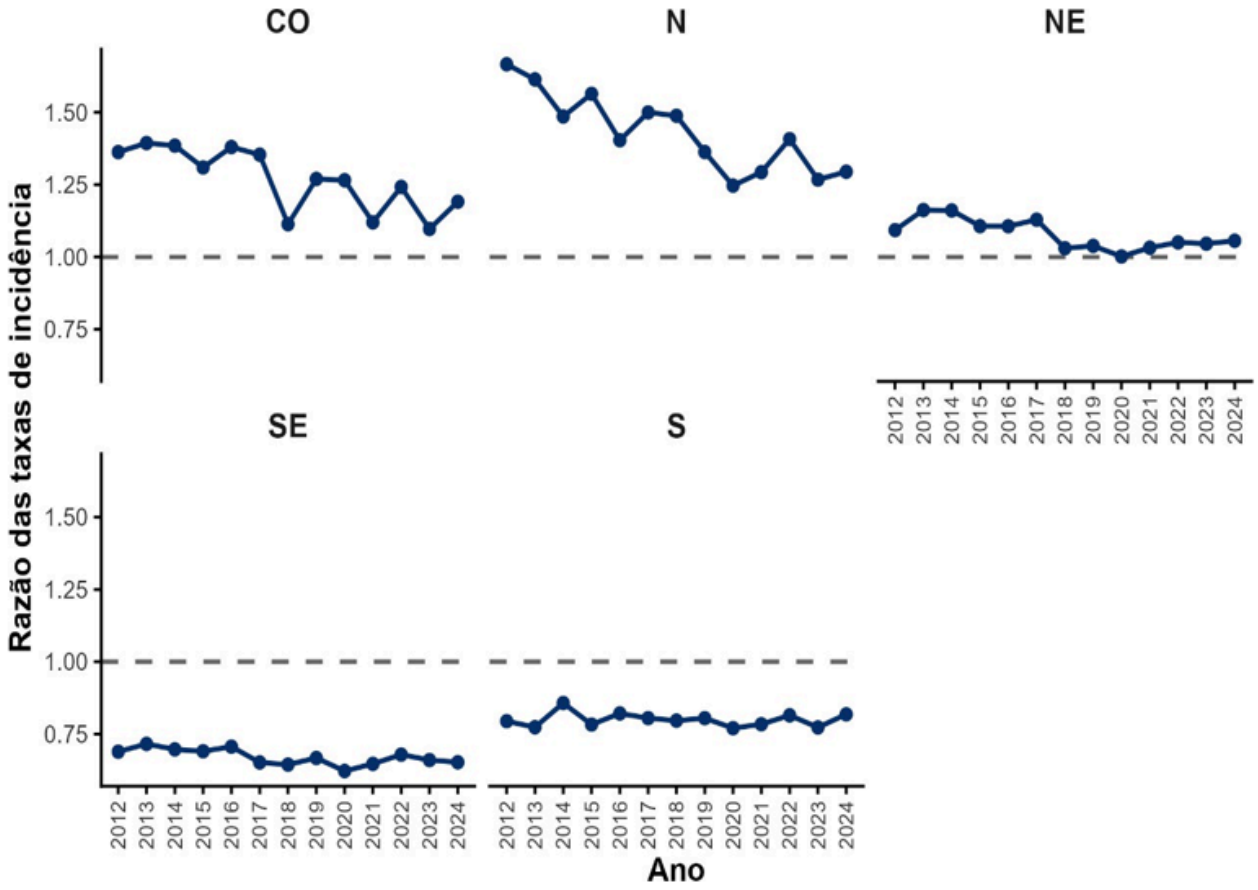


Figure 2

Incidence rate ratio between older adults (≥65 years) and adults (15–64 years) by Brazilian region, 2012–2024.

Note: CW, Central-West; N, North; NE, Northeast; SE, Southeast; S, South.

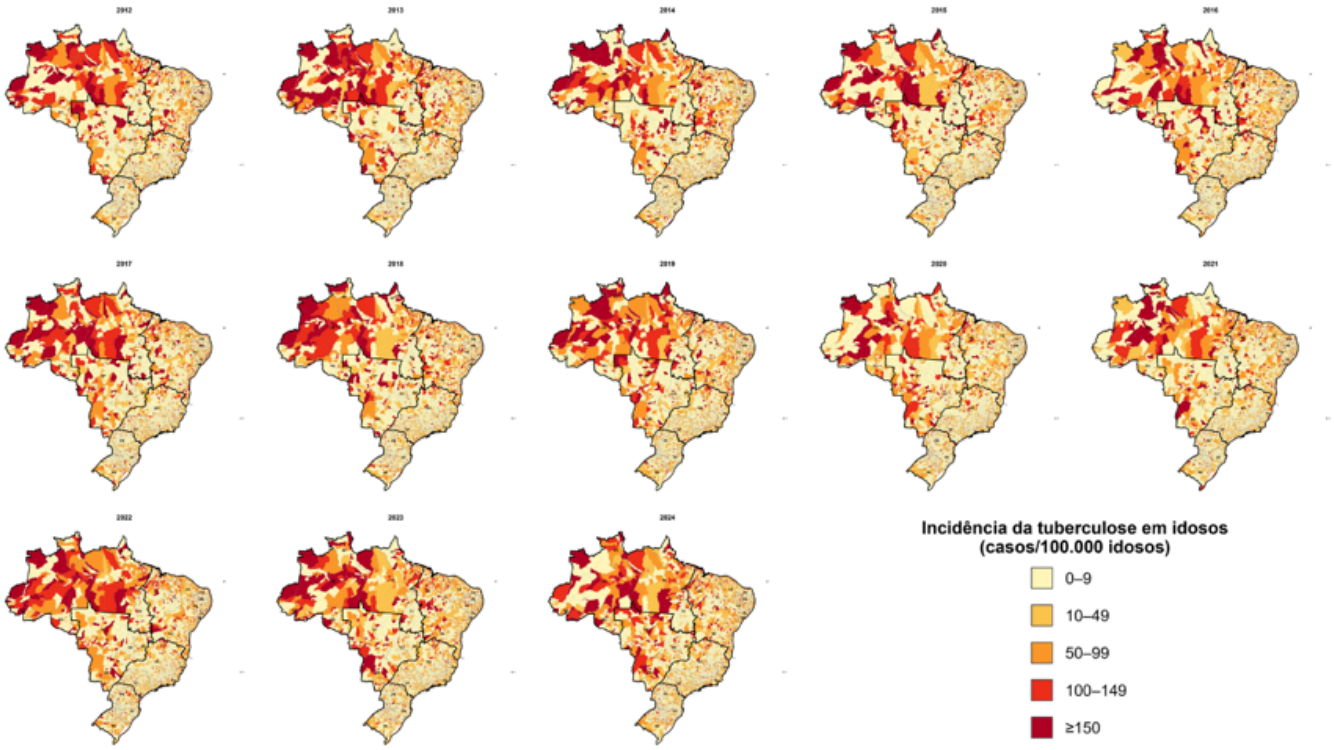


Figure 3

Municipal distribution of tuberculosis incidence rates among older adults in Brazil, 2012–2024.

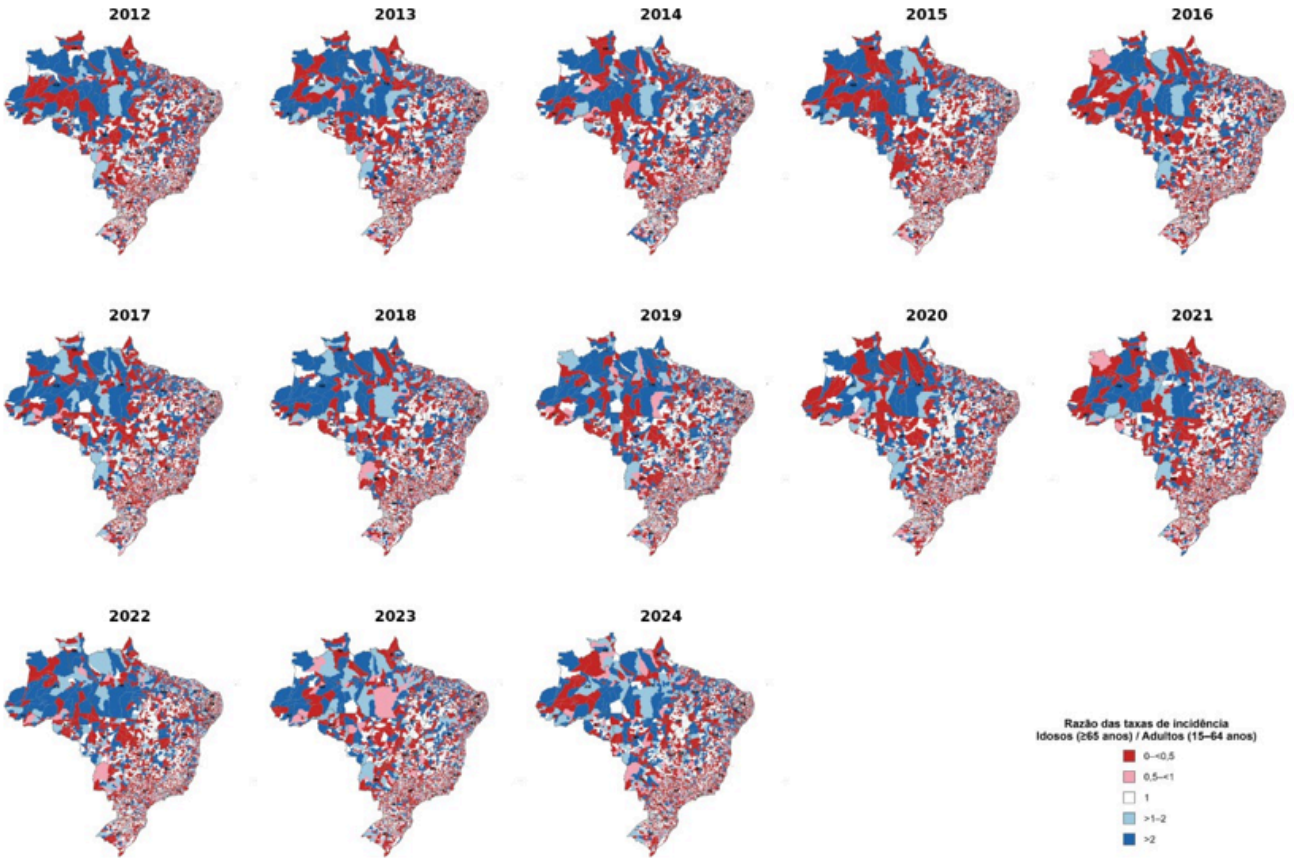


Figure 4

Municipal distribution of the incidence rate ratio between older adults (≥65 years) and adults (15–64 years) in Brazil, 2012–2024.

Supplementary Files

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- SUPPLEMENTARYMATERIAL.docx