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Temporal trend of tuberculosis in Brazil

Tendência temporal da tuberculose no Brasil

Evolución temporal de la tuberculosis en Brasil

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Abstract

The objective was to analyze the temporal trend of tuberculosis incidence rates in Brazilian states and regions to identify patterns and inequalities. We carried out an ecological study of incidence rates per 100,000 inhabitants aged between 20 and 59 years with tuberculosis in Brazil and in their respective states from 2001 to 2017 according to annual percentage change and joinpoint regression. A significant decrease of -15.1% in the annual variation (95%CI: -27.2; -1.0) was observed in Roraima between the years 2003-2007. In the Central Region, Goiás registered an annual average variation of -2.5% per year (95%CI: -3.6; -1.3). Five out of nine Northeastern states had decreasing annual variations throughout the studied series. Espírito Santo and Rio de Janeiro were the states of the Southeast that presented decreasing between 2001-2017. In the Southern Region, the state of Paraná was the only one with the same annual variation of -3.7% (95%CI: -4.1; -3.2). In Brazil, the average annual percentage change was -1.8% (95%CI: -2.4; -1.1). The results of this study showed a decline in the incidence of tuberculosis in Brazil. However, regional and intra-regional differences were observed. Determining the trend pattern of tuberculosis incidence may assist in the planning and implementation of national tuberculosis control policies.

Tuberculosis; Incidence; Epidemiologic Measurements; Regression Analysis; Uses of Epidemiology

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Introduction

Global confrontation of tuberculosis (TB) requires progress in prevention and care of patients in countries with high incidence, including Brazil. The percentage reduction in TB incidence rates was 1.5% between 2014 and 2015 in the world, but an average annual reduction of 4% to 5% is expected by 2020 to achieve the goals of the reduction strategy stipulated by the World Health Organization (WHO) [1].

In the Americas, Brazil has a significant role in the fight against tuberculosis, although it presents characteristics common to the region, such as high levels of urbanization, social inequalities, and ethnic and cultural diversity. Other characteristics may help in understanding the Brazilian response capacity, among them: having the second largest Gross Domestic Product (GDP) among the countries of the Americas; ranking 15th in Human Development Index (HDI) among American countries, 5th in the list of countries with the highest income per capita in South America, and 6th in life expectancy, among Latin American countries [2].

Since 2003, TB has been considered a priority disease in the political agenda of the Ministry of Health, as Brazil is one of the countries with the highest number of cases in the world. However, there are still barriers in the population's access to diagnosis and treatment, which are performed universally and free of charge by the Brazilian Unified National Health System (SUS). About 69,000 new cases of tuberculosis and 4,500 deaths were reported in 2016 [2].

In 2016, 66,796 new cases were diagnosed and registered in Brazil, of which 12,809 (19.2%) were cases of retreatment. Between 2007 and 2016, the incidence coefficient of the disease showed an average annual variation of -1.7%, changing from 37.9/100,000 in 2007 to 32.4/100,000 inhabitants in 2016 [3].

Operational indicators for the monitoring of TB control proposed by the National Tuberculosis Control Plan are important tools for assessing the trend of TB and its impact, reflecting the performance of health services and the quality of care provided for people with the disease [3,4].

According to the national plan for elimination of TB as a public health hazard [2], scenarios were defined to be worked in the following years with the objective of investigating their relationship with the reduction of TB incidence in Brazil. These scenarios present particularities that facilitate the planning of states and municipalities to combat the disease and assist in the identification of priorities.

The National Tuberculosis Control Program has implemented several actions to prevent and detect TB in the last decades. Studying the pattern of TB incidence in various parts of the country can assist in assessing the impact of the Program.

The objective of this study is to analyze the temporal trend of TB incidence rates in Brazilian states and regions to identify patterns and inequalities.

Method

This is an ecological study of the temporal trend of TB incidence rates per 100,000 inhabitants. The rates were constructed based on the total number of confirmed cases reported by the SINAN (Brazilian Information System for Notificable Disease) of people aged between 20 and 59 years in Brazil and in the respective states from 2001 to 2017.

Incidence rates were calculated by dividing the number of TB cases in the age group by the estimated population of the same range in each year of study, multiplied by 100,000. Population estimates were retrieved from a study sponsored by the Inter-Agency Health Information Network (RIPSA) and by the Brazilian Ministry of Health/Health Surveillance Secretariat/General Information Coordination and Epidemiological Analysis of the mentioned years as denominators per 100,000 inhabitants.

The annual percentage change (APC) was calculated using segmented regression (SR), allowing the turning points that indicate the variations of rates with greater significance in the increase of the line to be identified. The number of points required for the adjustment of each segment was automatically selected by the default configuration of the software (without logarithmic transformation of the response variable). The measure that explains several variations is the average annual percentage

change (AAPC). In situations where only one APC comprises the entire period studied, the AAPC corresponds to the APC.

The assumption of homoscedasticity, autocorrelation, and normality of distribution of residuals in the most suitable models for adjustments in each region were tested in order to verify the compatibility of the proposed analysis. For APC and AAPC, 95% confidence intervals (95%CI) were calculated. Data were presented in the form of tables and graphs of segmented regression (joinpoint regression), annual percentage changes with the respective 95%CI. The Excel 2016 (https://products.office.com/), Joinpoint Regression Software version 4.5.0.1 (https://surveillance.cancer.gov/joinpoint/) provided by the US National Cancer Institute (NCI) [5], and the Stata Software version 11 (https://www.stata.com) were used. The results of the predictions are presented for each Brazilian Region.

The project was approved by the Ethics Research Committee with Human Beings – School of Medical Sciences, University of Campinas (FCM/Unicamp) under process number 2,903,348.

Results

A total of 69,661 TB cases were reported in 2017 in Brazil, with the lowest incidence in the historical series (55.2/100,000 inhabitants). Among the incidence rates in the Brazilian Regions, the Northern Region had the highest (69.2 per 100,000 inhabitants) and the Central Region had the lowest (32.1 per 100,000 inhabitants). We observed a decrease in incidence in all regions in the period, although high incidences of disease were recorded in the first years of the time series (Figure 1).

Figure 1

Incidence coefficients (per 100,000 inhabitants) associated with the number of tuberculosis cases confirmed in individuals between 20 and 59 years of age, according to State, Brazil, 2001 to 2017.

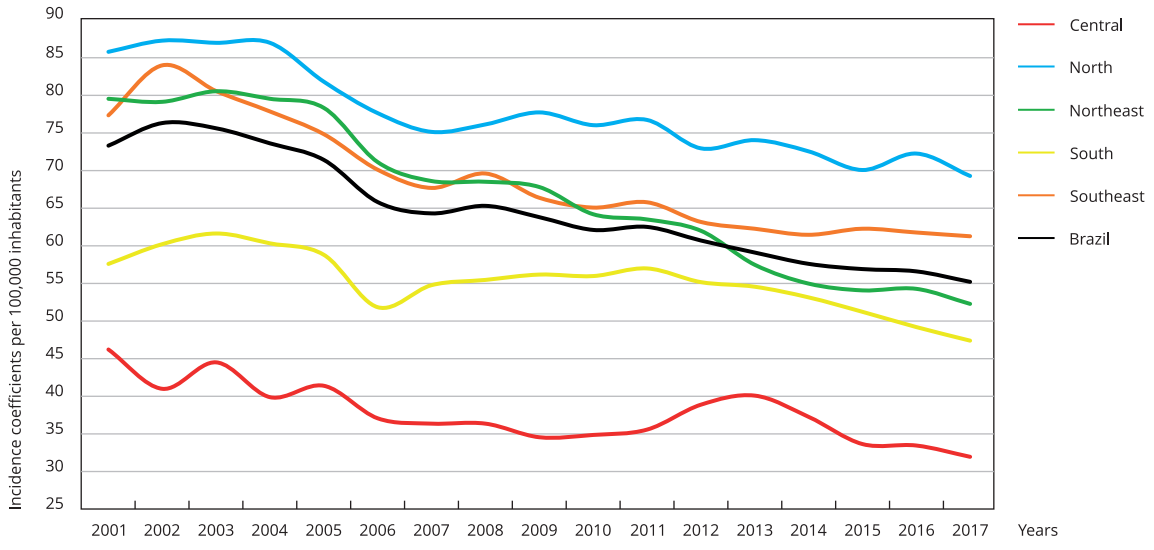


Table 1

Percentage annual variation of tuberculosis incidence coefficients (confirmed cases) by State obtained by joinpoint regression, Brazil, 2001 to 2017.

	APC (%)	95%CI	p-value	AAPC (%)	95%CI	p-value
Northern Region						
Acre						
2001-2017	-1.2	-2.3; -0.2	0.026	-	-	-
Amapá						
2001-2015	-4.7	-5.8; -0.36	0.000	-2.7	-5.5; 0.2	0.065
2015-2017	12.1	-12.5; 43.5	0.335			
Amazonas						
2001-2012	-0.8	-1.6; -0.1	0.039	0.1	-0.8; 1.0	0.803
2012-2017	2.2	-0.4; 4.9	0.091			
Pará						
2001-2017	-2.1	-2.6; -1.6	0.000	-	-	-
Rondônia						
2001-2006	-6.0	-10.2; -1.6	0.013	-1.0	-2.6; 0.5	0.186
2006-2017	1.3	-0.1; 2.7	0.067			
Roraima						
2001-2003	20.5	-11.4; 63.8	0.203	-2.4	-6.8; 2.8	0.384
2003-2007	-15.1	-27.2; -1.0	0.039			
2007-2017	-0.60	-3.0; 1.8	0.556			
Tocantins						
2001-2017	-5.2	-6.3; -4.1	0.000	-	-	-
Central Region						
Federal District						
2001-017	-4.8	-5.8; -3.7	0.000	-	-	-
Goiás						
2001-2007	-5.7	-8.3; -3.0	0.001	-2.5	-3.6; -1.3	0.000
2007-2017	-0.5	-1.7; 0.8	0.429			
Mato Grosso						
2001-2009	-3.0	-5.5; -0.4	0.031	-1.9	-5.1; 1.4	0.256
2009-2013	9.1	-3.3; 23.2	0.138			
2013-2017	-9.9	-16.6; -2.7	0.013			
Mato Grosso do Sul						
2001-2017	-0.5	-1.3; 0.3	0.203	-	-	-
Northeastern Region						
Alagoas						
2001-2003	-2.9	-3.6; -2.2	0.000	-	-	-
Bahia						
2001-2017	-4.8	-5.2; -4.4	0.000	-	-	-
Ceará						
2001-2017	-2.6	-3.0; -2.2	0.000	-	-	-
Maranhão						
2001-2014	-4.3	-5.0; -3.6	0.000	-3.0	-4.3; -1.8	0.000
2014-2017	2.6	-4.5; 10.2	0.451			
Paraíba						
2001-2017	-1.6	-2.4; -0.9	0.000	-	-	-

(continues)

Table 1 (continued)

	APC (%)	95%CI	p-value	AAPC (%)	95%CI	p-value
Pernambuco						
2001-2004	3.9	1.3; 6.7	0.011	-0.4	-1.4; 0.6	0.434
2004-2007	-5.3	-10.1; -0.2	0.043			
2007-2012	1.7	0.1; 3.4	0.042			
2012-2017	-2.1	-3.2; -0.9	0.005			
Piauí						
2001-2008	5.1	-2.2; 12.8	0.156	-6.4	-9.8; -2.9	0.000
2008-2017	-14.5	-18.5; -10.2	0.000			
Rio Grande do Norte						
2001-2004	4.4	-3.9; 13.3	0.268	-1.3	-4.3; 13.8	0.402
2004-2007	-8.5	-22.4; 7.8	0.252			
2007-2017	-0.7	-2.0; 0.6	0.241			
Sergipe						
2001-2017	-0.5	-1.5; 0.6	0.376	-	-	-
Southeastern Region						
Espírito Santo						
2001-2017	-3.2	-3.7; -2.6	0.000	-	-	-
Minas Gerais						
2001-2003	87.6	67.1; 110.7	0.000	3.0	1.6; 4.4	0.000
2003-2017	-5.5	-6.0; -5.0	0.000			
Rio de Janeiro						
2001-2017	-2.7	-3.0; -2.3	0.000	-	-	-
São Paulo						
2001-2007	-3.7	-4.5; -2.9	0.000	-1.1	-1.5; -0.7	0.000
2007-2017	0.5	0.1; 0.9	0.015			
Southern Region						
Paraná						
2001-2017	-3.7	-4.1; -3.2	0.000	-	-	-
Rio Grande do Sul						
2001-2003	6.0	1.4; 10.8	0.019	0.1	-0.8; 1.0	0.885
2003-2006	-4.7	-8.8; -0.3	0.039			
2006-2011	3.6	2.2; 5.1	0.001			
2011-2017	-2.3	-3.0; -1.5	0.000			
Santa Catarina						
2001-2003	2.8	-5.7; 12.0	0.770	-1.2	-2.9; 0.5	0.169
2003-2006	-3.1	-11.1; 5.6	0.402			
2006-2013	1.1	-0.3; 2.6	0.107			
2013-2017	-5.6	-8.1; -3.0	0.002			
Brazil						
2001-2003	2.0	-1.3; 5.4	0.210	-1.8	-2.4; -1.1	0.000
2003-2006	-4.5	-7.7; -1.2	0.013			
2006-2017	-1.7	-2.0; -1.4	0.000			

95%CI: 95% confidence interval; AAPC: average annual percentage change, $p < 0.05$; APC: annual percentage change, $p < 0.05$.

From the Northern states, only Acre, Pará and Tocantins presented a constant decrease in the annual variation in the period from 2001 to 2017. Amapá showed a fall from 2001 to 2015 and a 12.1% increase per year from 2015 to 2017. The state of Amazonas exhibited a slight decrease of -0.8% per year between 2001 and 2012, and Roraima a significant decrease of -15.1% (95%CI:-27.2; -1.0) between 2003 and 2007 (Table 1).

The Central Region was characterized by decreasing APC throughout the study period in the Federal District and Mato Grosso do Sul. Mato Grosso had a decrease between 2013 and 2017 and Goiás registered an annual average variation of -2.5% per year (95%CI: -3.6;-1.3) (Table 1).

Five out of nine Northeastern states had decreasing annual variations throughout the studied series, namely, Alagoas, Bahia, Ceará, Paraíba and Sergipe. For the other states, the AAPC was negative; they were Maranhão, Pernambuco, Piauí and Rio Grande do Norte (Table 1).

Espírito Santo and Rio de Janeiro were the states of the Southeast that presented decreasing APC between 2001 and 2017. São Paulo registered an AAPC of -1.1% (95%CI: -1.5; -0.7) and Minas Gerais was the state with the highest increasing annual variation among all Brazilian states (87.6%, 95%CI: 67.1; -110.7) between 2001 and 2003 and maintained a decreasing trend of -5.5% per year from 2003 to 2017 (95%CI: -6.0; -5.0) (Table 1).

As for the South, the State of Paraná was the only one with the same APC for the whole time series, while Rio Grande do Sul recorded a decrease in APC between 2011 and 2017, and Santa Catarina a decrease of -5.6% per year between 2013 and 2017. In Brazil, the AAPC was -1.8% per year (95%CI: -2.4; -1.1) (Table 1).

The evaluation of the historical series showed that the trend is uniform throughout the period in 12 Brazilian states (Acre, Alagoas, Bahia, Ceará, Espírito Santo, Mato Grosso do Sul, Pará, Paraíba, Paraná, Rio de Janeiro, Sergipe and Tocantins) and the Federal District. The adequacy of the adjustment of the TB incidence coefficients in the Brazilian states according to the most adequate segmented regression was the one that considered two, three, four or five turning points in the period depending on the state, that is, four segments in the states of Rio Grande do Sul, Santa Catarina and Pernambuco, three in Mato Grosso, Rio Grande do Norte and Roraima, two segments in Amapá, Amazonas, Goiás, Maranhão, Minas Gerais, Piauí, Rondônia and São Paulo, and a straight segment was enough to represent the trends of the other states, all with a constant decreasing trend (Figure 2).

The states with two-line segments, Amapá, Amazonas, Maranhão, Rondônia and São Paulo, were characterized by a decreasing initial and increasing final observation in APC. The states of Minas Gerais and Piauí had increasing APC at the beginning and decreasing at the end, while Goiás had a decreasing APC at two points between 2001 and 2017. Brazil (three segments) presented increasing and decreasing variations in the incidence of TB (Figure 2).

Discussion

In this study, high rates of TB incidence were observed at the beginning of the series in all Brazilian states.

In 2009, there were changes in the national policies of active search, follow-up and treatment of TB in Brazil, which resulted in the reduction of new cases [6].

The WHO intensified the goals to reduce the TB incidence rate by 90% (< 10/100,000 per inhabitant) by 2035, in relation to 2015. In 2014, WHO approved the Global Plan to End Tuberculosis. Its intermediate stages are expected to occur in 2020 (20%, < 85/100,000), 2025 (50%, < 55/100,000 inhabitants) and 2030 (80%, < 20/100,000 inhabitants) and it requires greater commitment on the part of governments, and focusing on providing better services to vulnerable populations [7]. Brazil has the lowest rates in the list of 30 countries with high TB burden [1].

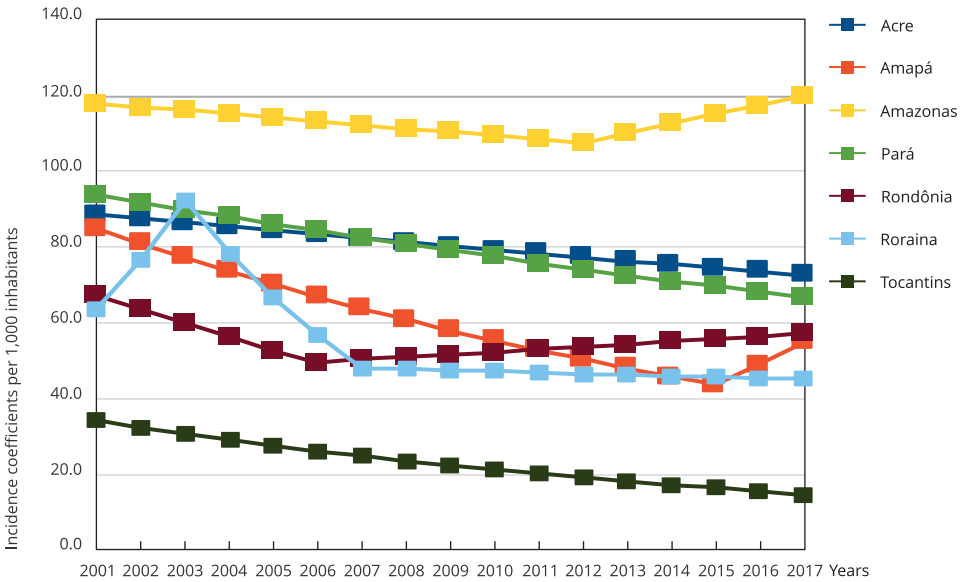
The SUS has the proper structure to reduce the disease, counting on universal coverage, access to diagnosis and treatment. However, the prioritization of investments in intersectoral articulation must be reinforced, as well as the participation of the civil society and public policies that combat the occurrence of the disease [8].

The Brazilian National Tuberculosis Control Program recognizes the importance of the horizontalization of TB care, aiming at the integration of TB control, especially with primary health care

Figure 2

Incidence coefficients (per 100,000 inhabitants) associated to confirmed cases of tuberculosis in individuals between 20 and 59 years of age according to Regions of the Federation, obtained through segmented regression (joinpoint regression), Brazil, 2001 to 2017.

2a) North



2b) Northeast

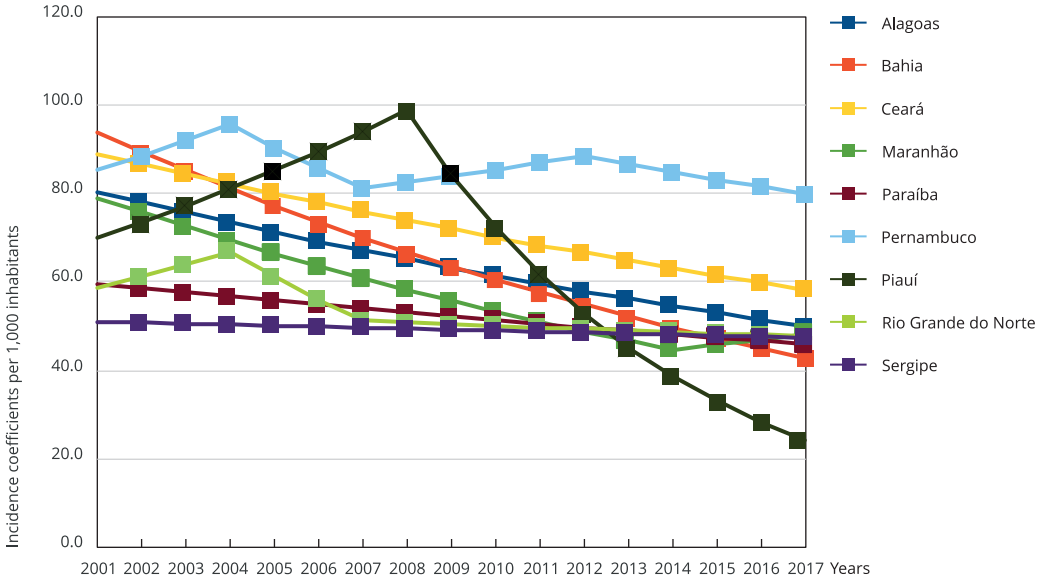


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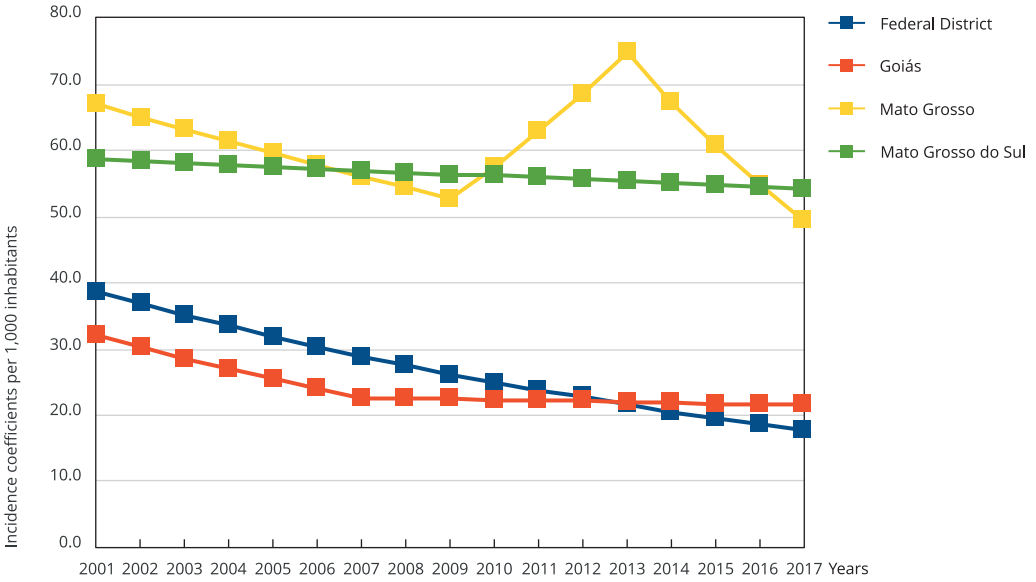
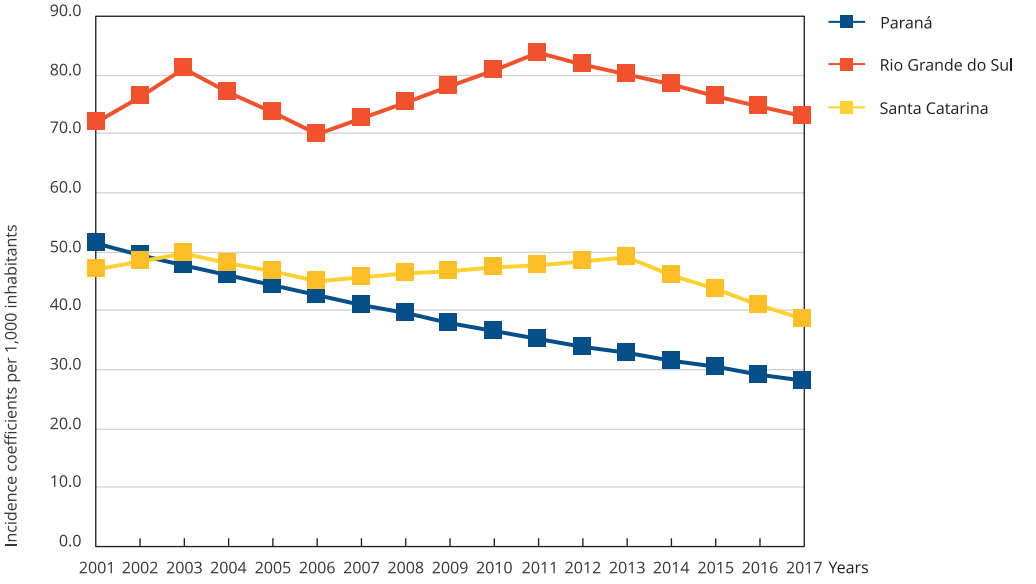
Figure 2 (continued)

2c) Central



2d) South



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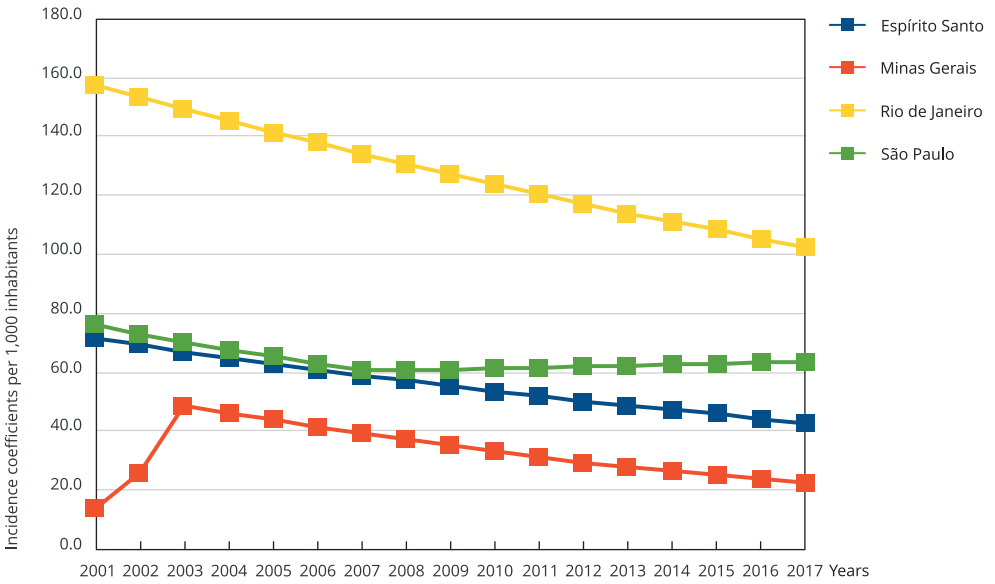
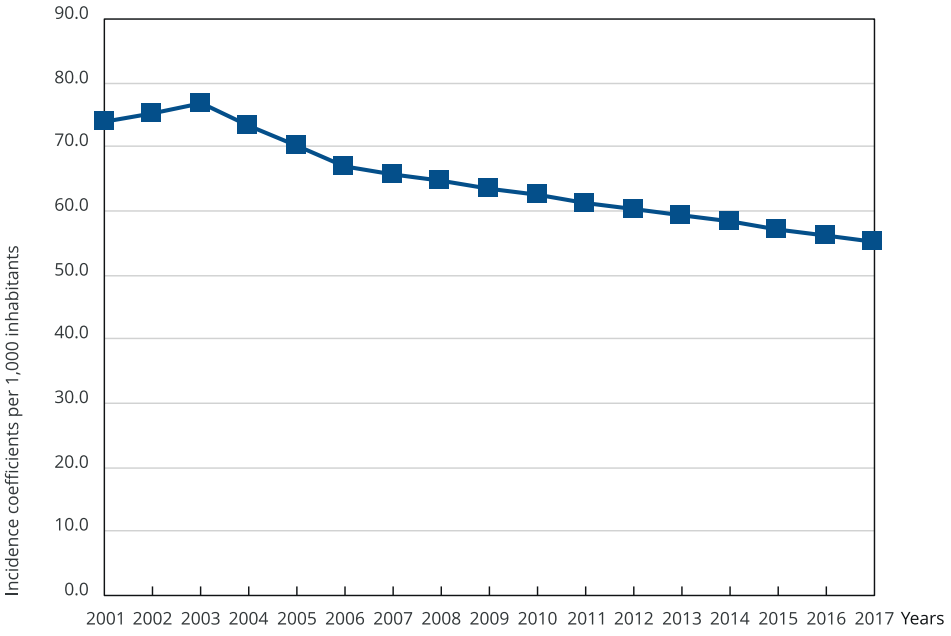
2e) Southeast



2f) Brazil



(PHC), which includes the Community Health Agents Program and the Family Health Program (FHP), expanding access to diagnosis and treatment [4]. Prevention is still the fundamental strategy for the elimination of TB in cases of first contact, reinfection or latent reactivation of the disease [8,9].

The region with the highest incidence rate of TB was the North, above the national average, with high endemism and marked impact on morbidity and mortality affecting mainly the indigenous population. Intra-regional heterogeneity has been identified in the spatial distribution of the disease, influenced by socioeconomic determinants and greater concentration of cases in the larger cities of the Northern Region [10].

A recent study that evaluated TB control actions in Brazil in PHC showed that 47.56% of the basic health units (UBS in portuguese) in the North Region did not collect material for laboratory examination as one of the protocols for identifying the disease. The absence of protocol items for TB control shows the still precariousness in all Brazilian Regions, and not only in the Northern Region [11].

The concepts of TB transmissibility that are based on the biomedical model of educational and curative interventions do not fit the reality of Northern populations (mainly indigenous and river-based) since educational and therapeutic actions should consider the unique cultural issues of these populations [12]. The sensitivity of the health system to capture new cases is directly associated with the coverage of primary health care and epidemiological surveillance, particularly in case investigation and early diagnosis, contributing to the reduction of incidence [13].

Poor access to services and lower diagnostic and therapeutic options in remote areas make it difficult to control the disease and increase the impact on morbidity and mortality [14]. Specific work processes with qualified teams and efficient action tools are needed to ensure access to the diagnosis in vulnerable people. These actions also depend on health education to populations that have specific demands or greater vulnerability [15,16].

The high rates may suggest flaws in health services, such as decentralization of care, insufficient supervised treatment, early diagnosis, effective protocols for dealing with the confirmed cases, and adequate training of professionals with strengthened teamwork [10]. However, there was a downward trend in incidence rates in the North Region in the study period, which may mean improved access and quality of services.

The state with the highest incidence of TB is Amazonas, followed by Rio de Janeiro, both with rates above 100/100,000 inhabitants. The cases in the former are concentrated in the capital and large cities. As this state has a great territorial extension, cities in the countryside have less access to reference services [3,17].

The Northern Region presents specific needs in view of the large territory, and difficult access to diagnosis, treatment and clinical follow-up. In addition, the vast international border, especially the northern arc of the state, requires integrated strategies of state and national governments and of neighboring nations for integrated epidemiological surveillance actions to address this public health problem [12].

The region with the lowest incidence is the Central, which showed an increase in the years 2012 and 2013, and then experienced a decline. These findings are like other studies in the country [18,19].

TB in the Northeast Region is characterized by its heterogeneous spatial distribution. The highest rates are found in the coastal cities, as they are more populous and have poor neighborhoods [20]. Social inequalities between Brazilian Regions and states show the difficulty in accessing basic health services, causing delayed diagnosis of various diseases, including TB [21].

Among the nine states in Northeast Region, Pernambuco recorded the highest incidence rates. The difficult access of patients to the capital Recife was 62.9%, the lowest percentage registered in a research that compared this factor in three Northeastern capitals (Salvador, Bahia State, with 84.6% and João Pessoa, Paraíba State, with 90.9%) [18]. Care for TB cases in these three capitals was predominantly provided in public health units (86% in Salvador, 98.8% in Recife, and 100% in João Pessoa), demonstrating the public financing and accountability of patient care under the coordination of the Tuberculosis Detection and Treatment Program at the state and national levels [21].

The results obtained in this study indicate the reduction of confirmed cases of TB in the Southeastern Region, but not in a homogeneous way. São Paulo stands out as the only state with a sharply increasing trend since 2007 while the rates have decreased in Rio de Janeiro and Espírito Santo. The Southeastern Region is characterized by consolidated actions to combat and provide care for TB

patients through the primary health care network, emergency care, Tuberculosis Control Programs and Specialized Services. The need to strengthen the Health Care Network in the different care settings and in the organization of work in an integrated way for the effective diagnosis of TB and reduction withdrawal, especially among HIV co-infected patients [22], should be emphasized. Thus, these actions in São Paulo have been insufficient to achieve the goals of the National Plan for Elimination of Tuberculosis and for reduction of the disease with a central public health strategy [23].

Although the Southern Region presents incidence rates below the national average, during 2006 to 2011, these remained stable, and decreased after 2012. This regional trend was strongly influenced by the states of Rio Grande do Sul and Santa Catarina. A study conducted in 2016 identified that the South Region had the lowest percentage of clinical follow-up (46.4%) of TB cases in Brazil. This follow-up includes the operationalization of strategies such as directly observed treatment (DOT) by UBS, search for missing persons to follow-up of DOT, surveillance of intra-household contacts and lack of knowledge about priorities of care for TB patients [24]. Rio Grande do Sul, which is the state with the highest incidence rate, has implemented short- to medium-term projects to improve TB control. The measures include intensifying training in priority municipalities, increasing the number of supervision visits to patients with TB, consolidating partnerships with other areas of care (HIV/AIDS, viral hepatitis, PHC, LGBT population) with awareness of civil society, among others [25].

The results of this study showed that, although five Brazilian states (Amapá, Amazonas, Maranhão, Rondônia and São Paulo) showed an increase in new cases [26] and consequently in annual percentage, the incidence had a decreasing trend in the time series studied in most states.

TB remains a major global health problem, affecting around 10 million people each year and one of the top 10 causes of death in all continents. In the last five years, it has been the leading cause of death by a single infectious agent, outweighing HIV. It is noteworthy that, with early diagnosis and correct treatment, most infected people can be cured [1].

The overall burden of the disease remains high in the world, but significant progress shows the impact of specific TB control policies. The rate of case detection has increased from 46% to 64% and the prevalence in the world had dropped by 47% by 2015. Since the year 2000, the global incidence of TB has been declining, albeit slowly, along with new reported cases each year; however, rates remain high in countries of Southeast Asia and sub-Saharan Africa [27,28].

In some regions of East Asia such as the metropolitan areas of Hong Kong, China, Japan, South Korea and Singapore, the incidence of TB is stagnating or increasing. This phenomenon can be explained by cases that arise due to reactivation of the disease in a previously infected human population [29] or by immigration from high incidence countries, an event that contributes to the transmission [28].

Countries such as Brazil, Indonesia, South Africa, Thailand and Vietnam have good indicators of TB control, ensuring mechanisms of notification of detected cases, as well as linking the supply of first-line drugs (as in Brazil) to rapid notification through a specific information system [1]. There has been tremendous progress over the last ten years when it comes to the development of new diagnostic and therapeutic methods and tools that support WHO policies. However, there is yet no prediction of a rapid and accurate test to diagnose patients outside the health care setting, which could result in clinical advances and reduced transmission [30].

Guidelines on disease, treatment, prevention and follow-up of patients are pointed as the strengths of PHC, but autonomy during treatment, related to DOT, is the main negative point of follow-up of TB [31], besides the weakness in the involvement of professionals in control actions, verticalization of control actions within PHC, turnover of professionals and weaknesses in professional training [32].

Segmented regression indicated significant turning points in the incidence rate trend of TB in the Brazilian states by means of the annual percentage change. The calculation of the crude incidence by region identified the behavior of the disease and the possible turning points in the time series identified by segmented regression and the refined estimates in each segment of the line.

The joinpoint regression is an efficient and flexible statistical method able to determine the turning points and the trend pattern of TB incidence rates per state in different periods. The behavior of the response variable (TB incidence) can be analyzed either in the different periods of the explanatory variable (time), or separately, linking the trends to cultural, socioeconomic and political specificities of each state.

It should be noted that an effective TB control program, including primary prevention, early detection and treatment, when well structured, tends to increase the number of new cases as a result of access to diagnosis and notification. This contributes to treatment and to reducing disease mortality, with emphasis on places with high social vulnerability. The use of secondary data can be pointed out as a limitation of this study, because of the underreporting and poor quality of information in several regions of the country.

However, the possibility of feedback for the official TB databases may partially lessen the insufficiency of the data. Changes in the TB reporting system since the implementation of new TB care policies do not allow the sharing of variables among information systems, making it difficult to analyze more widely national data. One limitation of the segmented regression is that the turning points identified by the segmented regression do not always coincide with the real points and variations, what happens because the regressions are connected continuously over time. Despite these limitations, all cases of TB reported in Brazil in the selected period were analyzed.

Conclusion

The results of this study showed a decline in the incidence rates of TB in Brazil. However, regional and intra-regional differences were observed. This heterogeneity can be explored in the epidemiological and quality contexts and access to health services in each state. The relevance of the use of the joinpoint regression in temporal trend analyses of epidemiological indicators must be highlighted as it allows the monitoring of variations with greater statistical precision. Determining the trend pattern of TB incidence may assist in the planning and implementation of national TB control policies. The support of Public Health Policies focused on TB in the definition of preventive and control actions, especially in PHC, is broadened regarding the dynamics of transmission in risk subgroups present in the Brazilian regional contexts.

Contributors

All the authors took part in the conception of the study, data analysis and interpretation, writing and critically reviewing the intellectual contents of the manuscript. They have approved the final version and take on responsibility for all aspects of this paper, including the guarantee of its accuracy.

Additional informations

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References

1. World Health Organization. Global tuberculosis report 2017. Geneva: World Health Organization; 2017.
2. Secretaria de Vigilância em Saúde, Ministério da Saúde. Plano nacional pelo fim da tuberculose. Brasília: Ministério da Saúde; 2017.
3. Secretaria de Vigilância em Saúde, Ministério da Saúde. Indicadores prioritários para o monitoramento do Plano Nacional pelo Fim da Tuberculose como Problema de Saúde Pública no Brasil. Boletim Epidemiológico 2017; 48(8).
4. Área Técnica de Pneumologia Sanitária, Coordenação Geral de Doenças Endêmicas, Departamento de Vigilância Epidemiológica, Secretaria de Vigilância em Saúde, Ministério da Saúde. Programa Nacional de Controle da Tuberculose. Brasília: Ministério da Saúde; 2016.
5. Martinez-Beneito MA, García-Donato G, Salmerón D. Bayesian joipoint regression model with unknown number of break-points. Ann Appl Stat 2011; 5:2150-68.
6. Rabahi MF, Silva Júnior JLR, Conde MB. Evaluation of the impact that the changes in tuberculosis treatment implemented in Brazil in 2009 have had on disease control in the country. J Bras Pneumol 2017; 43:437-44.

7. World Health Organization. The end tuberculosis strategy. Geneva: World Health Organization; 2015.
8. Barreira D. Os desafios para a eliminação da tuberculose no Brasil. Epidemiol Serv Saude 2018; 27:e00100009.
9. Silva Jr. JB. Tuberculose: guia de vigilância epidemiológica. J Bras Pneumol 2004; 30 Suppl 1:S57-S86.
10. Barbosa IR, Cosme CLF. Distribuição espacial dos casos novos de tuberculose pulmonar nos municípios da Região Norte do Brasil, no período de 2005 a 2010. Caminhos de Geografia 2013; 14:110-21.
11. Baumgarten A, Rech RS, Bulgarelli PT, Souza KR, Santos CM, Frichembruder K, et al. Ações para o controle da tuberculose no Brasil: avaliação da atenção básica. Rev Bras Epidemiol 2019; 22:e190031.
12. Belo EN, Orellana JDY, Levino A, Basta PC. Tuberculose nos municípios amazonenses da fronteira Brasil-Colômbia-Peru-Venezuela: situação epidemiológica e fatores associados ao abandono. Rev Panam Salud Pública 2018; 34:321-29.
13. Pelissari DM, Bartholomay P, Jacobs MG, Arakaki-Sanchez D, Anjos DSOD, Costa MLDS, et al. Offer of primary care services and detection of tuberculosis incidence in Brazil. Rev Saúde Pública 2018; 52:53.
14. Gonçalves JAA, Costa-Matos A, Tavares-Neto J. Tuberculose no Estado do Acre: série histórica de 1996 a 2000. Gazeta Médica da Bahia 2006; 76:3-11.
15. Scatena LM, Villa TCS, Ruffino Netto A, Kritski AL, Figueiredo TMRM, Vendramini SHF, et al. Dificuldades de acesso a serviços de saúde para diagnóstico de tuberculose em municípios do Brasil. Rev Saúde Pública 2009; 43:389-97.
16. Sevalho G. O conceito de vulnerabilidade e a educação em saúde fundamentada em Paulo Freire. Interface (Botucatu, Online) 2018; 22:177-88.
17. Oliveira GP, Pinheiro RS, Coeli CM, Barreira D, Codenotti SB. Mortality information system for identifying underreported cases of tuberculosis in Brazil. Rev Bras Epidemiol 2012; 15:468-77.
18. Oliveira GP, Torrens AW, Bartholomay P, Barreira D. Tuberculosis in Brazil: last ten years analysis – 2001-2010. Braz J Infect Dis 2013; 17:218-33.
19. Viana PV, Goncalves MJ, Basta PC. Ethnic and racial inequalities in notified cases of tuberculosis in Brazil. PLoS One 2016; 11:e0154658.
20. Barbosa IR, Pereira LMS, Medeiros PFM, Valentim RS, Brito JM, Costa ÍCC. Análise da distribuição espacial da tuberculose na região Nordeste do Brasil, 2005-2010. Epidemiol Serv Saúde 2013; 22:687-95.
21. Souza MSPL, Aquino R, Pereira SM, Costa MCN, Barreto ML, Natividade M, et al. Fatores associados ao acesso geográfico aos serviços de saúde por pessoas com tuberculose em três capitais do Nordeste brasileiro. Cad Saúde Pública 2015; 31:111-20.
22. Villa TCS, Ponce AZ, Andrade RLP, Arakawa T, Scatolin BE, Brunello MEF, et al. Diagnóstico oportuno da tuberculose nos serviços de saúde de diversas regiões do Brasil. Rev Latinoam Enferm 2013; 21(spe):190-98.
23. Secretaria de Vigilância em Saúde, Ministério da Saúde. Implantação do Plano Nacional pelo Fim da Tuberculose como Problema de Saúde Pública no Brasil: primeiros passos rumo ao alcance das metas. Boletim Epidemiológico 2018; 49(11).
24. Clementino FS, Marcolino EC, Gomes LB, Guerreiro JV, Miranda FAN. Tuberculosis control actions: analysis based on the access and primary health care quality improvement program. Texto & Contexto Enferm 2016; 25:e4660015.
25. Rodrigues MV, Godoy SC, Wilhelm D, Nakata PT. Tuberculose no Rio Grande do Sul: relatório técnico 2014-2015. Porto Alegre: Secretaria Estadual da Saúde; 2016.
26. Glaziou P, Floyd K, Korenromp EL, Sismanidis C, Bierrenbach AL, Williams BG, et al. Lives saved by tuberculosis control and prospects for achieving the 2015 global target for reducing tuberculosis mortality. Bull World Health Organ 2011; 89:573-82.
27. Bloom BR, Atun R, Cohen T, Dye C, Fraser H, Gomez GB, et al. Tuberculosis. In: Holmes KK, Bertozzi S, Bloom BR, Jha P, editors. Major infectious diseases. 3rd Ed. Washington DC: The International Bank for Reconstruction and Development/The World Bank; 2017. p. 233-313.
28. Wu P, Lau EH, Cowling BJ, Leung CC, Tam CM, Leung GM. The transmission dynamics of tuberculosis in a recently developed Chinese city. PLoS One 2010; 5:e10468.
29. Lawn SD. Advances in diagnostic assays for tuberculosis. Cold Spring Harb Perspect Med 2015; 5:a017806.
30. Coordenação-Geral do Programa Nacional de Controle da Tuberculose, Departamento de Vigilância das Doenças Transmissíveis, Secretaria de Vigilância em Saúde, Ministério da Saúde. Panorama da tuberculose no Brasil: a mortalidade em números. Brasília: Ministério da Saúde; 2016.
31. Beraldo AA, Andrade RLP, Orfão NH, Silva-Sobrinho RA, Pinto ESG, Wysocki AD, et al. dherence to tuberculosis treatment in primary health care: perception of patients and professionals in a large municipality. Esc Anna Nery Rev Enferm 2017; 21:e20170075.
32. Wysocki AD, Ponce MAZ, Brunello MEF, Beraldo AA, Vendramini SHF, Scatena LM, et al. Atenção primária à saúde e tuberculose: avaliação dos serviços. Rev Bras Epidemiol 2017; 20:161-75.

Resumo

O estudo teve como objetivo analisar a tendência temporal das taxas de incidência da tuberculose nas regiões e estados brasileiros para identificar padrões e desigualdades. Realizamos um estudo ecológico sobre as taxas de incidência da tuberculose por 100.000 habitantes (entre 20 e 59 anos de idade) no Brasil e nos respectivos estados, entre 2001 e 2017, de acordo com a variação percentual anual e regressão joinpoint*. Foi observada uma diminuição significativa (-15,1%) na variação anual (IC95%: -27,2; -1,0) em Roraima entre 2003 e 2007. Na Região Centro-oeste, o Estado de Goiás registrou uma variação percentual anual de -2,5% (IC95%: -3,6; -1,3). Cinco dos nove estados do Nordeste mostraram variações anuais decrescentes ao longo da série estudada. No Sudeste, Espírito Santo e Rio de Janeiro foram os estados com variações decrescentes entre 2001 e 2017. No Sul, o Estado do Paraná foi o único com a mesma variação anual de -3,7% (IC95%: -4,1; -3,2). No Brasil, a variação percentual anual média foi -1,8% (IC95%: -2,4; -1,1). Os resultados do estudo mostram uma queda nas taxas de incidência da tuberculose no Brasil. Entretanto, foram observadas diferenças regionais e intrarregionais. O estudo do padrão temporal na incidência da tuberculose pode ajudar no planejamento e implementação de políticas nacionais de controle da doença.*

Tuberculose; Incidência; Medidas em Epidemiologia; Análise de Regressão; Aplicações da Epidemiologia

Resumen

El objetivo del estudio fue analizar la tendencia temporal en las tasas de incidencia de tuberculosis en los estados brasileños y regiones para identificar patrones e inequidades. Llevamos a cabo un estudio ecológico de las tasas de incidencia por cada 100.000 habitantes, con edades comprendidas entre los 20 y 59 años, con tuberculosis en Brasil y en sus respectivos estados desde 2001 a 2017, según la variación porcentual anual y un análisis de regresión por puntos de inflexión. Se observó una disminución significativa de un -15.1% en la variación anual (IC95%: -27,2; -1,0) en Roraima, entre los años 2003-2007. En la región central, Goiás registró una variación promedio anual de un -2.5% por año (IC95%: -3,6; -1,3). Cinco de los nueve de los estados del noreste contaban con variaciones anuales decrecientes a través de las series estudiadas. Espírito Santo y Río de Janeiro fueron los estados del Sudeste que presentaron decremento entre 2001-2017. En la región del sur, el estado de Paraná fue la única con la misma variación anual de -3,7% (IC95%: -4,1; -3,2). En Brasil, la variación porcentual anual promedio fue -1,8% por año (IC95%: -2,4; -1,1). Los resultados de este estudio mostraron un declive en las tasas de incidencia de la tuberculosis en Brasil. No obstante, se observaron diferencias regionales e intrarregionales. Determinar el patrón de tendencia en la incidencia de tuberculosis puede ayudar en la planificación e implementación de las políticas de control nacionales frente a la tuberculosis.

Tuberculosis; Incidencia; Mediciones Epidemiológicas; Análisis de Regresión; Usos de la Epidemiología

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