Original Research Article

**Profile of tuberculosis deaths by mesoregion in the state of Pará from 2012 to 2022: an ecological study**

**ABSTRACT**

**INTRODUCTION**

Tuberculosis (TB) is an infection caused by bacteria from the *Mycobacterium tuberculosis* complex, transmitted through airborne aerosols, released during coughing, talking, or sneezing. Despite advancements in TB control and the availability of established treatments for over 40 years, there are still ten million new cases, and 1.5 million deaths reported annually worldwide.

**METHODS**

A descriptive and ecological study was performed on all TB-related deaths reported between 2010 and 2022, in Pará, Brazil. Data were obtained from Notifiable diseases Information System. The study have analyzed clinical, epidemiological and sociodemographic characteristics, as well as geographical and statistical trends in mortality, using binary logistic regression

**RESULTS**

A total of 1,253 TB-related deaths were reported in Pará. There was a significant increasing trend in the mortality rate, with the highest value observed in the metropolitan mesoregion. The mean age was 52.1 years, most were male, brown, without elementary education and lived in the urban area. New TB cases were the most frequently recorded, with the pulmonary clinical form accounting for 84% of cases and 15.5% of cases reported from alcoholism. The most common diagnosis was sputum smear microscopy, however, follow-up sputum smear microscopies were infrequently and directly observable treatment was rarely performed (19.2%). The multivariate analysis of deaths by mesoregion revealed significant differences with each mesoregion exhibiting distinct contributing variables.

**CONCLUSIONS**

Our results show the need for epidemiological surveillance professionals to implemente different surveillance measures and strategies for each mesoregion. Strengthening municipal healthcare system is a critical step to ensure early diagnosis and appropriate treatment for each clinical case. In addition, public policies should aim to improve socio-environmental and economic conditions addressing regional disparities to better serve the community

**Keywords:** tuberculosis, epidemiological surveillance, mortality, Amazon.

**INTRODUCTION**

Tuberculosis (TB) is an infection caused by bacteria from the Mycobacterium tuberculosis complex, transmitted by air, by exhaling aerosols when coughing, talking or sneezing (MS, 2019).

A total of 1.3 million people died from TB in 2022 (including 167,000 people with HIV). Worldwide, tuberculosis is the 13th leading cause of death and has become the leading cause of infectious disease replacing to COVID-19 (above HIV and AIDS). In 2022, an estimated 10.6 million people fell ill with TB worldwide. 5.8 million mens, 3.5 million women and 1.3 million children. Tuberculosis is present in all countries and age groups. But tuberculosis is curable and preventable (WHO, 2023).

Despite progress in TB control and the existence of reference treatments established more than 40 years ago, there are still ten million new cases per year worldwide and 1.5 million deaths (WHO, 2022). This is partially related to the complexity of TB treatment and its duration, with four anti-tuberculous drugs as a basic regimen - Isoniazid, Rifampicin, Ethambutol and Pyrazinamide, for a minimum period of two months (intensive phase) and four months in the maintenance phase of using Rifampicin and Isoniazid the ability of the bacillus to survive within macrophages with reduced metabolism, and the emerging resistance to antituberculosis drugs (Aubry & Veziris, 2023).

The present study aims to describe the clinical, epidemiological and demographic characteristics of TB cases that died between 2010 and 2022 by mesoregion, notified in the notifiable diseases information system (SINAN).

**MATERIALS AND METHODS**

**Study Types**

A descriptive and ecological study was carried out with all notified cases of TB and whose death information was filled out in the notification and follow-up form of SINAN/PA, residents of the State of Pará between 2010 and 2022. The population databases for calculating mortality rates were taken from the TABNET/DATASUS database.

**Selection of Participants**

Considering the criteria for defining TB cases, according to the Ministry of Health (MS), divided into **laboratory criteria** and **Clinical-Epidemiological**, we have: (i) **laboratory criteria,** any case that, regardless of the clinical form, presents at least one positive sputum smear microscopy, culture, or rapid molecular test specimen for TB (ii) **Clinical-epidemiological criteria**, It is any case that does not meet the laboratory confirmation criterion described above, but that has received the diagnosis of TB Active. This definition takes into account clinical-epidemiological data associated with the evaluation of other complementary tests (such as imaging, histological, among others).

Using the Microsoft Excel 2016 software, TB cases were filtered between 2010 and 2022. The total number of cases reported in the periods was 62,901 cases, but only 1,253 cases had field 62 of the TB follow-up form (Death from TB) filled out, and these 1253 cases were used for the analysis of this study.

**Place of Study**

The state of Pará is officially formed by the union of 144 municipalities, distributed in six mesoregions, with great social, geographical, economic, cultural and environmental differences:

1. **Metropolitan Mesoregion of Belém**: It is the most developed region of the state, with the highest population concentration and the greatest variety of economic activities. The municipality of Belém, which is the state capital, has the highest urbanization, presenting the best quality infrastructure and public services.
2. **Marajó Mesoregion**: Region composed of the municipalities of the island of Marajó, plus the municipalities of Gurupa, Melgaço, Portel and Bagre. In this region the characteristics are unique, characterized by riverside and quilombola communities, with an economy based on the primary activities of agriculture and plant and animal extraction. Unfortunately, some of its municipalities have the worst human development index (HDI) in the country.
3. **Northeast Pará Mesoregion**: Mesoregion that covers important municipalities in the state, bathed from the Tocantins rivers to the Guamá River, has an important influence on state agriculture with various types of plantations and cattle breeding, in addition to being a tourism region due to the Atlantic coastline that bathes the cities of the state. salty region.
4. **Southwest Pará Mesoregion**: Its highlights are the municipalities of Altamira and Itaituba. It preserves a large area of ​​the Amazon forest in the territory of Pará and the presence of the Tapajós and Xingu rivers. The economy is mainly based on mineral exploration (gold), agribusiness (soy) and plant extractivism.
5. **Southeast Pará Mesoregions**: It is an area with a large extension of land, presenting municipalities with varied urban characteristics, with a concentration of traditional indigenous peoples and regions with an extensive area of ​​mineral extraction, livestock and large-scale agriculture and energy generation with the Tucuruí hydroelectric plant.
6. **Lower Amazon Mesoregions:** Highlight for the Municipality of Santarém, which exports various products, mainly grains from the entire BR-163, however it has outstanding action in bauxite mineral extraction and agricultural activities in cassava, corn and soybean plantations. (Pará, 2024).

**Data Analysis**

The data were organized and tabulated using the Office Excel 2019 program, and were later statistically analyzed using the IBM SPSS Statistics 20 software. The variables studied were: race, sex, education, area of residence, type of entry, type of special populations, clinical form, comorbidity, sputum smear microscopy, sputum culture, histopathological, chest X-ray, HIV test, control sputum smear microscopy, and supervised treatment.

The choropleth maps were created using the QGIS 3.34.5 software and to perform the categorization into five classes, the average of the overall mortality rate for the entire study period (2010-2022) was used, ranging from Very Low, Low, Medium, High and Very High. First, the total amplitude (AA) of the samples was calculated, that is, the difference between the maximum value and the minimum value, five classes (k) were listed, and then the total amplitude was divided by the number of classes chosen (AA/k), resulting in the value of the amplitude of the classes. This result was added to the lower limit value to then create the threshold values for each category mentioned above.

The epidemiological profile was analyzed by absolute and relative frequencies and presented in tables. A binary logistic regression was performed with the dependent variable the mesoregion of residence, with a model for each mesoregion, to investigate the odds ratio of the independent variables by mesoregion. The Statistical Package for the Social Sciences (SPSS) 26.0

**RESULTS**

The situation of TB in Brazil, according to the 2023 epidemiological bulletin of the Ministry of Health, in which the incidence coefficient is remaining stable between 2010 and 2022, totaling values between 35.9~36.3/100 thousand inhabitants, and the mortality coefficient also showed temporal stability, staying above 2/100 thousand inhabitants. (BRAZIL, 2023). When compared to the state of Pará, the results showed a certain difference between the general trend in the historical series, with Brazil having some annual fluctuations, with a downward trend in the period, but with an upward perspective in the long term, and Pará, even with fewer annual fluctuations, has a trend of more accentuated growth in the mortality rate over the years (figure 1).

**Figure 1 – TB Mortality Rate in Pará and Brazil. 2010-2023.**

Source: DATASUS/MS.

A total of 1,253 deaths were reported in the state of Pará during the entire study period (2010-2022), considering all notifications that had marked "death from TB" in field 62 (Closure Status) in the SINAN follow-up form and the results of all descriptive data, using absolute and relative values (Table 1).

The results of the analysis of the age group crossed with sex show that most of the cases (65.9%) were included in the age groups of 31 – 70 years, with a mean age of 52.1 years, demonstrating how much the Economically Active Population (EAP) was affected, and the male gender was predominant in the notifications (Figure 2), as well as the brown race, reported in 75.8% (950/1253) of the death notifications in the state of Pará during the study period.

**Figure 2 – Age group x Sex of TB deaths, Pará. 2010-2022**.

Source: SINAN/SESP.

**Table 1 – Epidemiological variables of patients who died from TB, Pará. 2010-2022.**

|  |  |  |
| --- | --- | --- |
| EPIDEMIOLOGICAL VARIABLES | N (1253) | % |
| Race |  |  |
| Yellow | 8 | 0,6 |
| White | 131 | 10,5 |
| Ignored | 45 | 3,6 |
| Indigenous | 16 | 1,3 |
| Brown | 950 | 75,8 |
| Black | 99 | 7,9 |
| No information | 4 | 0,3 |
| EPIDEMIOLOGICAL VARIABLES | **N (1253)** | **%** |
| Zone |  |  |
| Peri urban | 4 | 0,3 |
| Rural | 202 | 16,1 |
| Urban | 1037 | 82,8 |
|  |  |  |
| Schooling |  |  |
| Illiterate | 135 | 10,8 |
| 1st to 4th grade incomplete | 245 | 19,6 |
| 4th grade | 86 | 6,9 |
| Incomplete 5th to 8th grade | 150 | 12 |
| Complete Fundamental | 73 | 5,8 |
| Incomplete high school | 45 | 3,6 |
| High School | 94 | 7,5 |
| Incomplete Superior | 7 | 0,6 |
| Complete Superior | 12 | 1 |
| Ignored | 322 | 25,7 |
| Not applicable | 19 | 1,5 |

|  |  |  |
| --- | --- | --- |
| Ticket Type |  |  |
| New case | 1037 | 82,8 |
| Don't know | 6 | 0,5 |
| Postmortem | 26 | 2,1 |
| Recidivism | 70 | 5,6 |
| Re-entry after abandonment | 63 | 5 |
| Transfer | 51 | 4,1 |
| Special populations\* |  |  |
| Population Deprived of Liberty | 21 | 1,7 |
| Homeless Population | 19 | 1,5 |
| Health Professional | 6 | 0,5 |
| Immigrant | 2 | 0,2 |
| Clinical form |  |  |
| Pulmonary | 1057 | 84,4 |
| Extrapulmonary | 121 | 8,7 |
| Pulmonary + extrapulmonary | 75 | 6 |
| Associated diseases and conditions\* |  |  |
| AIDS | 141 | 11,3 |
| Alcoholism | 197 | 15,7 |
| Diabetes | 169 | 13,5 |
| Mental illness | 35 | 2,8 |
| Illicit Drug Use | 68 | 5,4 |
| Smoking | 158 | 12,6 |
| EPIDEMIOLOGICAL VARIABLES | **N (1253)** | **%** |
| HIV |  |  |
| Positive | 152 | 12,1 |
| Negative | 553 | 44,1 |
| In progress | 51 | 4,1 |
| Not realized | 497 | 39,7 |
| Laboratory and imaging tests\*\* |  |  |
| Sputum Smear Smear Smear | 596 | 47,6 |
| Escarro Culture | 62 | 4,9 |
| Histopathological | 119 | 9,3 |
| Chest X-ray | 947 | 75,6 |
| Rapid Molecular Test - TB | 33 | 2,6 |
| Supervised treatment |  |  |
| Yes | 236 | 18,8 |
| No | 194 | 15,5 |
| Ignored | 30 | 2,4 |
| No information | 793 | 63,3 |
|  |  |  |

Source: SINAN/SESPA. \* In the variables SPECIAL POPULATIONS AND ASSOCIATED DISEASES AND INJURIES, only the cases that were marked as "Yes" on the Notification form were added to the table. \*\* In the item LABORATORY AND IMAGING TESTS, the variable HISTOPATHOLOGICAL were considered only with a POSITIVE AFB result, in the variable TMR-TB the results of SENSITIVE TO RIFAMPICIN were referenced, and in the CHEST X-RAY, only the cases were referenced as CONSTIPATION.

Regarding the area of occurrence, it was reported that 82.9% (1021/1232) of the cases occurred in the urban area, while only 16% (197/1232) occurred in the rural area, in the descriptive analysis of schooling 54.6% cumulatively of the cases did not complete elementary school, of which 10.8% were illiterate.

Regarding the type of admission and/or treatment, i.e., how the patient was introduced into the notification system, 83.1% (1024/1232) were reported as new cases, confirming a high incidence rate of TB in Pará

With regard to special populations, the TB notification form is divided into four groups: Population deprived of liberty, Homeless population, health professional, and Immigrant. According to these groups, 4517 cases and 21 deaths of the population deprived of liberty, 596 cases and 19 deaths of the homeless population, 568 cases and 6 deaths of health professionals and 130 cases and only 2 deaths of immigrants were notified, considering the notified cases that were not included in the aforementioned groups, there were 57,215 cases and 1207 deaths, demonstrating that this population had more deaths than special populations.

The pulmonary clinical form was the most reported among deaths (84% - 1035/1232) in Pará, and among the diseases and conditions notified, alcoholism was the most reported (193/1232 - 15.7%), emphasizing that this information was higher than HIV/TB comorbidity, which is so relevant to the clinical evolution of the patient and demands a lot of attention, being reported positive in 151 cases (12.3%). Many of these factors and individual behaviors make it difficult for patients to heal, as they need to adjust habits and leave addictions to access treatment and this generates personal conflicts.

Regarding the TB diagnostic techniques performed in the reported deaths, 47.4% (583/1232) had positive sputum smear microscopy, 5.1% (63/1232) had positive sputum culture, 9.3% (115/1232) had positive Acid-Resistant Bacillus (AFB0 in the histopathological test. Regarding chest X-rays, 75.6% (931/1232) had a suspicious result for TB, possibly as cavitations, hilar or mediastinal lymph node enlargement and pleural effusion, and only 3% (37/1232) had a normal chest X-ray

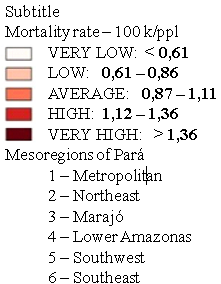
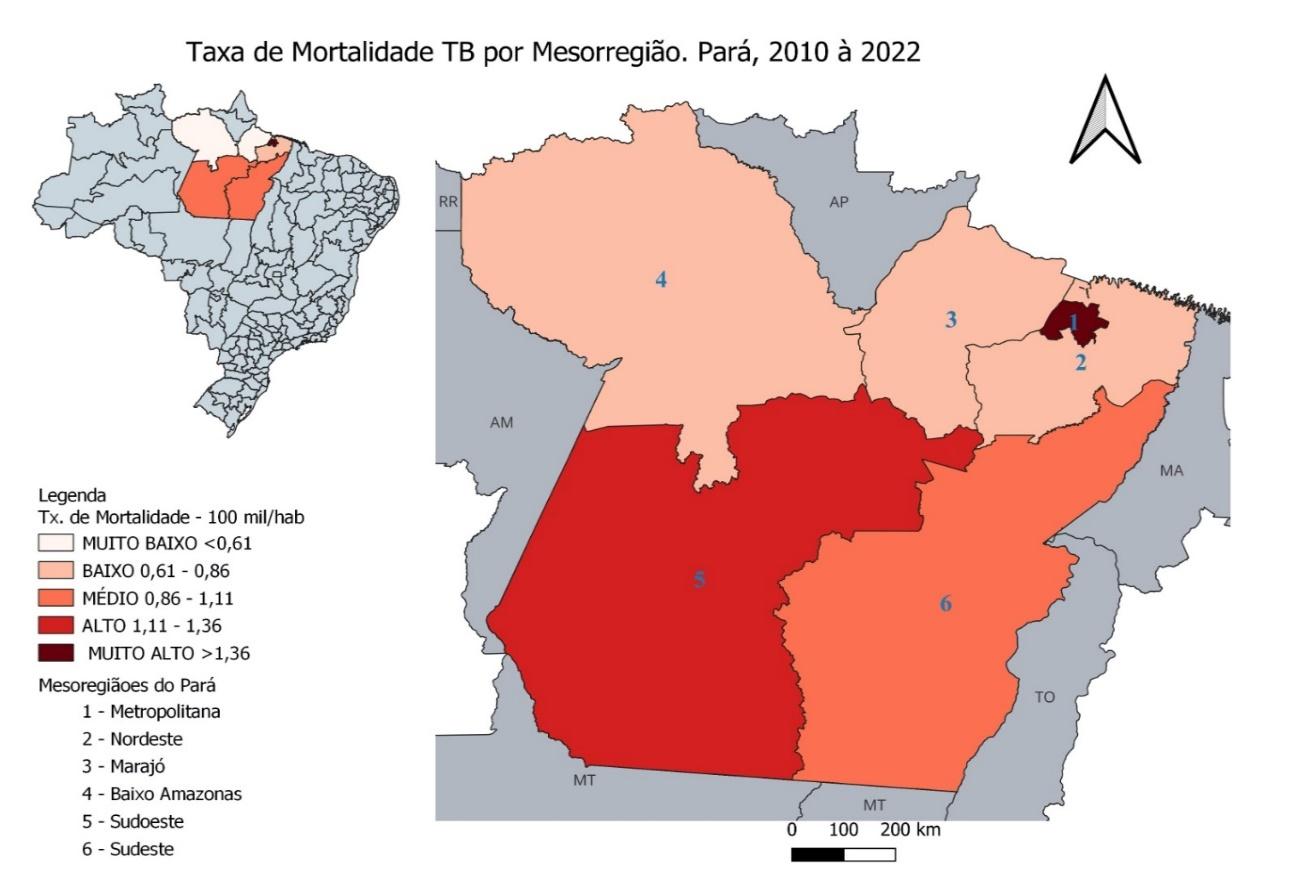
Regarding TB follow-up sputum smear microscopy, which is performed monthly to analyze the patient's improvement or cure, there was a precipitous drop in the tests performed from the 1st month onwards in deaths reported during the study period. Failure to perform follow-up sputum smear microscopy impairs the team's analysis to identify patients with treatment failure, which could lead to drug resistance, or if they are undergoing treatment. (Figure 3).

**Figure 3 - Follow-up sputum smear microscopy of cases that progressed to death, Pará. 2010 to 2022.**

Source: SINAN/SESPA

Of the cases studied, only 236 (19.2%) were informed that there was Directly Observable Treatment (DOT), while the number of patients who did not undergo DOT was 3.2x higher (772). Regarding the analysis of the mortality rate in Pará in the deaths studied by mesoregion, a variety of values were evidenced, but with an expected result to have the highest mortality rate in the Metropolitan mesoregion, and it can be inferred that it is the place with the largest agglomeration of people in the state, as well as the largest number of health units with the greatest potential to diagnose TB (Figure 4).

**Figure 4 – Overall TB Mortality Rate by Mesoregion. Pará, 2010-2022.**



Source: SINAN/SESPA

Based on the mean overall TB mortality rate, categories were created that served as the basis for analysis of the annual temporal variation of the mortality rate by mesoregion, which showed great variation during the time series, with the year 2022 having the worst mortality rates globally, where 4 (66.6%) mesoregions were classified in the very high category (figure 5).

Regarding the multivariate analysis of deaths according to each health mesoregion of Pará, it showed differences between them, where each of them presented a significant variable divergent from the other, with the Metropolitan of Belém emphasizing that deaths in this region were less associated with men (p-0.031 OR 0.763 95%CI 0.597-0.976), smokers (p-<0.001 OR 0.484 95%CI 0.340-0.690) and deaths with the pulmonary clinical form (p-<0.001 OR 0.424 95%CI 0.305-0.588).

**Figure 5 - Annual maps of TB Mortality Rate by Mesoregion. Pará, 2010 – 2022.**

2010

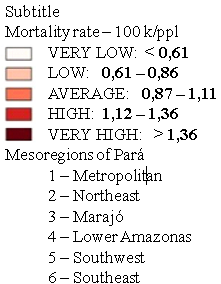
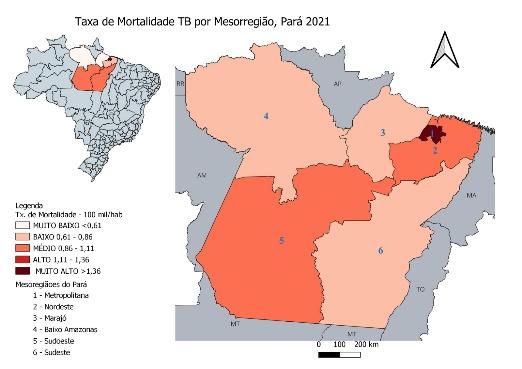
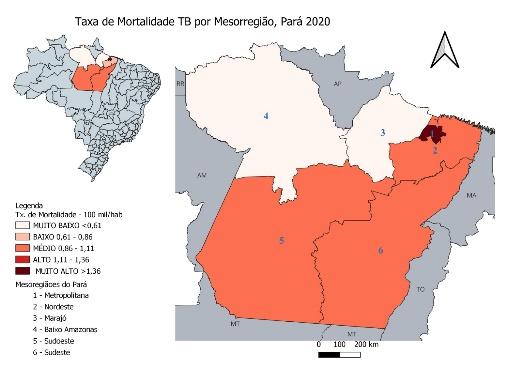
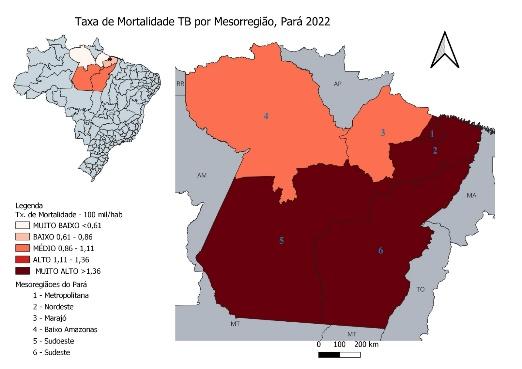
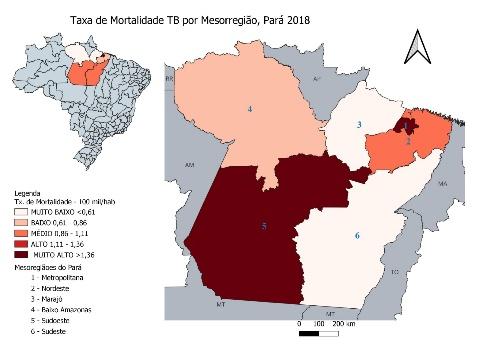
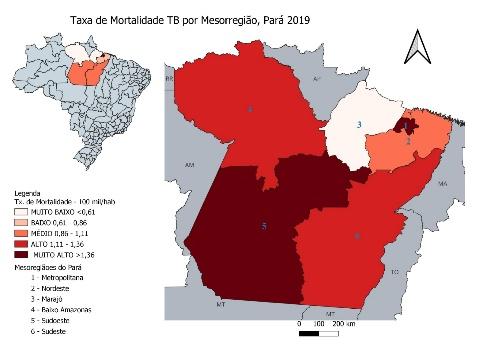
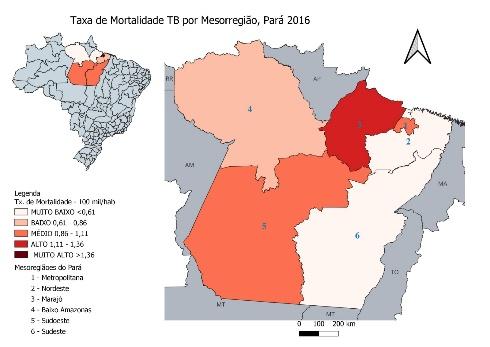
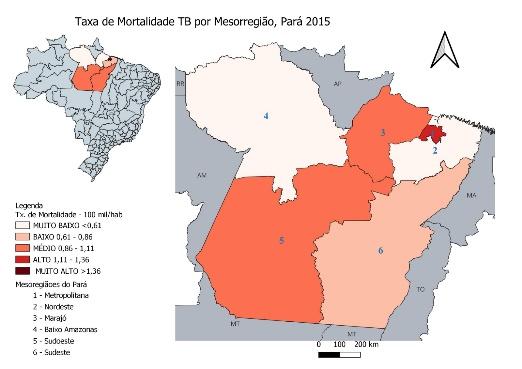
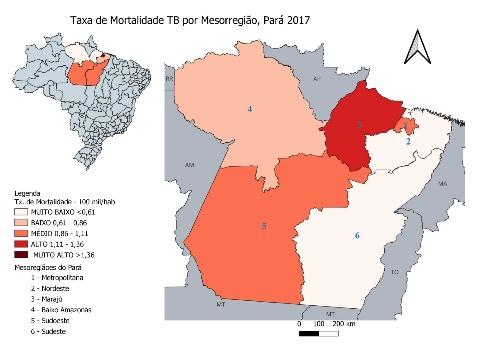
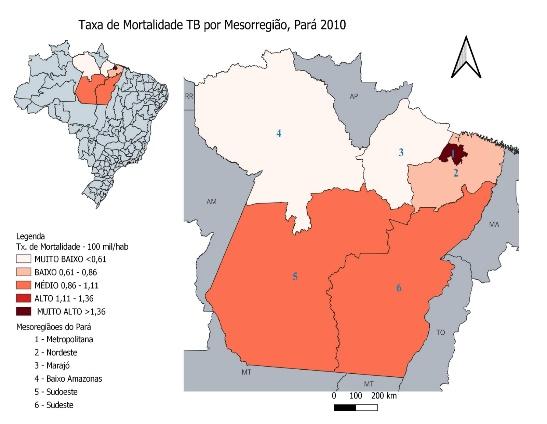
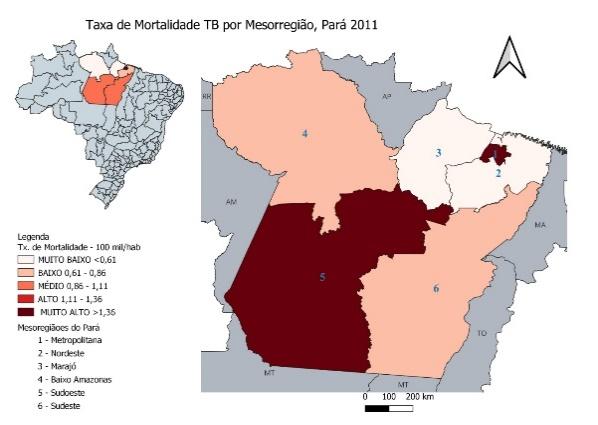
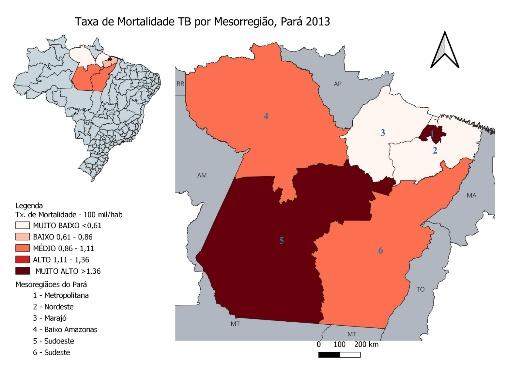
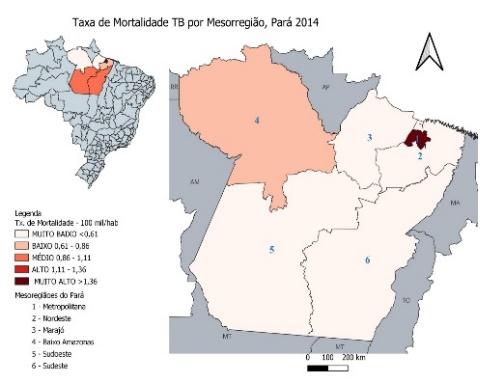
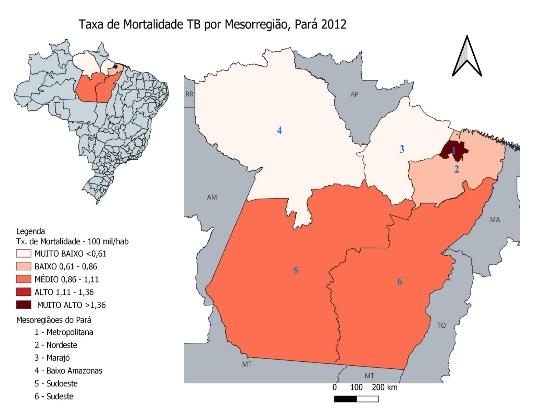
2011

2012

2014

2013

2013



2019

2018

2017

2016

2015

2020

2021

2022

Source: SINAN/SESPA

In the Lower Amazonas, age was a factor associated with death (p-0.042 OR 1.013 95%CI 1.000-1.027). In the Southwest of Pará, it was already alcoholism (p-0.014 OR 2.005 95%CI 1.153-3.488). The population deprived of liberty (p-0.036 OR 2,694 95%CI 1,067-6,803) and the pulmonary clinical form (p-0.003 OR 2,205 95%CI 1,307-3,720) in the Northeast of Pará had a greater statistical association with death, and in the Southeast of Pará, smoking (p-<0.001 OR 0.429 95%CI 0.293-0.627) and pleural clinical form (p-0.028 OR 0.202 95%CI 0.048-0.844) had less association with deaths. The Marajó mesoregion did not have any statistically significant dependent variables, as shown in Table 2.

**Table 2 – Final multivariate model for the variables associated with the health mesoregions of Pará.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Metropolitan of Belém | | | | |
| Variables | p-value | OR | IC95% | |
|  |  |  | Minimal | Maximum |
| Male | 0,031 | 0.763 | 0.597 | 0.976 |
| Smoking | <0,001 | 0.484 | 0.340 | 0.690 |
| Lung Form | <0,001 | 0.424 | 0.305 | 0.588 |
| Constant | <0,001 | 2.858 |  |  |
| Baixo Amazonas | | | | |
| Age | 0.042 | 1.013 | 1.000 | 1.027 |
| Diabetes Mellitus | 0.043 | 0.345 | 0.123 | 0.966 |
| Constant | <0,001 | 0.031 |  |  |
| Southwest Pará | | | | |
| Styling | 0.014 | 2.005 | 1.153 | 3.488 |
| Drug use | 0.055 | 0.238 | 0.055 | 1.031 |
| Constant | <0,001 | 0.068 |  |  |
| Northeast Paraense | | | | |
| Deprived of Liberty | 0.036 | 2.694 | 1.067 | 6.803 |
| Lung Form | 0.003 | 2.205 | 1.307 | 3.720 |
| Constant | <0,001 | 0.093 |  |  |
| Marajó (none of the variables was significant) | | | | |
| Southeast Pará | | | | |
| Smoking | <0,001 | 0.429 | 0.293 | 0.627 |
| Forma Pleural | 0.028 | 0.202 | 0.048 | 0.844 |
| Constant | <0.001 | 0.441 |  |  |

Font: SINAN/SESPA.

**DISCUSSION**

The study showed us divergent results compared to the national level in terms of the mortality rate during the study period, and can attribute the greater trend of increase in the mortality rate in Pará to socioeconomic factors, since the state has higher indicators for the risk factors of poverty, malnutrition and housing conditions, as well as the factor of differences in the sensitivity capacity of the Pará health system compared to the national level, as it influences the diagnosis and treatment of TB affecting mortality rates.

Regarding the age group found in the study, the profile of those affected is the same result presented by Dong et al (2022), because in their study the most affected age groups were between 20 and 74 years old, in another study by Eddabra & Neffa (2020), they found an age group with different variation, ranging from 15 to 59 years old, however, it remains within the PEA and Dhali et al (2021) demonstrated in their survey the mean age of 45 years in their reported cases, while Oliveira et al, 2019 the mean age of patients who died from TB was 54.0 ± 16.3. This situation of TB affecting and consequently evolving to death plus ASD is reinforced by many studies that report that it affects the most productive adults and generating personal financial losses and their families (Snow et al. 2018, Eddabra & Neffa, 2020).

Regarding the comparison of the proportion between males and females, the results found are consolidated by other studies that also had proportions of 1.45 and 1.50 between male/female, which report that the hypothesis for this occurrence refers to the male sex, which still has the greatest tendency to have occupational relations outside the home environment, they start to have more contact with third parties, who are infected, in addition to the resistance factor to seek medical care, thus generating a higher incidence of TB in men. However, mycobacterial infections are expected to worsen in postmenopausal women. It is possible that hormonal changes resulting from this period contribute to a worse immune response to infections by intracellular microorganisms (Medeiros et al, 2007, Eddabra & Neffa, 2020; Brito et al, 2020; Chahboune et al, 2022).

Chahboune et al (2022) found in their research that a little more than two-thirds of the patients (68.66%) lived in urban areas, which is expected, because in urban areas there is greater agglomeration, contributing to TB transmission. Another factor that affects the incidence in urban areas is the greater availability of health services and professionals, increasing the chance of making the diagnosis.

With regard to the theme of education, the finding is directly related to the profile already found in other studies and in what is mentioned in the literature, which reports on the population, that the lower the level of education, the more susceptible to having more diseases, thus being more affected by TB, because the lower the education, the worse the living conditions in all aspects, because it leads proportionally to lower family income, also contributing to treatment abandonment due to not understanding the severity of the disease and understanding the treatment and its consequences, increasing the probability of mycobacterial resistance to drugs and death (Santos-Junior et al. 2016; Araújo et al. 2017; Oliveira et al. 2017; Wanzeller & Mello, 2018).

In the study by Oliveira et al (2019), a result equivalent to the results found in Pará (83%) was found, that is, a prevalence of 88% in notifications of new cases in relation to all other "types of entry" in the notification form. The result found in the study is different from what is referred to in the process of contamination of special populations, which is usually more contaminated, since there are already reports of recognition that incarcerated populations are at high risk of exposure and development of tuberculosis, but receive less attention in the main policies to combat TB, as well as more association with early death (Oliveira et al, 2019; Cords et al, 2021; Who, 2023).

The predominant clinical pulmonary form in the study in Pará is the same as the survey of the study by Eddabra & Neffa (2020), which was present in 63.5% of the cases, as well as Brito et al (2020), which also had a high predominance (86.37%) of pulmonary presentation and 54.78% of bacillary cases, emphasizing that the bacillary cases may be even larger, as 23.60% of their cases did not undergo tests. Pulmonary tuberculosis, a transmissible form of the disease, was responsible for almost 80% (755/944) of deaths (Oliveira et al, 2019).

Regarding associated diseases and conditions, the study showed that Alcoholism (15.7%) was the most common problem among deaths, results that were followed by the study by Oliveira et al (2019), which also surveyed deaths in southeastern Brazil, showing that 50% had some habits that impair treatment adherence, 30.4% used alcohol, 13.3% tobacco and 5.6% other psychoactive substances, other information intensifies that such habits may be risk factors for tuberculosis infection and tuberculosis lung disease (Bates et al 2007; Feng et al, 2014; Oliveira et al, 2019; Eddabra & Neffa, 2020).

Sputum smear microscopy, among the available tests, even because the logistics and performance process is less costly, it still continues to be the most performed in the State of Pará, such a result was highlighted by the study by Brito et al (2020) which had 54.78% of the positive cases in the 1st sputum smear microscopy sample and 5.92% in the culture and in the study by Chahboune et al (2022) that the diagnosis of TB was bacteriologically confirmed by 84.09% of the Patients. In southern Brazil, a study showed results equivalent to those found in deaths in Pará, where 86.9% had chest X-rays suspected of TB (Oliveira et al, 2019).

Periodic follow-ups with sputum smear microscopy are an essential component in follow-up, and negative sputum smear microscopy at the second month of treatment is an important result of its evolution, and a guide for decisions about drug therapy (Stoffel et al, 2014). Failure to perform control sputum smear microscopies can have consequences such as delaying the identification of patients who do not adhere to treatment, or do not respond to drug therapy, and can hinder the early detection of bacterial multidrug resistance (Satyanarayana et al, 2011; Wanzeller & Mello, 2018), at this point, the study showed a negative evolution in the continuous performance of sputum smear microscopy over the months of follow-up, generating a problem for the surveillance of the disease to analyze the aforementioned indicators, and through the analysis of the follow-ups of the cases by the date of closure, we realized that more than 50% (745-1253) died within 30 days after the date of notification, contributing to the drastic decrease in the Follow-up sputum smear microscopy.

The study by Satyanarayana et al (2011) showed results that corroborate our findings on the time reduction in the performance of control sputum smear microscopies, pointing out as possible reasons for not performing follow-up sputum smear microscopies, the lack of cough or expectoration by patients, incomplete or inadequate information provided by the health team regarding the need to perform sputum tests. Stoffel et al (2014) added another casuistry reporting the centralization of the test in a reference laboratory far from the home, and Wanzeller & Mello (2018) ratifies the relevance of the responsibility of the service that accompanies the TB patient for the collection and delivery of the sample to the laboratory, which reduces travel costs for the patient and ensures the agility of the result.

According to the Ministry of Health, directly supervised treatment is defined as the direct observation of the taking of tuberculosis medication, ideally, on all working days of the week, or exceptionally, three times a week during the first month of treatment, combined with political will, regular acquisition and distribution of medications, and a regular information system.

DOT is an important tool for controlling the disease, but it is necessary to reinforce that it goes beyond supervising the taking of the drug to increase the effectiveness of the treatment (Lâvor et al, 2015). It is the municipal responsibility to operationalize DOT and monitor prevention measures, however, due to the occurrence of the decentralization of DOT to units other than the one where the patient was notified, it generates inconvenience and increases the possibility of treatment abandonment, as reported by Souza et al (2017) that this strategy alters the daily routine and generates embarrassment in the patient when performed in the health unit, one of the factors associated with difficulty in adhering to treatment (Santos et al, 2021).

In the maps by mesoregions of Pará where the general mortality rate was used for preparation in the choropleth method, it shows us that within the state there is a great difference between the mesoregions, in terms of the mortality rate, but it presents an expected result that is related to the higher rate being in the metropolitan mesoregion, where the highest population concentration and coverage of health care is found in relation to the other mesoregions.

Comparing with studies at the national level, some results show that the low development status of the North and Northeast regions has a direct impact on the provision of actions and services for prevention, health promotion, surveillance, and health care for people with tuberculosis. These regions have fewer health care resources, with a lower density of health professionals and number of doctors, which can influence tuberculosis mortality rates (Cortez et al, 2021; Queiroz et al, 2023), that is, within their particularities, studies show that regions with higher population density tend to have improved health conditions, increasing the quality of health care in the place.

**CONCLUSIONS**

According to the results found in our study, it shows that epidemiological surveillance professionals need to adopt different surveillance measures and strategies for each mesoregion.

The study shows that TB is a stable public health problem in the state of Pará, but with high incidence and mortality rates, showing that it is a significant point of attention for health management

Regarding social, demographic, and clinical outcomes, Pará maintains a pattern similar to other places with high mortality, with the pulmonary clinical form, the age group of the economically active population, which leads to financial impacts on the families involved, increasing the social problem involving TB and association with risk factors such as alcoholism and smoking and morbidities such as HIV and diabetes.

However, a strategy that presents a global need for the State is to improve the quality of diagnosis and follow-up of patients, because without incomplete information or data, health professionals will not have adequate support to know how the level of TB control is and about anti-TB drug resistance.

The demonstration in the variation of the mortality rate of each mesoregion indicates great disparities from one region to another, as well as considering the discrepancy between deaths from urban to rural areas, highlighting the need to discover the profile of specific risk factors occurring in each state region so that intervention strategies can be designed appropriate to their particularities.

In summary, even though Pará managed to maintain the epidemiological levels of incidence and mortality in the period studied, the struggle to achieve the global goals established in the eradication of TB still persists. For such a situation, it is extremely necessary to strengthen municipal health so that early diagnosis and appropriate treatment for each clinical case occur, in addition to public policies that improve socio-environmental and economic conditions, adapting to regional differences of the entire state population. Because without a comprehensive approach to all the problems identified in the relationship of the impact of TB, it will not be possible to improve the health of the people of Pará.

**LIST OF ABBREVIATIONS**

TB – Tuberculose

SINAN – Notifiable Diseases Information System

PA – Pará

MS – Ministry of Health

PEA – Economically Active Population

DOT – Directly Observable Treatment

**Ethical Approval:**

The present study used secondary data from the SINAN/PA database, the authorization of the use of the data is referenced by the consolidated opinion of the Ethics and Research Committee of the Evandro Chagas Institute, number 3,950,565, issued on April 2, 2020.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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