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Spatial analysis of abandonment of tuberculosis treatment in a health region of Maranhão

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Análise espacial do abandono do tratamento da tuberculose em uma região de saúde do Maranhão
Análisis espacial del abandono del tratamiento de la tuberculosis en una región de salud de Maranhão

RESUMO
Objetivo: analisar a distribuição espacial do abandono de tratamento da tuberculose (TB) na Região de Saúde de Pinheiro - Maranhão. Métodos: estudo ecológico dos casos novos de TB que abandonaram o tratamento, notificados no Sistema de Informação de Agravos de Notificação, de 2015 a 2021. Resultados: Cerca de 15,2% dos casos abandonaram o tratamento. Observou-se, em todos os anos, municípios com proporções superiores ao preconizado pela Organização Mundial da Saúde (5%). A distribuição espacial dos casos ocorreu de forma não aleatória e heterogênea, com cluster de alto-risco formado por quatro municípios: Bacuri, Santa Helena, Serrano do Maranhão e Turilândia, com média do indicador de 27,9%. Conclusão: o abandono do tratamento da TB na região de saúde de Pinheiro é elevado, apresentando áreas de alto risco. A identificação dessas áreas pode contribuir para a elaboração e fortalecimento de políticas públicas voltadas ao controle do abandono do tratamento da tuberculose nesta região.
DESCRITORES: Tuberculose; Análise Espacial; Pacientes Desistentes do Tratamento.

ABSTRACT
Objetivo: analizar la distribución espacial del abandono del tratamiento de la tuberculosis (TB) en la Región de Salud de Pinheiro - Maranhão. Métodos: estudio ecológico de los casos nuevos de TB que abandonaron el tratamiento, reportados en el Sistema de Información de Enfermedades de Declaración Obligatoria, desde 2015 hasta 2021. Resultados: Alrededor del 15,2% de los casos abandonaron el tratamiento. En todos los años se observaron municipios con proporciones superiores a las recomendadas por la Organización Mundial de la Salud (5%). La distribución espacial de los casos ocurrió de forma no aleatoria y heterogénea, con un conglomerado de alto riesgo formado por cuatro municipios: Bacuri, Santa Helena, Serrano do Maranhão y Turilândia, con un indicador medio de 27,9%. Conclusión: el abandono del tratamiento de la TB en la región de salud de Pinheiro es alto, presentando áreas de alto riesgo. La identificación de estas áreas puede contribuir para la elaboración y fortalecimiento de políticas públicas dirigidas al control del abandono del tratamiento de la tuberculosis en esta región.
DESCRIPTORS: Tuberculosis; Spatial analysis; Patient dropouts.

RESUMEN
Objetivo: analizar la distribución espacial del abandono del tratamiento de la tuberculosis (TB) en la Región de Salud de Pinheiro - MA. Métodos: estudio ecológico de la distribución espacial de los casos nuevos de TB que abandonaron el tratamiento, reportados en el Sistema de Información de Enfermedades de Declaración Obligatoria, de 2015 a 2021. Resultados: en el período analizado, el 15,2% de los casos abandonaron el tratamiento. Todos los años se observaron municipios con proporciones superiores al 5%, porcentaje máximo recomendado por la Organización Mundial de la Salud. La distribución espacial de los casos ocurrió de forma no aleatoria y heterogénea, con un conglomerado de alto riesgo formado por cuatro municipios: Bacuri, Santa Helena, Serrano do Maranhão y Turilândia, con un indicador medio de 27,9%. Conclusión: el abandono del tratamiento de la TB en la región de salud de Pinheiro es alto, presentando áreas de alto riesgo. La identificación de estas áreas puede contribuir para la elaboración y fortalecimiento de políticas públicas y para la planificación de acciones que puedan contribuir al control del abandono del tratamiento de la tuberculosis en esta región.
DESCRIPTORES: Tuberculosis; Análisis espacial; Pacientes desistentes del tratamiento.

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INTRODUCTION

Tuberculosis (TB), a disease caused by Mycobacterium tuberculosis, has affected humanity for several centuries, with records in the biblical period, and its pathogen was isolated in 1882. It is configured as an ancient evil that persists as an important public health problem, despite all the efforts made to control it. [1]

According to the World Health Organization (WHO), it is estimated that in 2020 around 9.9 million people developed TB worldwide, of which 56% were men, 33% women and 11% children. Brazil is among the 22 priority countries for TB control actions, being the 20th country in the number of new cases in the world, with an abandonment rate of around 12.9%. [1,2]

Despite being a serious pathology, TB is curable in practically 100% of cases, as long as the treatment is timely and assertive, and correct adherence to treatment is essential, which impacts on the control of the disease, since it allows the discontinuity of the epidemiological chain of transmission and reduces the chances of resistance of the bacilli. If there is abandonment, there is a prolongation of treatment, use of multiple medications and

> Interventions to minimize the abandonment of TB treatment involve knowledge of priority locations in the geographic space, as linking the occurrence of health events to the space where they occur provides an assertive response to associated problems.

more unpleasant side effects. [3-5]

Considered one of the main barriers to TB control, abandonment has as a direct consequence the persistence of morbidity and the increase in mortality and relapse rates, which favors the development of bacterial resistance and increases the burden of treatment on health systems. [6]

In the national scenario, treatment is offered free of charge by the Unified Health System (SUS), with the possibility of carrying out supervised treatment for cases with a greater possibility of abandonment. Despite this, in 2014, a variation of 2.8% to 15.9% of abandonment was recorded among Brazilian federative units 7 and between 2012 and 2018, 52,249 cases had typified closure with this outcome among the 496,764 reported TB cases, representing 10.51%, when the recommended percentage, according to the WHO, is ≤ 5%. [5]

Interventions to minimize the abandonment of TB treatment involve knowledge of priority locations in the geographic space, as linking the occurrence of health events to the space where they occur provides an assertive response to associated problems. Understanding that TB is closely related to the living conditions of a population, and may have an

artigo

Araújo, S. S., Soeiro, V. M. S., Nina, L. N. S., Vieira, V. R., Caldas, A. J. M., Silva, T. C.,
Spatial analysis of abandonment of tuberculosis treatment in a health region of Maranhão

unequal impact on different geographical spaces, it is necessary to carry out research to better understand the dynamics of TB abandonment. [5,8]

Therefore, the present study, through spatial analysis in health, using data from SINAN, proposes to answer the following questions: How are cases of TB treatment abandonment distributed in time and space in the Pinheiro Health Region - MA? Is there spatial autocorrelation between these cases? Are there high or low risk clusters for treatment dropout?
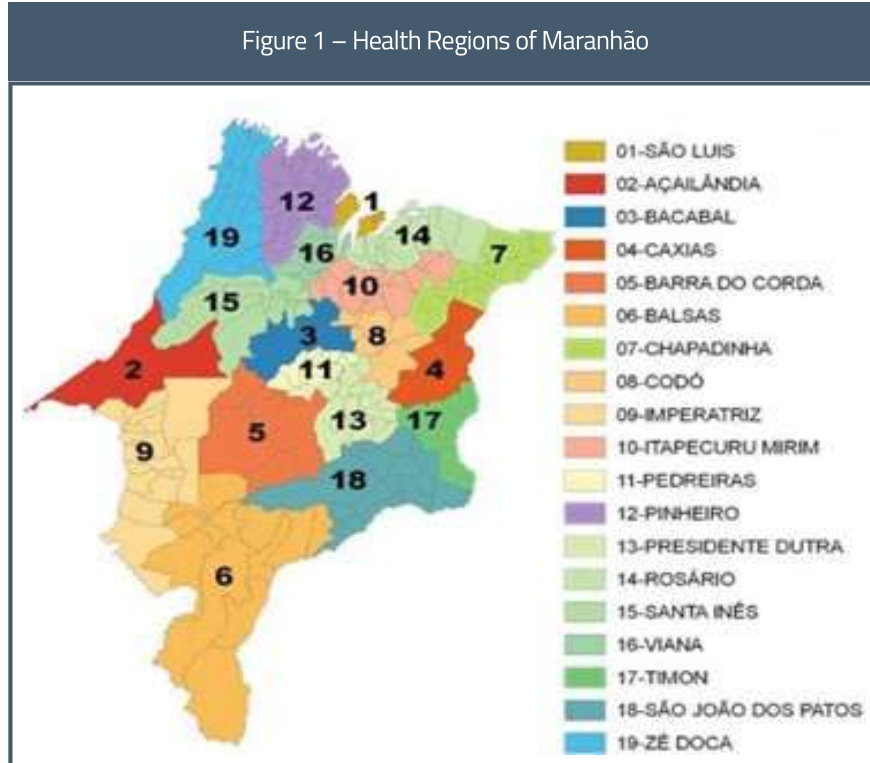
From this perspective, the objective is to analyze the spatial distribution of the abandonment of tuberculosis treatment in the Health Region of Pinheiro - MA in the period from 2015 to 2021.

METHODS

This is an ecological study of the treatment abandonment of new TB cases in the Pinheiro Health Region, Maranhão, notified in the Notifiable Diseases Information System (Sinan), in the period from 2015 to 2021. Maranhão is one of the states belonging to the Northeast region and covers an area of 329,651,495 km², has an estimated population of 7,153,262 inhabitants, with a population density of 21.46 inhab/Km. 2 As for its political-administrative organization, it has 217 municipalities and 19 Health Regions. [9,10] (Figure 1).

The study was developed with data referring to the Health Region of Pinheiro - MA, which is composed of 17 municipalities including the headquarters, they are: Apicum-Açu, Bacuri, Bequimão, Cedral, Central do Maranhão, Cururupu, Guimarães, Mirinzal, Pedro do Rosário, Peri Mirim, Pinheiro (headquarters), Puerto Rico do Maranhão, Presidente Sarney, Santa Helena, Serrano do Maranhão, Turiaçu and Turilândia. The regional assists a total population of 380,642 inhabitants. [11]

The study population consisted of all new cases of TB, of all clinical forms, whose outcome was treatment abandon-

Figure 1 – Health Regions of Maranhão

01-SÃO LUIS
02-AÇAILÂNDIA
03-BACABAL
04-CAXIAS
05-BARRA DO CORDA
06-BALSAS
07-CHAPADINHA
08-CODÓ
09-IMPERATRIZ
10-ITAPECURU MIRIM
11-PEDREIRAS
12-PINHEIRO
13-PRESIDENTE DUTRA
14-ROSÁRIO
15-SANTA INÊS
16-VIANA
17-TIMON
18-SÃO JOÃO DOS PATOS
19-ZÉ DOCA

Source: Silva et al.10.

ment. We chose to work with new cases because this dataset reflects the dynamics with which TB cases appear in the population and the strength of morbidity (through transmissibility) and all clinical forms due to the abandonment of TB treatment, in all its forms, generate an overload and burden on the health system.

New cases of TB with termination typified as abandonment of treatment that did not present identification of the municipality of residence (which would make spatialization unfeasible) were excluded. The data source used was Sinan, available online and free of charge through the Department of Informatics of the SUS (DATASUS) via health information from the TABNET program. Data was collected in May 2022.

The analysis started with the calculation of the proportion of TB treatment abandonment by dividing the number of new TB cases closed as treatment abandonment, per year of diagnosis, by the number of new TB cases reported, per

year of diagnosis, the result being multiplied by 100.

For the spatial analysis, the municipalities of the Health Region of Pinheiro - MA were used as an ecological unit. After the capture phase, the data were transferred to an Excel spreadsheet and, later, descriptive statistical analysis was performed using the STATA® software, version [14]. Thematic maps of the distribution of the proportion of TB abandonment by municipalities were made for each year.

In order to estimate the spatial variability in the data analysis, a Queen-type Spatial Proximity Matrix was built. Subsequently, the Global Moran Index (spatial autocorrelation) was calculated, a general measure of spatial association for a data set, which tests, between connected areas, the degree of autocorrelation for the indicators studied ($p < 0.05$), being validated through the pseudo-significance test, with 99 permutations. [12]

In addition, the Moran Local index was calculated to delimit clusters of TB treatment abandonment. The Local Spa-

tial Association Index (LISA) or local Moran was determined to detect regions with significant local spatial correlation (p<0.05%).[12] The last stage of the analysis allowed the unification of areas with positive spatial correlation, for the identification of clusters and priority areas for abandoning TB treatment.

High-risk clusters were considered to be those municipalities that had a high proportion of TB treatment dropout (above 5%) and were surrounded by municipalities that also had a high proportion of TB treatment dropout (autocorrelation pattern called High-High). Conversely, low-risk clusters were defined as those municipalities that had a dropout rate within the acceptable range recommended by the WHO and were surrounded by municipalities that also had a low dropout rate (low-low autocorrelation pattern). [5,13]

The calculation of global and local spatial autocorrelation indices were performed in GeoDa, version 1.14.0. The georeferencing of the information was based on the digital grid of Maranhão, based on the cartographic base of the IBGE and the construction of thematic maps using the QGis software, version 3.22.3.

Due to the use of secondary data in the public domain, it was not necessary to review this study by research ethics committees, according to article 1, in its sole paragraph, of Resolution No. 510/2016 of the National Health Council.

RESULTS

In the period from 2015 to 2021, 584 new cases of TB were reported in the Health Region of Pinheiro - MA. Of these, 89 (15.2%) had closure typified as treatment abandonment. On average, [13] new cases drop out of TB treatment per year. The highest proportion in the Region was observed in 2016 (22.3%), and the lowest in 2020 (7.7%) (Table 1).

The percentage of municipalities with a dropout rate above 5% ranged from

Table 1 – Proportion of abandonment of tuberculosis treatment in the Pinheiro Health Region – MA, 2015 – 2021.

	Abandonment Ratio 2015-2021	Minimum value	Maximum Value
Apicum Açu	8.1	0	33,3
Bacuri	28.9	0	66,6
Bequimão	9.6	0	66,6
Cedral	0	0	0
Central do Maranhão	0	0	0
Cururupu	13.9	6,2	30,0
Guimarães	15.3	50,0	100,0
Mirinzal	0	0	0
Pedro do Rosário	10,0	0	22,2
Peri Mirim	7.1	0	16,6
Pinheiro	20.5	5,5	31,5
Porto Rico do Maranhão	0	0	0
Presidente Sarney	5.8	0	50,0
Santa Helena	20.4	0	50,0
Serrano do Maranhão	37.5	0	100,0
Turiaçu	10.2	0	50,0
Turilândia	25.0	0	50,0
Regional de Pinheiro	15,2	7,7	22,3

Source: Authors, from SINAN data (2015-2021).

Figure 2 – Distribution of the proportion of tuberculosis treatment abandonment in the Pinheiro Health Region - MA, 2015 – 2021*.
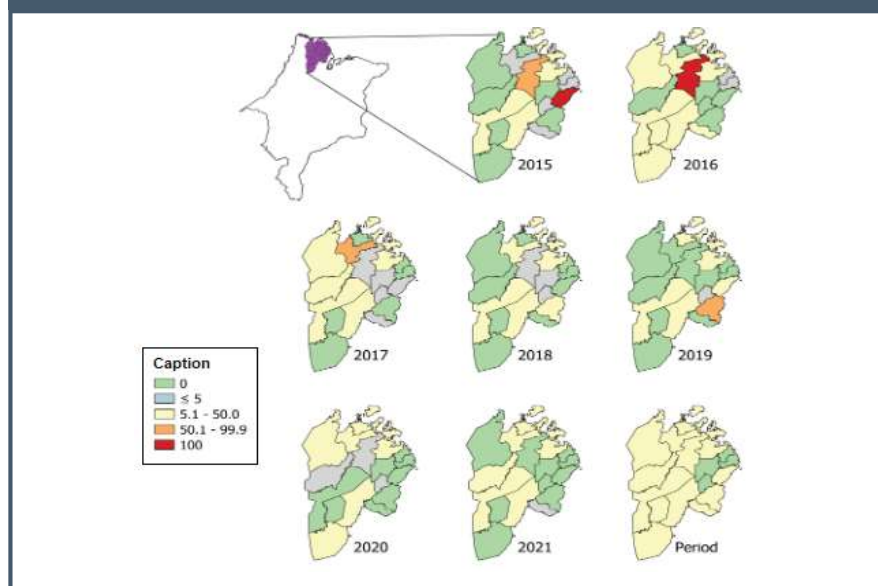
Source: Authors, from SINAN data (2015 - 2021).
*Caption values are percentages. Obs.: spaces in gray on the maps refer to municipalities where there were no notifications of new cases of tuberculosis, which made it impossible to calculate the proportion of abandonment of treatment.

artigo

Araújo, S. S., Soeiro, V. M. S., Nina, L. N. S., Vieira, V. R., Caldas, A. J. M., Silva, T. C.,
Spatial analysis of abandonment of tuberculosis treatment in a health region of Maranhão

29.4% in 2015 to 52.9% in 2016. It is worth mentioning that in all years, municipalities with proportions of this indicator were observed, above the recommended by the WHO (Figure 2).

In the historical framework analyzed, three municipalities had a proportion of abandonment of TB treatment above 50%: Serrano do Maranhão, Guimarães and Bequimão (all with 66.6%) in 2015, 2017 and 2019, respectively. It should also be noted that the municipalities of Guimarães and Serrano do Maranhão had a proportion of 100% of anti-TB therapy abandonment in the years 2015 and 2016, respectively.

TB treatment abandonment cases were heterogeneously distributed in the municipalities of the Pinheiro health region and did not occur randomly, with a positive spatial autocorrelation in the period (global Moran index 0.261 and p-value ≤ 0.05).

In the spatial analysis, statistically significant clusters of high risk (High-High cluster) and low risk (Low-Low cluster) and two transition zones with low-high and high-low patterns were identified (Table 2 and Figure 2) .

The high risk cluster (High-High) for the period (2015-2021) was formed by four municipalities with an average proportion of treatment abandonment equal to 27.9%, they are: Bacuri, Santa Helena, Serrano do Maranhão and Turilândia (Table 2 and Figure 3).

The low-risk cluster (Low-Low) included only the municipality of Puerto Rico do Maranhão and the transition zones classified as Low-High and High-Low were represented by the municipalities of Turiaçu and Guimarães, respectively.

DISCUSSION

The results of this research show the magnitude of the high proportions of abandonment of antituberculous therapy in the Health Region of Pinheiro - MA. They also demonstrate that treatment abandonment was distributed non-randomly and heterogeneously, with the

Table 2 – Characteristics of the clusters of the proportion of abandonment of tuberculosis treatment in the health region of Pinheiro - MA, 2015-2021.

Cluster	No. of municipalities in the cluster	Average cluster abandonment proportion
High-high	4	27,9%
Low-low	1	0%
Low-high	1	10,2%
High-low	1	15,4%

Source: Authors, from SINAN data (2015-2021).

Figure 3 – Characteristics of TB treatment dropout proportion clusters
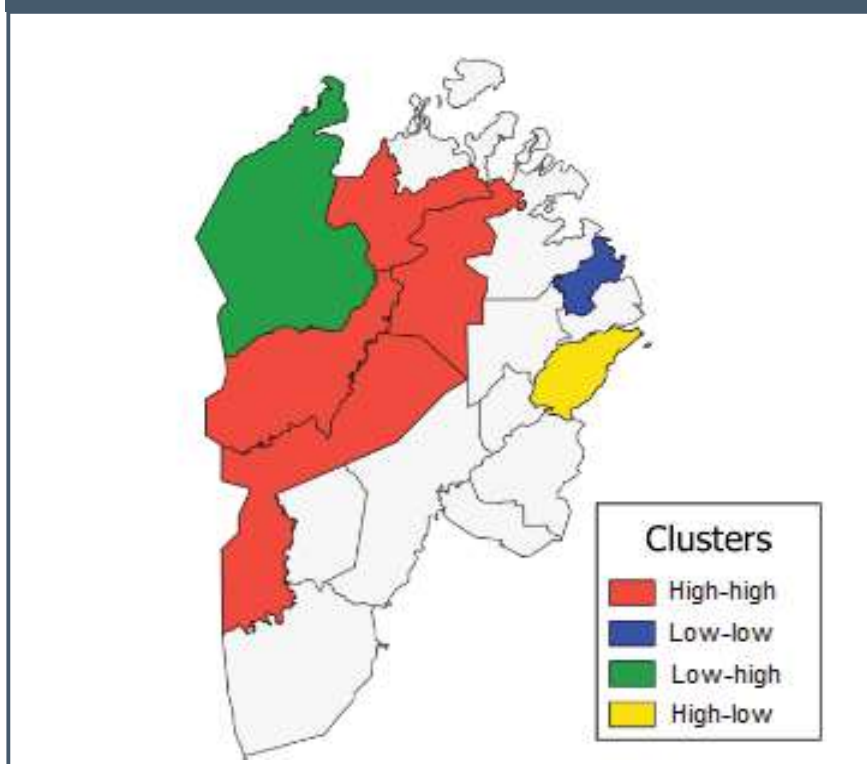
Source: Authors, from SINAN data (2015-2021).
Note: spaces in gray on the map refer to municipalities in which none of the four clusters were included (no statistical significance).

existence of a high-risk area formed by four municipalities.

The results show that, in the period under study, treatment dropout rates were three times higher (15.2%) than recommended by the WHO (5%). [1] In addition, it was found that, on average, 13 people dropped out of treatment annually.

Abandonment of treatment for tu-

berculosis has a significant impact on the continuity of the disease transmission chain, since a single patient who abandons treatment can contaminate another 15 people over a period of one year. [14]

In all the years of the analyzed series, municipalities were observed with proportions of this indicator above the recommended by the WHO. The literature shows that the abandonment of TB tre-

artigo

Araújo, S. S., Soeiro, V. M. S., Nina, L. N. S., Vieira, V. R., Caldas, A. J. M., Silva, T. C.,
Spatial analysis of abandonment of tuberculosis treatment in a health region of Maranhão

atment is strongly linked to the mortality rate from the disease and it is understood that the mortality rate denotes possible weaknesses in the provision of health services provided to the population, as well as the ineffectiveness of the active search for new cases, follow-up and tracking of contacts to be examined. [15]

It should be noted that the highest proportion of treatment abandonment in the Region was observed in 2020 (7.7%) and that this year was marked by the COVID-19 pandemic, which changed the flows and offers of care, especially with regard to Primary Health Care (PHC).

Within this context, the PHC, which is responsible for ordering and coordinating care for chronic conditions, including tuberculosis, has undergone changes due to the pandemic, new care flows have emerged, cancellation of appointments, limitations in human and financial resources, difficulties in accessing care services and lower demand by the population for care services, led to the disruption and demobilization of local programs that treat tuberculosis. [16-18]

The health scenario in the face of the pandemic was one of prioritizing the care of individuals affected by COVID-19, which consequently limited the access of users with different care needs, among them, those affected by TB. [19] In this context, Brazil has experienced several changes and readjustments in its health system that have led to service interruptions, resulting in a reduction in TB-related notifications. [20,21]

Three municipalities had a proportion of abandonment of TB treatment above 50% in the years 2015, 2017 and 2019. In addition, it is also noteworthy that two municipalities had a proportion of 100% of anti-TB therapy abandonment in the years 2015 and 2016. Such results allow the reflection that the actions and health services of these places denote concern and the need for studies that enable mapping of the local reality regarding the offer, access and monitoring of TB treatment in these locations.

It is noteworthy that despite the unsatisfactory results in relation to treatment abandonment identified in this study, the state of Maranhão and its health regions, including the Pinheiro Health Region and its municipalities, are configured as a territory that has been the target of several measures to combat TB. It is worth noting that the National Plan for the End of Tuberculosis aims, in its second stage, at the identification and analysis of scenarios and sub-scenarios of the regions and their municipalities according to the needs and possibilities of each territory. [7,20]

The findings showed that TB treatment abandonment cases in the Pinheiro health region showed positive spatial autocorrelation, as they were heterogeneously distributed and did not occur randomly. Statistically significant clusters of high risk (High-High cluster) and low risk (Low-Low cluster) and two transition zones with a Low-High and High-Low pattern were identified.

The high risk cluster (High-High) for the period (2015 - 2021) was formed by four municipalities: Bacuri, Santa Helena, Serrano and Turilândia. These municipalities have low income, health and education indicators. [22] This finding corroborates other studies that indicate a strong correlation of factors related to social vulnerability with the incidence, mortality and abandonment of treatment and retreatment of TB. [5,23,24]

The sum of factors both in relation to health, income, education, as well as the very operationalization of the assistance offered to the user, encompasses the complexity associated with the abandonment of treatment for TB, knowledge of which regions are at high risk for such abandonment is important. [25,26]

Another important point to be emphasized is that treatment abandonment has often been pointed out as a parameter to evaluate the quality and effectiveness of health services, thus, highlighting risk territories and associated factors contributes to the evaluation of the effectiveness and/or impact of the measures

implemented in the territories. [5,27,28]

The low-risk cluster (Low-Low) included the municipality of Puerto Rico do Maranhão. This finding, that only one municipality remained with a low-risk cluster, enhances the reflection that the territory should be analyzed with caution, therefore, it may indicate underreporting or incorrectly or incompletely filled information regarding the treatment outcome.

The transition zones classified as Low-High and High-Low were represented by the municipalities of Turiaçu and Guimarães, respectively. It is worth mentioning that areas considered to be transitional should be closely observed and targeted by public policies so that they do not become a high-risk area for TB.

The limitations of this study are those related to underreporting and inconsistencies in the database used. As a positive point, the pioneering spirit in presenting data on treatment abandonment in the Health region of Pinheiro - MA stands out, expanding the analysis and providing subsidies for health planning in this geographical area.

CONCLUSION

The proportion of abandonment of TB treatment in the health region of Pinheiro - MA is still higher than the WHO recommendations, in the period from 2015 to 2021. A non-random and heterogeneous distribution of the indicator was observed, with four municipalities in this region appearing as high-risk areas for abandoning tuberculosis treatment.

The results of this research can contribute to the expansion of health policies and actions, being an important subsidy for the reduction of therapeutic abandonment. It is suggested to carry out interventions aimed at areas of greatest risk, with a view to improving the health conditions of the population in this spatial area and better management of public health resources.

artigo

Araújo, S. S., Soeiro, V. M. S., Nina, L. N. S., Vieira, V. R., Caldas, A. J. M., Silva, T. C.,
Spatial analysis of abandonment of tuberculosis treatment in a health region of Maranhão

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