Social Vulnerability and Interruption of Tuberculosis Treatment Among People Experiencing Homelessness

Vulnerabilidade Social e Interrupção do Tratamento da Tuberculose em Pessoas em Situação de Rua

Vulnerabilidad Social e Interrupción del Tratamiento de la Tuberculosis en Personas Sin Hogar

RESUMO

Objetivo: Analisar a interrupção do tratamento da tuberculose na PSR em São Paulo, considerando variações temporais trimestrais e desigualdades territoriais associadas ao desfecho. **Métodos:** Estudo ecológico com dados secundários do SINAN-TB/TBWEB referentes a adultos em situação de rua no período de 2012 a 2023, com análise de tendência entre 2015 e 2023. As tendências foram estimadas por regressão *Joinpoint*, com cálculo das variações percentuais trimestrais (VPT) e médias (VPTM), estratificadas por características sociodemográficas, clínicas, comportamentais e programáticas. A análise territorial foi conduzida no nível das subprefeituras por meio de agrupamento não hierárquico (*k-means*), uso de indicadores de desenvolvimento humano, desigualdade de renda, vulnerabilidade social, incidência de aids e desempenho da atenção primária. **Resultados:** Observou-se variação temporal não linear da interrupção, com tendências crescentes em homens, indivíduos de 40 – 59 anos, usuários de substâncias e pessoas sem TDO. A condição de pessoa em situação de rua permaneceu associada a maiores chances de interrupção e óbito nos modelos ajustados **Conclusões:** A interrupção do tratamento da tuberculose na população em situação de rua está associada a desigualdades sociais e territoriais, descreve a necessidade de estratégias intersetoriais e territorial focalizadas.

DESCRITORES: Tuberculose; Pessoa em Situação de Rua; Atenção Primária; Desigualdade em Saúde.

ABSTRACT

Objective: To analyze tuberculosis treatment interruption among people experiencing homelessness in São Paulo, considering quarterly temporal variations and territorial inequalities associated with this outcome. **Methods:** This was an ecological study using secondary data from SINAN-TB/TBWEB on adults experiencing homelessness from 2012 to 2023, with trend analysis performed for the period 2015 to 2023. Trends were estimated using Joinpoint regression, with calculation of quarterly percent change and average quarterly percent change, stratified by sociodemographic, clinical, behavioral, and programmatic characteristics. Territorial analysis was conducted at the subprefecture level using non-hierarchical clustering (k-means), incorporating indicators of human development, income inequality, social vulnerability, AIDS incidence, and primary health care performance. **Results:** A nonlinear temporal variation in treatment interruption was observed, with increasing trends among men, individuals aged 40–59 years, people who used substances, and those not receiving directly observed treatment. Homelessness remained associated with higher odds of treatment interruption and death in the adjusted models. **Conclusions:** Tuberculosis treatment interruption among people experiencing homelessness is associated with social and territorial inequalities, underscoring the need for intersectoral and territorially targeted strategies.

DESCRIPTORS: Tuberculosis; Homeless Persons; Primary Health Care; Health Inequality.

RESUMEN

Objetivo: Analizar la interrupción del tratamiento de la tuberculosis entre personas en situación de calle en São Paulo, considerando las variaciones temporales trimestrales y las desigualdades territoriales asociadas a este desenlace. **Métodos:** Se realizó un estudio ecológico con datos secundarios del SINAN-TB/TBWEB referentes a adultos en situación de calle entre 2012 y 2023, con análisis de tendencia para el período de 2015 a 2023. Las tendencias se estimaron mediante regresión Joinpoint, con cálculo de la variación porcentual trimestral y de la variación porcentual trimestral media, estratificadas por características sociodemográficas, clínicas, conductuales y programáticas. El análisis territorial se realizó a nivel de subprefecturas mediante agrupamiento no jerárquico (k-means), incorporando indicadores de desarrollo humano, desigualdad de ingresos, vulnerabilidad social, incidencia de sida y desempeño de la atención primaria de salud. **Resultados:** Se observó una variación temporal no lineal de la interrupción del tratamiento, con tendencias crecientes entre hombres, personas de 40 a 59 años, usuarios de sustancias y personas que no recibieron tratamiento directamente observado. La condición de persona en situación de calle permaneció asociada a mayores probabilidades de interrupción del tratamiento y muerte en los modelos ajustados. **Conclusiones:** La interrupción del tratamiento de la tuberculosis entre personas en situación de calle está asociada a desigualdades sociales y territoriales, lo que evidencia la necesidad de estrategias intersectoriales y territorialmente focalizadas.

DESCRIPTORES: Tuberculosis; Personas en situación de calle; Atención Primaria de Salud; Desigualdad en Salud.

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INTRODUCTION

Tuberculosis (TB) is a serious public health problem in Brazil, even given the availability of diagnosis and treatment within the Unified Health System (SUS). Its occurrence reflects the interplay between active transmission, social inequalities, barriers to access, and weaknesses in the continuity of care, particularly among populations exposed to extreme conditions of vulnerability. Among these groups, the homeless population (PSR) stands out, characterized by extreme poverty, food insecurity, substandard housing, alcohol and other drug use, psychosocial distress, and limited regular access to health services. Under these conditions, tuberculosis does not result solely from biological exposure to *Mycobacterium tuberculosis*, but from the social structure that shapes risk, diagnosis, treatment, and outcome[1-5].

In the PSR, interruption of TB treatment is the sentinel event for epidemiological surveillance, as it compromises cure, sustains chains of transmission, promotes relapses, and may contribute to drug resistance[6–8]. This outcome should not be reduced to individual adherence, since continued treatment depends on links to services, active case finding, community-based outreach, social support, and the network's capacity to monitor individuals with high urban mobility. National and international studies indicate that, among people experiencing homelessness, problematic substance use, HIV coinfection, and discontinuation of care are linked to adverse social conditions, increasing the likelihood of unfavorable outcomes and requiring programmatic responses guided by equity[6–8, 11–13, 20]. In large urban centers, such as São Paulo, analyzing interruptions in tuberculosis treatment among people experiencing homelessness requires methods capable of capturing temporal variations and territorial inequalities at the submunicipal level—in this case, at the level of sub-districts. Quarterly time series allow for the identification of changes in outcome patterns, fluctuations associated with critical contexts, and possible shifts in surveillance capacity, access, and continuity of care. The incorporation of territorial indicators—such as human development, income inequality, social vulnerability, and primary care performance—broadens the epidemiological interpretation by situating the outcome within the social organization of urban space[7,16–18].

Therefore, the objective of this study was to analyze interruptions in tuberculosis treatment within the PSR in the city of São Paulo, considering quarterly temporal variations and territorial inequalities associated with the outcome.

METHODS

Study Design

An ecological study analyzing temporal trends and spatial patterns of tuberculosis treatment discontinuation at primary care clinics in the city of São Paulo.

Setting and Population

The study was conducted in the city of São Paulo, using sub-districts as territorial units of analysis. The population consisted of individuals aged 18 years or older who were diagnosed with tuberculosis and registered as homeless, as defined by the National Policy for the Homeless Population[16].

Data Source

Secondary data from SINAN-TB/TBWEB/SIM were used, derived from a municipal database consolidated through deterministic and probabilistic *linkage*, with records updated through December 2023. The database was provided in anonymized form by the Municipal Health Secretariat[17].

Eligibility criteria

The study included new cases of tuberculosis in individuals aged 18 years or older who were registered as PSR and for whom a case closure was reported. Records with missing, blank, or unrecorded variables of in-

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terest were excluded. The period from 2011 to 2023 was used for descriptive and inferential analyses; for temporal trends[17,18] , the period from 2015 to 2023 was considered, due to greater consolidation of the PSR variable and in accordance with the implementation of legislation defining the National Policy for the Homeless Population.

Outcomes and variables

The primary outcome was treatment discontinuation, defined as treatment dropout or interruption and primary dropout. Cure and death were analyzed as secondary outcomes. The

analyses accounted for sex, age, HIV status, diabetes, and use of alcohol, tobacco, and other drugs, as well as directly observed therapy (DOT) and sub-district.

Data Analysis

We calculated frequencies, proportions, and quarterly discontinuation rates. Trends were estimated using *Joinpoint* regression, with quarterly percentage change and mean quarterly percentage change, both with a 95% confidence interval[16,17,18] .

Territorial Analysis

K-means clustering was applied, using variables standardized by z-score. Socioeconomic, epidemiological, and primary care performance indicators were included. The clusters were compared using the *Kruskal–Wallis* test[17,18] .

Ethical Considerations

The study is part of a project titled "Support for Public Policies for the Homeless Population in the State of São Paulo: Analysis of Ecosystem, Laboratory, and Public Health Data Using Artificial Intelligence," affiliated with the School of Nursing at the University of São Paulo. The research was approved by the Research Ethics Committee of the School of Nursing at the University of São Paulo, within the Department of Public Health Nursing, under CAAE No. 87506025.7.0000.5392 and Opinion No. 7,513,909, approved on April 17, 2025. Secondary data were used from official health information systems, made available in an anonymized form without the nominal identification of individuals. For this reason, no Informed Consent Form was required. All stages of the study adhered to the ethical principles set forth in Resolution No. 466/2012 of the National Health Council.

RESULTS

Table 1 shows that among people with diabetes, the VPTM was −0.01% (95% CI −1.04 to 1.19), and among those without diabetes, it was 0.00% (95% CI −0.04 to 0.04). For HIV, the VPTM was

−1.47% among those who tested positive (95% CI −3.57 to 0.66; p=0.171) and −1.19% among those who tested negative (95% CI −2.91 to 0.56; p=0.175). For AIDS, the VPTM was −1.51% among those who tested positive (95% CI −3.60 to 0.62; p=0.160)

Table 1. Quarterly trend in tuberculosis treatment discontinuation in the PSR and territorial characterization of sub-municipal groupings, São Paulo, 2011–2023 (n = 3,439).

Dimension	Category	Period (Quarter–Year)	VPT (95% CI)	VPTM (95% CI)
Gender	Male	Q1/2011 – Q4/2012	49.56 (42.12 a 57.38)*	4.46 (3.68 a 5.26)*
		Q1/2013 – Q4/2023	-2.13 (-2.44 a -1.82)*	
	Female	Q1/2011 – Q4/2012	59.84 (45.29 a 75.84)*	4.71 (3.23 a 6.20)*
		Q1/2013 – Q4/2023	-3.05 (-3.59 a -2.50)*	
Age group (years)	18–39	Q1/2011 – Q1/2016	3756.79 (3494.62 a 4038.07)*	-12.68 (-13.00 a -12.35)*
		Q2/2016 – Q4/2023	-93.29 (-93.61 a -92.95)*	
	40–59	Q1/2011 – Q4/2012	51.32 (43.88 a 59.16)*	4.39 (3.61 a 5.17)*
		Q1/2013 – Q4/2023	-2.43 (-2.73 a -2.12)*	
	≥60	Q1/2011 – Q4/2012	54.37 (39.80 a 70.47)*	4.98 (3.45 a 6.54)*
		Q1/2013 – Q4/2023	-2.12 (-2.68 a -1.56)*	
TDO	Yes	Q1/2011 – Q4/2012	48.30 (36.63 a 60.96)*	4.69 (3.43 a 5.97)*
		Q1/2013 – Q4/2023	-1.73 (-2.22 a -1.24)*	
	No	Q1/2011 – Q4/2012	50.64 (41.93 a 59.88)*	3.35 (2.45 a 4.27)*
		Q1/2013 – Q4/2023	-3.49 (-3.89 a -3.08)*	
Diabetes mellitus	Yes	Q1/2011 – Q4/2012	51.40 (29.30 a 77.26)*	4.94 (2.52 a 7.42)*
		Q1/2013 – Q4/2023	-1.83 (-2.73 a -0.91)*	
	No	Q1/2011 – Q4/2012	52.04 (45.07 a 59.35)*	4.48 (3.76 a 5.21)*
		Q1/2013 – Q4/2023	-2.41 (-2.69 a -2.13)*	

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Alcohol and Other Drugs	Yes	Q1/2011 – Q4/2012	51.75 (38.27 a 66.54)*	5.45 (4.01 a 6.91)*
		Q1/2013 – Q4/2023	-1.30 (-1.81 a -0.80)*	
	No	Q1/2011 – Q4/2012	52.31 (44.67 a 60.35)*	4.17 (3.38 a 4.97)*
		Q1/2013 – Q4/2023	-2.78 (-3.10 a -2.46)*	
Tobacco use	Yes	Q1/2011 – Q2/2015	16.12 (12.93 a 19.39)*	4.31 (3.40 a 5.23)*
		Q3/2015 – Q4/2023	-1.45 (-2.20 a -0.69)*	
	No	Q1/2011 – Q4/2012	50.02 (43.22 a 57.14)*	3.61 (2.90 a 4.32)*
		Q1/2013 – Q4/2023	-3.14 (-3.45 a -2.83)*	
HIV	Positive	Q1/2011 – Q4/2012	49.34 (40.32 a 58.95)*	3.35 (2.40 a 4.31)*
		Q1/2013 – Q4/2023	-3.34 (-3.77 a -2.91)*	
	Negative	Q1/2011 – Q4/2012	59.03 (44.11 a 75.50)*	6.70 (5.15 a 8.27)*
		Q1/2013 – Q4/2023	-0.77 (-1.23 a -0.31)*	
AIDS	Yes	Q1/2011 – Q4/2012	49.70 (40.42 a 59.60)*	3.42 (2.44 a 4.41)*
		Q1/2013 – Q4/2023	-3.31 (-3.74 a -2.87)*	
	No	Q1/2011 – Q4/2012	54.65 (45.15 a 64.78)*	5.35 (4.36 a 6.34)*
		Q1/2013 – Q4/2023	-1.76 (-2.10 a -1.41)*	

Territorial Clusters by Sub-Municipalities				
Cluster	Subdistrict	IDHM	Gini Index	% Vulnerable
1	Santana/Tucuruvi	0,83	0,47	26
	Butantã	0,82	0,48	28
	Mooca/Aricanduva	0,81	0,49	29
	Sé	0,80	0,52	32
	Casa Verde/Cachoeirinha	0,80	0,51	29
	Santo Amaro/Cidade Ademar	0,79	0,50	30
2	Penha	0,75	0,59	42
	Guaianases	0,74	0,60	45
	Tiradentes City	0,70	0,61	50
	São Mateus	0,73	0,57	43
	Itaim Paulista	0,72	0,59	47
	São Miguel	0,71	0,60	46
	Ó Parish/Brasilândia	0,74	0,58	44
3	Vila Prudente/Sapopemba	0,76	0,58	38
	Ermelino Matarazzo	0,78	0,55	35

Source: Notifiable Diseases Information System (SINAN-TB/TBWEB/SIM). ***:** QPV: quarterly percentage change; MPQPV: mean quarterly percentage change; 95% CI: 95% confidence interval. The QPV was estimated for each segment identified by the segmented log-linear regression model (*Joinpoint*). The AWQPV is the weighted average of the QPVs for the entire analyzed period (Q2 2015–Q3 2023) and is presented only once for each category. * indicates statistical significance (95% CI that does not include 0).

The TDO showed a negative average trend, while the group without this strategy exhibited alternating segments of growth and decline. Cluster 1 presented the most favorable profile, with the highest average IDHM (0.81), the lowest Gini Index (0.50), and the lowest vulnerability rate (29.0%). Cluster 2 exhibited greater structural vulnerability, with a lower mean IDHM (0.73), higher inequality (Gini = 0.59), and a higher proportion of PSR/vulnerability (45.3%). Cluster 3 exhibited an intermediate profile, with an average IDHM of 0.77, a Gini coefficient of 0.57, and a vulnerability rate of 36.5%.

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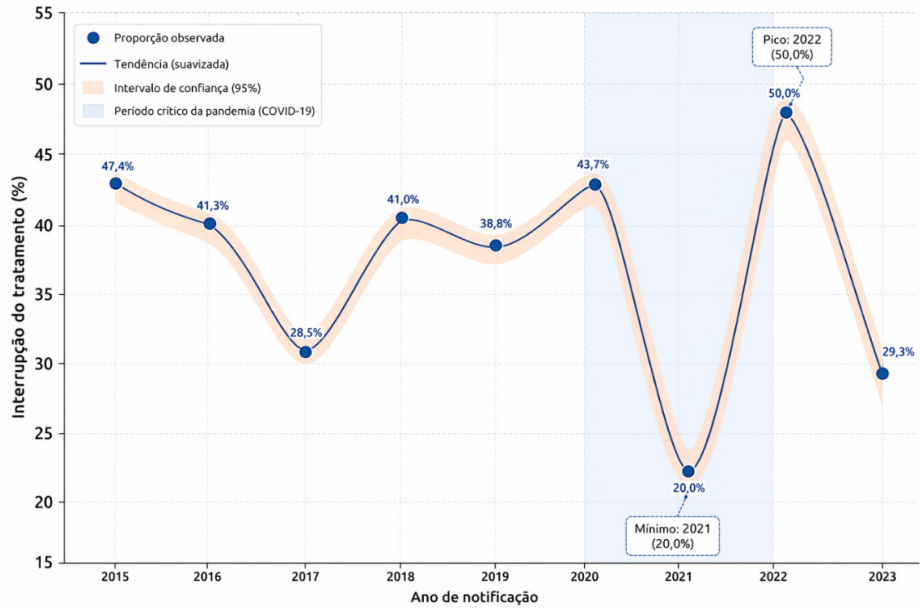
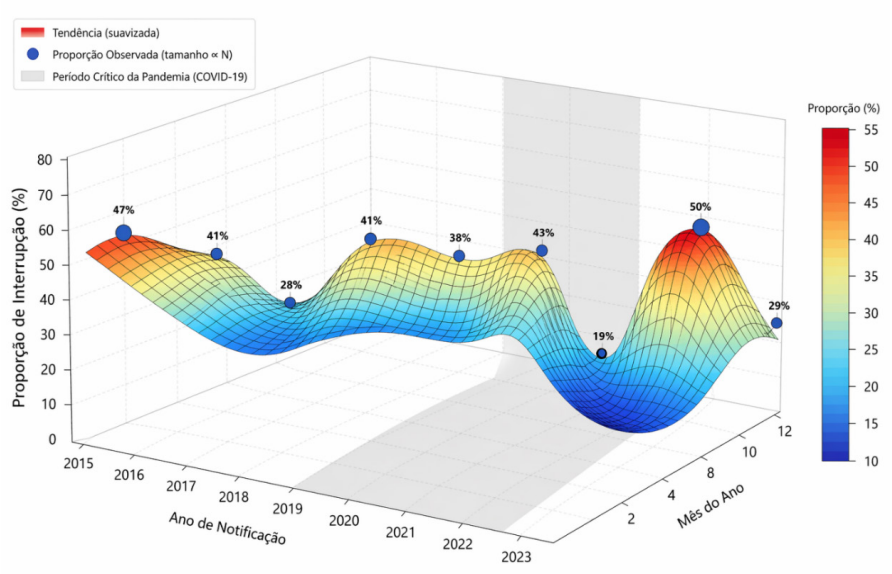
Figure 01. Smoothed trend in tuberculosis treatment discontinuation among PSR from 2015 to 2023.



Between 2015 and 2023, 168 cases of tuberculosis were recorded at the PSR, of which 65 resulted in treatment discontinuation, corresponding to 38.7%. The annual proportion ranged from 20.0% in 2021 (4/20) to 50.0% in 2022 (2/4), with a range of 30 percentage points. The highest percentages occurred in 2015 (47.62%), 2020 (43.75%), and 2022 (50.0%). LOESS smoothingindicated nonlinear behavior, with the interruption ranging from 47.62% in 2015 to 28.57% in 2017, 43.75% in 2020, 20.0% in 2021, 50.0% in 2022, and 29.41% in 2023. In 2022, the interruption reached 50.0% with only four recorded cases (2/4), indicating greater imprecision and the absence of a monotonic linear trend during the period.

Figure 2. Temporal trend in tuberculosis treatment discontinuation at primary care facilities, Brazil, 2015–2023 (Impact of the Pandemic and Sampling Variability).



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Between 2015 and 2023, the proportion of tuberculosis treatment interruptions in the PSR ranged from 19% in 2021 to 50% in 2022, a variation of 31 percentage points. A decrease was observed between 2015 and 2017, followed by an increase through 2020 and another decline in 2021. The largest annual change occurred between 2021 and 2022, with an increase from 19% to 50%. The average for the period was 37.3%, with values concentrated between 38% and 43% in four of the nine years analyzed.

DISCUSSION

The results of this study indicate that treatment discontinuation among people experiencing homelessness in the city of São Paulo should not be interpreted as an isolated manifestation of individual nonadherence. This outcome stems from a combination of social vulnerability, programmatic barriers, territorial instability, and limitations in the continuity of care. The proportion of treatment discontinuation observed between 2015 and 2023, combined with the nonlinear annual variation, demonstrates that retention

Therapeutic care for this population depends on material and institutional conditions that go beyond the formal availability of diagnosis and treatment within the Unified Health System. This interpretation is consistent with the concept of health vulnerability, in which health outcomes result from the interaction between individual, social, and programmatic factors, and not solely from individual choices or behaviors[1,3-5] .

The asymmetric distribution of outcomes—with a lower proportion of treatment discontinuation and higher tuberculosis mortality—suggests distinct trajectories of risk development. Treatment discontinuation reflects a breakdown in the therapeutic relationship, difficulty in maintaining care, and weaknesses in longitudinal follow-up. Mortality, in turn, points to late entry into the system, clinical deterioration, multimorbidity, and an inadequate timely care response. This difference reinforces the fact that treatment completion indicators cannot be analyzed in isolation, as treatment discontinuation, cure, and death are part of the same social and programmatic chain of disease development[2,11,13] .

The absence of a monotonic trend in the time series indicates that treatment discontinuation did not follow a simple linear trajectory during the period analyzed. Among people experiencing homelessness, annual fluctuations may reflect changes in diagnostic detection, active case finding, case closure, the operational capacity of teams, and the movement of service users between services, shelters, the streets, and emergency departments. Thus, the time series describes not only the epidemiological evolution of tuberculosis but also the institutional history of surveillance and care. In populations characterized by high mobility and low social protection, the stability of indicators depends on the territorial organization of services and the ability to maintain continuity of care throughout treatment[17-19] .

The shift observed during the pandemic requires careful interpretation. This is because the COVID-19 pandemic led to a reduction in patient flows, an interruption in surveillance routines, a redirection of resources, and a decline in the timely detection of tuberculosis cases. For the homeless population, these effects were magnified, as access to care depends on active case finding, community-based outreach, social support, and flexible follow-up strategies. The fluctuation recorded after 2021 may reflect both a partial resumption of detection capacity and the accumulation of care discontinuities that occurred during the critical period of the pandemic[6,11,2] .

The greater instability observed in 2022, when the interruption rate reached 50.0% with only four reported cases, underscores the need to interpret percentages in light of their denominators. In epidemiological series with small sample sizes, high percentage variations may result from random fluctuations, reporting delays, incomplete data collection, or operational changes in the surveillance network. This finding does not invalidate the analysis; on the contrary, it highlights the importance of specifying numerators and denominators, using smoothing methods, and avoiding undue causal inferences. The application of quarterly analysis, segmented regression, and local smoothing helps to refine the interpretation, provided that the results are discussed in relation to the consistency of the series and the context in which the data were generated[16–18] .

The findings by subgroup show that clinical markers, such as HIV, AIDS, and diabetes mellitus, do not, on their own, explain the temporal variation in treatment interruption. This finding does not diminish the importance of these conditions, but indicates that their effects are mediated by social and programmatic factors. HIV coinfection increases the clinical complexity of tuberculosis; however, its impact on outcomes depends on the timeliness of diagnosis, the integration of services, regular access to medications, the availability of social support, and the capacity of primary care to provide long-term care. Thus, the analysis of clinical factors must be integrated with an examination of social determinants and the territorial organization of the network [3,4,8,11-15] . The use of alcohol, tobacco, and other drugs should be interpreted as a clinical and social marker of vulnerability, and not merely as an individual risk factor for treatment interruption. Among the homeless population, these behaviors

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are intertwined with social exclusion, psychological distress, food insecurity, broken social ties, daily violence, and the lack of stable housing, creating a context that hinders timely diagnosis, treatment adherence, and continuity of care. This interpretation is consistent with the approach to vulnerability in health and the social determinants of tuberculosis[1,3,4,19,20].

The interaction between substance use, housing instability, and poor treatment continuity constitutes a syndemic condition, in which clinical and social risks reinforce one another. This approach helps avoid moralizing interpretations of neglect and shifts the focus to the concrete conditions that hinder treatment retention [1,8,19,20] .

The territorial analysis adds a fundamental dimension to the interpretation of the results. The sub-municipal clusters revealed a consistent gradient between human development, income inequality, and social vulnerability. The *cluster* with the highest Municipal Human Development Index, lowest Gini Index, and lowest proportion of vulnerability exhibited a more favorable profile, while the *cluster* with the highest vulnerability concentrated lower development, greater inequality, and a higher proportion of the vulnerable population. This pattern confirms that tuberculosis is not randomly distributed in urban areas but follows the city's social organization, the unequal availability of resources, and the territorial concentration of poverty[7,5,3,19] .

In this sense, territory should not be understood merely as a place of residence or registration, but as a space where risk is generated and opportunities for care arise. Peripheral and degraded central areas are characterized by precarious housing conditions, disrupted mobility, barriers to access, structural violence, and limited availability of safety nets [7, (19), (20)]. For people experiencing homelessness, the relationship with territory is even more complex, as it involves daily movements between the streets, social services, health facilities, emergency units, and shelters. This mobility challenges traditional models of support based on a fixed residence and requires monitoring strategies capable of operating on a flexible territorial scale[7,19,20] .

The role of primary care in coordinating care is central to reducing treatment interruption, relapse, transmission, and death. However, the analysis suggests that tuberculosis care for the homeless population cannot depend solely on the formal existence of primary care clinics or clinical protocols. Primary care must operate in an integrated manner with epidemiological surveillance, street clinics, social assistance, mental health services, shelter facilities, and social protection strategies. Care coordination must include active case finding, monitoring of missed appointments, follow-up on treatment completion, tracing of potential contacts, and collaboration with local resources capable of sustaining treatment in unstable settings[11,12,13–15] .

For nursing, these findings reinforce the need for comprehensive care that goes beyond monitoring medication adherence. Nurses play a strategic role in epidemiological surveillance, primary care, street clinics, patient intake, risk stratification, monitoring of directly observed treatment, and coordinating care in the community. Identifying subgroups and areas of greater vulnerability can guide care priorities, improve active case-finding, anticipate the risk of treatment interruption, support shared visits, and link treatment to the social support necessary for continuity of care [12, (13), (20)]. In this way, nursing can transform surveillance data into clinical and community-based action, strengthening the patient-nurse relationship, therapeutic continuity, and equity in care [11,13,19,20] . For example, TDO remains an effective strategy, but its limitations must be acknowledged. Among the homeless population, TDO alone tends to have limited reach when it is not combined with food, transportation, shelter, income support, substance use management, mental health care, and community ties. Supervision of medication intake is necessary but insufficient when the problem involves a concrete inability to remain in care. Therefore, OMT should be understood as a component of a broader, person-centered strategy linked to intersectoral policies [11–13, 20] .

From a programmatic perspective, the results indicate that the elimination of tuberculosis among vulnerable groups depends on the ability to integrate surveillance, care, and social protection. The World Health Organization's End Tuberculosis Strategy recognizes the need for person-centered care, addressing social determinants, and protection against catastrophic costs. In Brazil, this challenge is compounded by persistent territorial, racial, and social inequalities that limit access, diagnosis, and treatment continuity. Thus, the response to tuberculosis among the homeless population must combine timely diagnosis, supervised treatment, material support, community-based care, active surveillance, and shared case management[2–4, 11, 12] .

The integration of time series and territorial analysis represents a methodological contribution of this study. The use of *Joinpoint* regression allowed us to estimate quarterly percentage changes and identify trend shifts; smoothing helped visualize nonlinear behavior; and *k-means* clustering enabled us to synthesize territorial patterns of vulnerability. This methodological combination is useful for epidemiology applied to the SUS because it allows routine data to be transformed into evidence for management. However, such methods require contextu-

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alized interpretation, especially when applied to small populations, rare events, or time series with intense fluctuations [17,18,16].

The study's limitations stem from the use of secondary surveillance data. There may be data incompleteness, underreporting, delays in data collection, variations in the quality of data entry, and underidentification of homelessness. Furthermore, while the ecological design allows for the identification of spatial and temporal patterns, it does not permit causal inferences at the individual level. Nevertheless, the use of a municipal-level dataset, combined with submunicipal-scale analysis and the incorporation of socioeconomic and programmatic indicators, enhances the explanatory power of the results and provides a basis for local planning of control measures[7,16,18].

In summary, treatment discontinuation among people experiencing homelessness in São Paulo reflects the convergence of social inequality, urban segregation, program weaknesses, and limitations in the continuity of care. The absence of a linear trend does not indicate that the problem is becoming less significant, but rather highlights its dependence on the institutional and territorial conditions under which care is provided. Reducing the burden of tuberculosis in this population requires intersectoral, territorially focused responses supported by active surveillance, social support, the strengthening of primary care, and the strategic participation of nurses in the longitudinal coordination of care[1–4,20].

CONCLUSIONS

The findings reveal an unequal distribution of outcomes, with higher tuberculosis mortality and the absence of a monotonic temporal trend, indicating that the course of the disease among the homeless population is influenced by programmatic and structural factors, as well as by the pandemic context. In this population, social, clinical, and territorial vulnerabilities overlap and increase the risk of adverse outcomes. Reducing the burden of tuberculosis requires intersectoral strategies, geographically targeted, and linked to social support, moving beyond the logic of directly observed treatment as an isolated intervention.

References

1. Ayres JR, Paiva V, França I Jr, et al. Vulnerability, human rights, and comprehensive health care needs of young people living with HIV/AIDS. Am J Public Health. 2006;96(6):1001-1006. doi:10.2105/AJPH.2004.060905. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/16449593/

2. Barreira, D. Os desafios para a eliminação da tuberculose no Brasil. Epidemiol. Serv. Saude, Brasília, 27(1):e00100009, 2018. doi: 10.5123/S1679-49742018000100009. Disponivel em: https://www.scielo.br/j/ress/a/fNjZKr5rJxrbvgbfQXTtkcS/?lang=pt&format=pdf

3. Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JD. The social determinants of tuberculosis: from evidence to action. Am J Public Health. 2011;101(4):654-662. doi:10.2105/AJPH.2010.199505. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/21330583/

4. Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. Soc Sci Med. 2009;68(12):2240-2246. doi:10.1016/j.socscimed.2009.03.041. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/19394122/

5. Maciel EL, Reis-Santos B. Determinants of tuberculosis in Brazil: from conceptual framework to practical application. Rev Panam Salud Publica. 2015;38(1):28-34. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/26506318/

6. Kyu H, Ledesma J. What is the impact of the COVID-19 pandemic on tuberculosis? The Lancet Global Health, 11, e1323-e1324. Disponivel em: https://www.thelancet.com/journals/langlo/article/PIIS-2214-109X(23)00360-1/fulltext

7. Pelissari DM, Rocha MS, Bartholomay P, et al. Identifying socioeconomic, epidemiological and operational scenarios for tuberculosis control in Brazil: an ecological study. BMJ Open 2018;8:e018545. doi:10.1136/ bmjopen-2017-018545. Disponivel em: https://bmjopen.bmj.com/content/bmjopen/8/6/e018545.full.pdf

8. Barreto-Duarte, B., Klauss Villalva-Serra, Miguez-Pinto, J. P., Araújo-Pereira, M., Campos, V. M. S., Ferreira, I. B. B., Nogueira, B. M. F., Queiroz, A. T. L., Rolla, V. C., Cordeiro-Santos, M., Kritski, A. L., Martinez, L., Rebeiro, P. F., Sterling, T. R., Rodrigues, M. M., Andrade, B. B., Barreto-Duarte, B., Klauss Villalva-Serra, Miguez-Pinto, J. P., & Araújo-Pereira, M.

DOI: https://doi.org/10.36489/nursing.2026v32i341p22212-22238

(2025). Interplay between biological & social vulnerability and poor tuberculosis treatment outcome in Brazil: a nationwide study using multivariate modelling with excess risk. The Lancet Regional Health - Americas, 53, 101305–101305. https://doi.org/10.1016/j.lana.2025.101305

9. Boletim Epidemiológico de Tuberculose da Cidade de São Paulo PROGRAMA MUNICIPAL DE CONTROLE DA TUBERCULOSE PREFEITURA DE SÃO PAULO, Disponível em: https://drive.prefeitura.sp.gov.br/cidade/secretarias/upload/saude/Boletim_Epidemiologico_TB_Cidade_SP_2023.pdf

10. São Paulo (Estado). Secretaria da Saúde. Centro de Vigilância Epidemiológica "Prof. Alexandre Vranjac". Divisão de Tuberculose. Boletim epidemiológico de tuberculose 2025 [Internet]. São Paulo: Secretaria da Saúde; 2025. Disponível em: https://saude.sp.gov.br/resources/cve-centro-de-vigilancia-epidemiologica/areas-de-vigilancia/tuberculose/boletins/boletim2025_tuberculose.pdf

11. World Health Organization. (2023). Global Tuberculosis Report 2023. Who.int. https://www.who.int/teams/global-programme-on-tuberculosis-and-lung-health/tb-reports/global-tuberculosis-report-2023

12. World Health Organization. (2015). The End TB Strategy. Www.who.int. https://www.who.int/publications/i/item/WHO-HTM-TB-2015.19

13. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância Epidemiológica. Manual de recomendações para o controle da tuberculose no Brasil / Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de Vigilância Epidemiológica. – Brasília : Ministério da Saúde, 2011. 284 p. : il. – (Série A. Normas e Manuais Técnicos) ISBN 978-85-334-1816-5. Disponivel em: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/tuberculose/manual-de-recomendacoes-e-controle-da-tuberculose-no-brasil-2a-ed.pdf/view

14. Rio de Janeiro (RJ). Secretaria Municipal de Saúde Guia rápido : tuberculose : atenção primária à saúde : transmissíveis. -- 2. ed. -- Rio de Janeiro : Secretaria Municipal de Saúde do Rio de Janeiro, 2023. -- (Série F. comunicação e educação em saúde) Vários colaboradores. ISBN 978-65-86417-25-8. Disponivel em: https://subpav.org/aps/uploads/publico/repositorio/Guia_R%C3%A1pido_Tuberculose.pdf

15. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Doenças de Condições Crônicas e Infecções Sexualmente Transmissíveis. Protocolo de vigilância da infecção latente pelo Mycobacterium tuberculosis no Brasil / Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de Doenças de Condições Crônicas e Infecções Sexualmente Transmissíveis. – 2. ed. – Brasília: Ministério da Saúde, 2022. Disponivel em: https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/tuberculose/protocolo-de-vigilancia-da-infeccao-latente-pelo-mycobacterium-tuberculosis-no-brasil.pdf/

16. Hernán MA, Robins JM. Using Big Data to Emulate a Target Trial When a Randomized Trial Is Not Available. Am J Epidemiol. 2016;183(8):758-764. doi:10.1093/aje/kwv254. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/26994063/

17. Peres TG, Castro YM, Corrêa ML, Emmendorfer LR, Zhang L. Trends in tuberculosis mortality among children and adolescents in Brazil, 1996-2020: a joinpoint analysis. J Bras Pneumol. 2023;49(3):e20230019. Published 2023 May 26. doi:10.36416/1806-3756/e20230019. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/37255164/

18. Bowser DM, Maurico K, Ruscitti BA, Crown WH. American clusters: using machine learning to understand health and health care disparities in the United States. Health Aff Sch. 2024 Feb 14;2(3):qxae017. doi: 10.1093/haschl/qxae017. Erratum in: Health Aff Sch. 2024 Dec 09;2(12):qxae146. doi: 10.1093/haschl/qxae146. PMID: 38756919; PMCID: PMC10986293. Disponivel em: https://pmc.ncbi.nlm.nih.gov/articles/PMC10986293/

19. Story A, Murad S, Roberts W, Verheyen M, Hayward AC; London Tuberculosis Nurses Network. Tuberculosis in London: the importance of homelessness, problem drug use and prison. Thorax. 2007;62(8):667-671. doi:10.1136/thx.2006.065409. Disponivel em: https://pubmed.ncbi.nlm.nih.gov/17289861/

20. Ramos, EM et al. Tuberculosis in the South America's homeless: a systematic review of social determinants, control strategies and health equity. Revista da Escola de Enfermagem da USP, v. 60, e20250222, 2026.

DOI: https://doi.org/10.36489/nursing.2026v32i341p22212-22238