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# Vulnerability to loss of follow-up and death due to tuberculosis among homeless individuals in Brazil: a retrospective cohort study

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**Abstract** *This retrospective cohort study identified factors associated with loss of follow-up and death due to tuberculosis (TB) in the homeless population (HP) in Brazil, estimating odds ratios (OR) and their 95% confidence intervals (95%CI) by multinomial logistic regression. A total of 3,831 TB cases in this population were analyzed, of which 57.0% had unfavorable outcomes. Loss of follow-up was associated with: history of abandonment (OR=2.38; 95%CI 2.05-2.77), unknown HIV serology (OR=1.79; 95%CI 1.38-2.32), HIV coinfection (OR=1.73; 95%CI 1.46-2.06), drug use (OR=1.54; 95%CI 1.31-1.80), age (OR=0.98; 95%CI 0.97-0.99), mixed clinical form (OR=0.64; 95%CI 0.42-0.97), extrapulmonary form (OR=0.46; 95%CI 0.29-0.73), government beneficiary (OR=0.64; 95%CI 0.50-0.81), and supervised treatment (OR=0.52; 95%CI 0.45-0.60). Regarding death, the following were associated: age (OR=1.03; 95%CI 1.01-1.05), unknown HIV serology (OR=2.39; 95%CI 1.48-3.86), alcohol consumption (OR=1.81; 95%CI 1.27-2.58), and supervised treatment (OR=0.70; 95%CI 0.51-0.96). Overlapping vulnerabilities in the health-disease process of homeless individuals with TB were observed, requiring comprehensive and cross-sectoral care practices.*

**Key words** *Homeless People, Health Inequities, Tuberculosis, Cohort Studies*

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## Introduction

Despite the universal availability of treatment – within the scope of the Unified Health System (SUS) – and the possibility of a cure, tuberculosis (TB) still represents a social and public health problem worldwide[1]. TB has a strong relationship with the processes of social production that generate and perpetuate situations of inequality and poverty[2]. Therefore, it is essential to boost knowledge and conduct debates on endemic TB, focused on achieving its elimination[2].

Brazil, a developing nation with great social disparities in its geopolitical territory, is ranked among the top thirty countries with the highest burden of the disease[3]. Therefore, a better understanding of the process of social determination linked to the occurrence and persistence of TB is of utmost importance, especially in the most vulnerable strata of society[3], of which victims of social, political, and economic inconsistencies likely suffer the most severe consequences of the disease[3].

Considering the susceptibility of populations that are most likely to become ill due to TB, especially due to social issues, responsible and committed action on the part of health professionals and managers is essential in an attempt to overcome obstacles to eliminating the disease[4,5]. Meanwhile, the homeless population (HP) stands out, as it presents a high risk of contracting the disease and having worse outcomes, especially in countries with a high burden of TB[5], such as Brazil.

Homeless individuals face barriers to accessing education, work, food, hygiene, medical care, and health services, especially because they are targets of prejudice and stigma. They are therefore inserted in contexts of the overlapping of different vulnerabilities[1,2,6]. This scenario represents a major challenge, especially for health services, since the persistence of TB has repercussions for both individuals and groups.

Previous studies have highlighted the close relationship between biological, social, economic, and programmatic factors, and the incidence of unfavorable outcomes from TB treatment in Brazil[7,8]. However, the impact of living on the streets on such outcomes still requires further investigation, especially when considering the notable challenges in ensuring effective indicators of disease control in this vulnerable population, as has been observed in prior research[9].

From the perspective of the concept of vulnerability, this work adds a new interpretation to the contexts of the fragility of homeless individuals undergoing TB treatment, by highlighting how this situation can influence the loss of follow-up and death due to infection in this population group. Therefore, to collaborate with more assertive disease control strategies, this study aimed to identify the factors associated with the unfavorable outcomes of TB cases in the HP in Brazil.

## Methods

This work is a non-concurrent, population-based cohort study, conducted using data from notifications of TB cases in the HP in Brazil, between 2015 and 2021. These records were obtained from the Notifiable Diseases Information System (*Sistema de Informação de Agravos de Notificação* - SINAN), which is fed throughout the treatment of TB patients, which lasts approximately six months[10]. The information from this follow-up is included in the case monitoring and notification forms, serving as a retrospective source of data for SINAN[10].

The time frame is justified by the inclusion of the variable "homeless population (yes; no; ignored)" in the notification form, which was applied in 2015[11]. The data were accessed through the Brazilian National Health System Information Technology Department (*Departamento de Informática do Sistema Único de Saúde* - DATASUS) in November 2022, which is why the analysis ended in 2021. The files were downloaded in the ".dbc" format, read by the R® software, using the "read.dbc" package, and exported to the ".csv" format[12].

TB cases were considered in people aged 18 to 59 years, in which the variable "homeless population" was marked as "yes". For inclusion, only records were selected whose variable "entry type" was filled with the options: "new case" – person never subjected to treatment or treated for less than 30 days; "relapse" – person with reinfection or recurrence of the previous infection; and "re-entry after abandonment" – person who started new treatment after abandonment[10].

In this study, the dependent variable was constructed by "closure situation", considering the following: "cure" (treatment completed as recommended); "primary abandonment" (use of medication for less than 30 days and interruption for 30 consecutive days), and "abandonment" (use of medication for more than 30 days and interruption for 30 consecutive days) – called "loss of fol-

low-up"; and "death" (with TB as the underlying cause)[10]. The independent variables were:

a) sociodemographic: sex (male; female), age (in years), self-declared race/color (white; non-white – black/yellow/brown/indigenous), education (no study; up to 8 years of study; more than 8 years of study), and beneficiary of a government income transfer program (yes; no).

b) clinical-epidemiological: type of entry (reentry after abandonment; relapse; new case), diabetes (yes; no), use of drugs/alcohol/tobacco (yes; no), mental illness (yes; no), infection by human immunodeficiency virus – HIV (yes; no; unknown – not carried out/in progress), clinical form (pulmonary; extrapulmonary; mixed – pulmonary/extrapulmonary), and directly observed treatment – DOT (yes; no).

The complete case analysis approach was adopted, which consisted of excluding records with at least one ignored/blank variable. This decision was based on a previous exploration of the bank, observing a considerable amount of missing data. Given this finding, we opted for the aforementioned approach, since the presence of missing data could compromise the integrity and reliability of the analysis, preventing an appropriate interpretation of the results.

For the descriptive analysis of the data, the absolute and relative frequencies of the categorical variables, as well as the measures of central tendency and dispersion for the variable "age" (mean - me; median - md; standard deviation - sd), were calculated. To verify the associations between the dependent and independent variables, multinomial (multiclass)[13] logistic regression models were used, given the categorical nature with more than two categories in the response variable (cure; loss of follow-up; death).

Cure was considered to be the reference category for the dependent variable in order to model the factors that influenced the loss of follow-up and death due to TB in homeless individuals. Initially, bivariate models were constructed and associations were reported as odds ratios (OR) – not adjusted for any confounding factors (crude analysis) – and their 95% confidence intervals (95% CI). Variables with a p-value<0.20 were considered for multiple analysis.

Multicollinearity of variables was assessed and discarded before the multiple models. Afterwards, a selection was carried out using the backward stepwise method, in which all variables with a p-value<0.20 were initially included in the likelihood ratio test. They were then removed one by one, keeping only those with a p-value<0.05. From this, the adjusted ORs were presented and were considered to be significant when their 95%CI did not cross the null value (1,00).

To verify the robustness of the findings and point out possible association biases related to the exclusion of cases with missing information, a post hoc analysis was performed, considering the missing data as a subcategory of the independent variables present in the final model. All analyses were performed using the SPSS® software, version 21.0. Furthermore, it should be noted that the findings were discussed in light of the concept of vulnerability, proposed by Ayres *et al.*[14].

This study is derived from the Master's thesis entitled *Tuberculosis in homeless individuals in Brazil: evidence of geoprogrammatic disparities and predictors of unfavorable outcome*, defended in the Programa de Pós-Graduação em Enfermagem of the Universidade Estadual de Maringá, in 2023. According to Resolutions no. 466/2012 and no. 674/2022, a favorable opinion was obtained from the Research Ethics Committee, logged under certificate of presentation for ethical assessment (CAAE) no. 63981922.6.0000.0104.

## Results

In the period from 2015 to 2021, 13,839 TB cases were reported in homeless individuals in Brazil, considering those aged between 18 and 59 years and whose "closure status" on SINAN was filled in as "cure", "primary abandonment/abandonment" or "death due to TB". Of these, 10,008 (79.7%) cases were excluded due to a lack of information on a given variable; therefore, 3,831 (20.3%) cases remained and were included in the analysis of this cohort study.

Exclusions due to missing data for each specific variable are presented below, in descending order: beneficiary of government program (n=6,283; 45.4%), education (n=4,862; 35.1%), DOT (n=1,218; 8.8%), self-declared race/color (n=1,055; 7.6%), mental illness (n=1,005; 7.3%), diabetes (n=943; 6.8%), tobacco use (n=815; 5.9%), drug use (n=685; 4.9%) and alcohol consumption (n=663; 4.8%), HIV serology (n=67; 0.5%), and sex (n=1; 0.0%).

Regarding the outcome of the cases included, 42.8% (n=1,640) were concluded as cured, 52.6% (n=2,016) were loss of follow-up, and 4.6% (n=175) death due to TB. Among the notifications, it was observed that the majority referred to male individuals (n=2,973; 77.6%), of non-white race/color (n=2,863; 74.7%), with up

to eight years of education (n=2,965; 77.4%), and who were not beneficiaries of income transfer programs (n=3,476; 90.7%) (Table 1).

Furthermore, the highest occurrence of TB cases was observed with the entry type filled as new case (n=2,051; 53.5%), pulmonary clinical form (n=3,605; 94.1%), DOT performed (n=1,930; 50.4%), and who consumed alcoholic beverages (n=2,129; 55.6%), tobacco (n=2,309; 60.3%), and/or drugs (n=2,600; 67.9%). Regarding comorbidities, it was observed that the absence of HIV, diabetes, and mental illness predominated among the included cases (Table 1).

In the bivariate analysis, significant associations were seen in the following variables: sex, race/color, age, education, government beneficiary, type of entry, clinical form, consumption of alcohol, diabetes, HIV, DOT, use of drugs, and use of tobacco (Table 2). Subsequently, eight variables remained associated in the final model, through multivariate analysis, namely: age, government beneficiary, type of entry, clinical form, alcohol consumption, HIV, DOT, and drug use.

Factors associated with loss to follow-up were: drug use (OR=1.54; 95%CI 1.31-1.80), reentry after dropout (OR=2.38; 95%CI 2.05-2.77), co-infection with HIV (OR=1.73; 95%CI 1.46-2.06) and unknown serology (OR=1.79; 95%CI 1.38-2.32), age (OR=0.98; 95%CI 0.97-0.99), mixed form (OR=0.64; 95%CI 0.42-0.97) and extrapulmonary form (OR=0.46; 95%CI 0.29-0.73), government beneficiary (OR=0.64; 95%CI 0.50-0.81), and completion of the DOT (OR=0.52; 95%CI 0.45-0.60) (Table 3).

Regarding death due to TB, the following factors were significantly associated in the multiple model: age (OR=1.03; 95%CI 1.01-1.05), lack of knowledge of HIV serology (OR=2.39; 95%CI 1.48-3.86), alcohol consumption (OR=1.81; 95%CI 1.27-2.58), and completion of DOT (OR=0.70; 95%CI 0.51-0.96) (Table 3). Sensitivity analysis revealed similar estimates for the final model variables in the complete case and missing indicator approaches (Table 4).

## Discussion

This study made it possible to identify sociodemographic and clinical-epidemiological factors associated with unfavorable outcomes in TB cases among homeless individuals in Brazil. Despite advances in combating infection, it is commonly recognized that the HP represents a group that suffers the effects of the social determination of the health-disease process, and may find itself in a context that is less sensitive to TB prevention and management actions, even in developed countries[15,16].

It is well-known that homeless individuals are daily subject to challenges arising from the precarious and often inhumane living conditions in which they find themselves, requiring specific strategies to guarantee comprehensive and equitable care[16,17]. Therefore, it is essential to employ the epidemiological approach associated with the concept of vulnerability for a more in-depth understanding of the contexts of street dwelling[17] and its relationship with TB.

According to Ayres *et al.* precepts[14,18], vulnerability can be understood in three interrelated dimensions, namely: individual – which involves access to information and the ability to incorporate it into attitudes, knowledge, beliefs, values, among others; social – related to social and cultural norms, encompassing stigma, prejudice, social support, among others; and programmatic – which refers to the actions and responses of social institutions (health, education, social assistance, public security, among others)[14,18].

In other words, in addition to individual and behavioral issues that influence illness, social and structural aspects related to access to health services are also considered[18]. Therefore, to understand the social determination of TB, it is necessary to identify the specific needs of this social group – which certainly originate from vulnerable contexts – and consider the situations that discriminate, subordinate, and weaken these subjects.

In this retrospective cohort at a national level, it was observed that the following variables were positively associated with the chance of losing TB treatment follow-up, as compared to a cure, among people who are homeless: reentry after abandonment (OR=2.38; 95%CI 2.05-2.77), lack of knowledge of HIV serology (OR=1.79; 95%CI 1.38-2.32) and co-infection with HIV (OR=1.73; 95%CI 1.46-2.06), and drug use (OR=1.54; 95%CI 1.31-1.80).

One literature review, which did not investigate the loss of follow-up specifically in the HP, identified different factors related to treatment interruption and, among these, it was observed that the history of abandonment is an important predictor of a new episode of abandonment[19]. Considering the precarious contexts known to be faced by the HP[2,6], the high number of reentry after abandonment seen in this study raises an alert for professionals involved in providing health care.

**Table 1.** Descriptive measures of the sociodemographic and clinical-epidemiological characteristics of tuberculosis cases among homeless individuals, according to treatment outcomes, in Brazil, 2015-2021.

| Variable | Total | | Outcome | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Cure | | Loss of follow-up | | Death | |
| Sex (n, %) | | | | | | | | |
| Masculine | 2,973 | 77.6 | 1,295 | 79.0 | 1,527 | 75.7 | 151 | 86.3 |
| Feminine | 858 | 22.4 | 345 | 21.0 | 489 | 24.3 | 24 | 13.7 |
| Race/color (n, %) | | | | | | | | |
| White | 968 | 25.3 | 382 | 23.3 | 557 | 27.6 | 29 | 16.6 |
| Not white | 2,863 | 74.7 | 1,258 | 76.7 | 1,459 | 72.4 | 146 | 83.4 |
| Age (me/md, dp) | | | | | | | | |
| 18 to59 years old | 38.0/37.0 | 9.6 | 39.0/37.0 | 10.1 | 36.8/37.0 | 9.1 | 42.1/37.0 | 9.7 |
| Education (n, %) | | | | | | | | |
| No study | 297 | 7.8 | 131 | 8.0 | 145 | 7.2 | 21 | 12.0 |
| Up to 8 years | 2,965 | 77.4 | 1,239 | 75.5 | 1,597 | 79.2 | 129 | 73.7 |
| More than 8 years | 569 | 14.8 | 270 | 16.5 | 274 | 13.6 | 25 | 14.3 |
| Government beneficiary (n, %) | | | | | | | | |
| Yes | 355 | 9.3 | 190 | 11.6 | 146 | 7.2 | 19 | 10.9 |
| No | 3,476 | 90.7 | 1,450 | 88.4 | 1,870 | 92.8 | 156 | 89.1 |
| Type of entry (n, %) | | | | | | | | |
| Reentry after abandonment | 1,502 | 39.2 | 432 | 26.3 | 1,017 | 50.4 | 53 | 30.3 |
| Relapse | 278 | 7.3 | 143 | 8.8 | 115 | 5.8 | 20 | 11.4 |
| New case | 2,051 | 53.5 | 1,065 | 64.9 | 884 | 43.8 | 102 | 58.3 |
| Clinical form (n, %) | | | | | | | | |
| Pulmonary/extrapulmonary | 120 | 3.1 | 53 | 3.3 | 58 | 2.9 | 9 | 5.2 |
| Extrapulmonary | 106 | 2.8 | 61 | 3.7 | 35 | 1.7 | 10 | 5.7 |
| Pulmonary | 3,605 | 94.1 | 1,526 | 93.0 | 1,923 | 95.4 | 156 | 89.1 |
| Alcohol consumption (n, %) | | | | | | | | |
| Yes | 2,129 | 55.6 | 884 | 53.9 | 1,122 | 55.7 | 123 | 70.3 |
| No | 1,702 | 44.4 | 756 | 46.1 | 894 | 44.3 | 52 | 29.7 |
| Diabetes (n, %) | | | | | | | | |
| Yes | 113 | 2.9 | 58 | 3.5 | 48 | 2.4 | 7 | 4.0 |
| No | 3,718 | 97.1 | 1,582 | 96.5 | 1,968 | 97.6 | 168 | 96.0 |
| Mental illness (n, %) | | | | | | | | |
| Yes | 318 | 8.3 | 136 | 8.3 | 169 | 8.4 | 13 | 7.4 |
| No | 3.513 | 91.7 | 1,504 | 91.7 | 1,847 | 91.6 | 162 | 92.6 |
| HIV (n, %) | | | | | | | | |
| Yes | 934 | 24.4 | 300 | 18.3 | 604 | 30.0 | 30 | 17.1 |
| Unknown | 336 | 8.8 | 113 | 6.9 | 198 | 9.8 | 25 | 14.3 |
| No | 2,561 | 66.8 | 1,227 | 74.8 | 1,214 | 60.2 | 120 | 68.6 |
| DOT (n, %) | | | | | | | | |
| Yes | 1,930 | 50.4 | 993 | 60.5 | 847 | 42.0 | 90 | 51.4 |
| No | 1,901 | 49.6 | 647 | 39.5 | 1,169 | 58.0 | 85 | 48.6 |
| Drug use (n, %) | | | | | | | | |
| Yes | 2,600 | 67.9 | 981 | 59.8 | 1,509 | 74.9 | 110 | 62.9 |
| No | 1,231 | 32.1 | 659 | 40.2 | 507 | 25.1 | 65 | 37.1 |
| Tobacco use (n, %) | | | | | | | | |
| Yes | 2,309 | 60.3 | 951 | 58.0 | 1,251 | 62.1 | 107 | 61.1 |
| No | 1,522 | 39.7 | 689 | 42.0 | 765 | 37.9 | 68 | 38.9 |

HIV: human immunodeficiency virus; DOT: directly observed treatment.

Source: Notifiable Diseases Information System.

**Table 2.** Bivariate analysis of factors associated with loss of follow-up and death in tuberculosis cases among homeless individuals, according to sociodemographic and clinical-epidemiological characteristics, in Brazil, 2015-2021.

| Variable | Loss of follow-up | Death | p-value† |
|---|---|---|---|
| | OR* (95%CI) | OR* (95%CI) | |
| Sex | | | |
| Masculine | 0.83 (0.71-0.97) | 1.67 (1.07-2.62) | 0.001 |
| Feminine | Reference | | |
| Race/color | | | |
| White | 1.25 (1.08-1.46) | 0.65 (0.43-0.99) | <0.001 |
| Not white | Reference | | |
| Age | | | |
| 18 to 59 years old | 0.97 (0.96-0.98) | 1.03 (1.01-1.05) | <0.001 |
| Education | | | |
| No study | 1.09 (0.81-1.45) | 1.73 (0.93-3.20) | 0.023 |
| Up to 8 years | 1.27 (1.05-1.52) | 1.12 (0.71-1.76) | |
| More than 8 years | Reference | | |
| Government beneficiary | | | |
| Yes | 0.59 (0.47-0.74) | 0.92 (0.56-1.53) | <0.001 |
| No | Reference | | |
| Type of entry | | | |
| Reentry after abandonment | 2.83 (2.45-3.27) | 1.28 (0.90-1.81) | <0.001 |
| Relapse | 0.96 (0.74-1.25) | 1.46 (0.87-2.43) | |
| New case | Reference | | |
| Clinical form | | | |
| Pulmonary/extrapulmonary | 0.86 (0.59-1.26) | 1.66 (0.80-3.43) | <0.001 |
| Extrapulmonary | 0.45 (0.29-0.69) | 1.60 (0.80-3.19) | |
| Pulmonary | | Reference | |
| Alcohol consumption | | | |
| Yes | 1.07 (0.94-1.22) | 2.02 (1.44-2.83) | <0.001 |
| No | Reference | | |
| Diabetes | | | |
| Yes | 0.66 (0.45-0.98) | 1.13 (0.51-2.53) | 0.086 |
| No | | Reference | |
| Mental disease | | | |
| Yes | 1.01 (0.79-1.28) | 0.88 (0.49-1.60) | 0.905 |
| No | Reference | | |
| HIV | | | |
| Yes | 2.03 (1.73-2.38) | 1.02 (0.67-1.55) | <0.001 |
| Unknown | 1.77 (1.38-2.26) | 2.26 (1.41-3.62) | |
| No | Reference | | |
| DOT | | | |
| Yes | 0.47 (0.41-0.53) | 0.69 (0.50-0.94) | <0.001 |
| No | Reference | | |
| Drug use | | | |
| Yes | 1.99 (1.73-2.30) | 1.13 (0.82-1.56) | <0.001 |
| No | Reference | | |
| Tobacco use | | | |
| Yes | 1.18 (1.03-1.35) | 1.14 (0.82-1.56) | 0.043 |
| No | Reference | | |

HIV: human immunodeficiency virus; DOT: directly observed treatment; OR: odds ratio; 95%CI: 95% confidence interval; *Analysis not adjusted for any variable in the model; †Value by the likelihood ratio test.

Source: Notifiable Diseases Information System.

**Table 3.** Multivariate analysis of factors associated with loss of follow-up and death in tuberculosis cases among homeless individuals, according to sociodemographic and clinical-epidemiological characteristics, in Brazil, 2015-2021.

| Variable | Loss of follow-up | Death | p-value† |
|---|---|---|---|
| | OR* (95% CI) | OR* (95% CI) | |
| Age | | | |
| 18 to 59 years old | 0.98 (0.97-0.99) | 1.03 (1.01-1.05) | <0.001 |
| Government beneficiary | | | |
| Yes | 0.64 (0.50-0.81) | 0.91 (0.55-1.51) | 0.001 |
| No | Reference | | |
| Type of entry | | | |
| Reentry after abandonment | 2.38 (2.05-2.77) | 1.34 (0.93-1.92) | <0.001 |
| Relapse | 0.94 (0.72-1.24) | 1.40 (0.83-2.35) | |
| New case | Reference | | |
| Clinical form | | | |
| Pulmonary/extrapulmonary | 0.64 (0.42-0.97) | 1.68 (0.79-3.58) | <0.001 |
| Extrapulmonary | 0.46 (0.29-0.73) | 1.83 (0.90-3.72) | |
| Pulmonary | | Reference | |
| Alcohol consumption | | | |
| Yes | 1.04 (0.90-1.20) | 1.81 (1.27-2.58) | 0.003 |
| No | Reference | | |
| HIV | | | |
| Yes | 1.73 (1.46-2.06) | 0.86 (0.55-1.34) | <0.001 |
| Unknown | 1.79 (1.38-2.32) | 2.39 (1.48-3.86) | |
| No | Reference | | |
| DOT | | | |
| Yes | 0.52 (0.45-0.60) | 0.70 (0.51-0.96) | <0.001 |
| No | Reference | | |
| Drug use | | | |
| Yes | 1.54 (1.31-1.80) | 1.27 (0.89-1.81) | <0.001 |
| No | Reference | | |

HIV: human immunodeficiency virus; DOT: directly observed treatment; OR: odds ratio; 95%CI: 95% confidence interval; *Analysis not adjusted for any variable in the model; †Value by the likelihood ratio test.

Source: Notifiable Diseases Information System.

One ecological study, which evaluated TB indicators in the HP between 2015 and 2019, pointed to the low HIV testing in the national territory, highlighting states, such as Mato Grosso and Pará, with percentages of lower than 75% in offering HIV tests to people with TB[9]. Although the strategy (double testing) is recommended for all people with TB or HIV[20], there are persistent challenges in implementing this approach among homeless individuals.

In Brazil, the high occurrence of TB-HIV co-infection in the HP is also a reality, corresponding to more than 30% of all cases in some states[9]. Considering that co-infection was recognized as a predictor of the loss to follow-up in other studies[7,19], it is highlighted that difficulties linked to understanding and accepting the double therapeutic regimen, side effects and lack of complacency on the part of health professionals when faced with complaints from people undergoing treatment can contribute to non-adherence[21].

The greatest risk of loss of TB treatment follow-up in the context of the lives of people who use legal/illicit drugs may be related to the overlapping and interrelationship of vulnerabilities, since stigma, discrimination, lack of financial resources, and risk behaviors tend to be high in these individuals[22,23]. Especially in the HP with TB, these results are even more worrying, given that a large proportion of individuals consume alcohol and drugs.

It is also important to note that protective aspects were also identified in the multiple model. For each additional year of life, there was a 2% decrease in the chances of interrupting treat-

**Table 4.** Post hoc multivariate analysis of factors associated with loss of follow-up and death in tuberculosis cases among homeless individuals, according to sociodemographic and clinical-epidemiological characteristics, in Brazil, 2015-2021.

| Variable | Loss of follow-up | Death | p-value† |
|---|---|---|---|
| | OR* (95% CI) | OR* (95% CI) | |
| Age | | | |
| 18 to 59 years old | 0.98 (0.97-0.98) | 1.02 (1.02-1.03) | <0.001 |
| Government beneficiary | | | |
| Yes | 0.69 (0.56-0.84) | 0.64 (0.41-1.02) | 0.001 |
| No | Reference | | |
| Type of entry | | | |
| Reentry after abandonment | 2.11 (1.92-2.32) | 1.38 (1.14-1.67) | <0.001 |
| Relapse | 0.90 (0.77-1.04) | 0.89 (0.67-1.18) | |
| New case | Reference | | |
| Clinical form | | | |
| Pulmonary/extrapulmonary | 0.62 (0.47-0.80) | 2.43 (1.64-3.59) | <0.001 |
| Extrapulmonary | 0.59 (0.46-0.75) | 1.18 (0.77-1.80) | |
| Pulmonary | Reference | | |
| Alcohol consumption | | | |
| Yes | 0.95 (0.87-1.04) | 1.58 (1.31-1.90) | <0.001 |
| No | Reference | | |
| HIV | | | |
| Yes | 1.58 (1.42-1.75) | 0.35 (0.25-0.47) | <0.001 |
| Unknown | 2.08 (1.81-2.39) | 2.21 (1.78-2.74) | |
| No | Reference | | |
| DOT | | | |
| Yes | 0.28 (0.25-0.31) | 0.36 (0.29-0.43) | <0.001 |
| No | Reference | | |
| Drug use | | | |
| Yes | 1.43 (1.30-1.57) | 1.20 (1.00-1.45) | <0.001 |
| No | Reference | | |

HIV: human immunodeficiency virus; DOT: directly observed treatment; OR: odds ratio; 95%CI: 95% confidence interval; *Analysis adjusted to all model variables; †Value by the likelihood ratio test.

Source: Notifiable Diseases Information System.

ment. This may be associated, for example, with the greater susceptibility of young people to risk and negligence scenarios related to self-care or even as a result of the person not accepting the diagnosis[19], which would explain their greater abandonment of TB treatment follow-up.

Obtaining government benefits and undergoing DOT also diminished the chances of the loss of follow-up by 36% and 48%, respectively. Such strategies are crucial for the protection and guarantee of social rights, routinely neglected in the HP. One cohort study conducted with 274 homeless individuals developed in the United States detected a significant improvement in the chances of completing TB treatment, mainly attributed to the use of DOT[24].

The mixed (OR=0.64; 95%CI 0.42-0.97) and extrapulmonary (OR=0.46; 95%CI 0.29-0.73) clinical forms of TB reduced the chances of the loss of follow-up. These results may be related to the logic of TB care in the care network, in which cases with more complex forms must also be treated on an outpatient and/or hospital basis. This could help, for example, to reduce the chances of abandonment, since people should be referred to services to continue their treatment.

Furthermore, it can be inferred that, by encompassing more teams and professionals involved in care, homeless individuals would be monitored at care levels in conjunction with primary health care (PHC)[25], which would thus enable greater opportunities to establish a tie and,

consequently, adherence to TB treatment. These findings suggest the importance of coordinated action between different levels of care to guarantee better TB indicators among the HP.

Regarding death from TB, it was found that with each year of increasing age, there was a 3% increase in the chance of this outcome; the consumption of alcohol (OR=1.81; 95%CI 1.27-2.58) and the lack of knowledge of HIV serology (OR=2.39; 95%CI 1.48-3.86) were also associated with greater chances of death due to TB. This result is close to the findings of an integrative review that identified that individuals, aged 43 years and over, and the consumption of alcoholic beverages were predictors of death due to the disease in the prison system[26].

Therefore, the potential influence of alcohol consumption on death due to TB can be assumed. The abuse of these substances can cause clinical and physiological repercussions, as it is commonly responsible for liver damage and nutritional and immunological deficiency[27], especially when there is prolonged exposure, primarily in adults of advanced age and/or diagnosed with alcoholism[15]. Furthermore, it is assumed that high levels of consumption can, in general, interfere with living conditions and wellbeing, harmfully influencing people's habits and daily lives.

Regarding the lack of knowledge about HIV serology, it must be considered that under-diagnosis, resulting from the failure to carry out tests – often resulting from the fragmentation of care in services – causes failures in HIV treatment, which can increase the risk of death due to TB, given the immunological compromise caused by the virus[28]. Therefore, it is urgent to promote dialogue between TB and HIV programs and other sectors so that universal testing can be offered to people at any given opportunity[20].

One possibility to integrate care is the creation and guidance of intersectoral and social protection strategies, such as the implementation of the singular therapeutic project (STP) for homeless individuals diagnosed with TB, in a humanized and comprehensive way[29]. Still, from this perspective, it is important to highlight and reiterate DOT together with HP as an effective strategy to treat the disease, which, in this cohort study, was able to reduce the chance of death due to TB in this population by 30%.

Despite the existence of public policies, programs, guidelines, and actions that, in theory, guarantee health care for the HP, there are important gaps in their operationalization[9], making these individuals more exposed to situations of violence and deprivation of rights[3]. In this study, this scenario of disparities was viewed by the high proportion of homeless individuals with unfavorable outcomes from TB cases, together with the contexts that exacerbate them.

It is essential to mitigate obstacles that affect the reality of homeless people living with the disease. In this sense, the Federal Government recently ratified Decree No. 11,908/2024, establishing the Healthy Brazil Program (*Programa Brasil Saudável*), coordinated by the Interministerial Committee for the Elimination of Tuberculosis and Other Socially Determined Diseases (*Comitê Interministerial para a Eliminação da Tuberculose e de Outras Doenças Determinadas Socialmente* - CIEDDS)[30]. This initiative seeks to promote intersectoral actions that eliminate such problems as public health issues by the end of this decade[30].

The implementation of strategies that involve different sectors to combat TB, such as CIEDDS, is essential for the elimination of TB by 2030[31]. This goal cannot be achieved without measures to reduce social inequality rooted in the country[31]. Therefore, it is urgent that the management spheres and services involved in the care of people with TB act in an integrated manner so that it will be possible to implement this audacious program, with the potential to eliminate socially determined diseases and to promote intersectoral care throughout Brazil.

The abyss of persistent inequality in our society demands social and health policies that fully address the needs of a population as vulnerable as the HP[32,33]. Therefore, the urgency for the integration and articulation of the various spheres of SUS and other governmental and non-governmental sectors should be reinforced, seeking continuous and longitudinal care through health services and actions to prevent and control the disease.

As limitations of this study, the use of secondary data is assumed, which may be subject to incorrect completion and the underreporting of cases, in turn falsifying the true epidemiological scenario of the disease, especially in the HP. Furthermore, the high quantity of missing data stands out, which can contribute to selection, information, and analysis biases; in other words, this may lead to uncertain conclusions about the relationship between the variables and reduce the power to generalize the results.

However, even when considering that the large number of exclusions may limit the interpretation of the findings, the post hoc analysis revealed similar estimates for the variables in

the final model when comparing the complete cases and missing indicator approaches. Thus, the inclusion of ignored information as a subcategory of the independent variables appears to have maintained the direction and strength of the association for most of the analyses presented in this study.

Furthermore, given the inclusion of the variable "homeless population" in the notification form only in 2015, another limitation arises related to the possible incompleteness of the records on the part of health professionals, who may not be used to filling out the variable properly. Accurate information about each case, especially those related to the HP, is essential for the organization and sustainability of a comprehensive, integrated, and effective health network.

Finally, it is worth noting that the COVID-19 pandemic may have influenced the analyses, given the inclusion of data from 2020 and 2021, generating incorrect measurements of unfavorable outcomes that need to be considered in future studies. Changes in the patterns of seeking health services, social isolation, prioritization of resources, changes in people's behavior, and adaptations of assistance and surveillance services may have influenced access to care, the quality of treatment, and the surveillance of TB cases[34,35].

## Conclusion

The loss of follow-up of TB cases in the HP was associated with younger age, reentry after abandonment, co-infection with HIV and the lack of knowledge of serology, and drug use. Receiving a government grant, undergoing DOT, and having mixed and extrapulmonary clinical forms diminished the chances. Death from TB was linked to advancing age, the lack of knowledge of HIV serology, and the consumption of alcohol, while performing the DOT reduced the chances of death.

These findings highlight the contexts that make people vulnerable and have an impact on the health-disease process of homeless individuals, making them more susceptible to the unfavorable outcomes of TB. Thus, the importance of analyzing the relationship between sociodemographic and clinical-epidemiological aspects, as well as other elements that weaken these people, is clear, seeking to qualify coping strategies to be sensitive to this well-known marginalized group.

Furthermore, the potential of surveillance is highlighted in relation to the planning, control, and management of TB, which leads to the need for a constant qualification of services and their tools. Finally, the demand for studies with different approaches is highlighted, which aims to elucidate the contexts experienced by this social group in order to broaden the understanding of the bases that support this reality and to enable the implementation of strategies that modify their structuring conditions.

## Collaborations

G Pavinati: conception and design of the study, data collection, survey of references, data analysis and interpretation, write-up of the article, and approval of the final version. LV Lima: study design, data analysis and interpretation, critical review, and approval of the final version of the article. CSS Teixeira, P Hino, MR Bertolozzi, and JS Nery: critical review and approval of the final version of the article. GT Magnabosco: study design, critical review, and approval of the final version of the article.

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