Original article

Tuberculosis cases with post-mortem notification in Brazil, 2014: a descriptive study based on surveillance data*

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Abstract

Objective: To characterize tuberculosis cases notified at post-mortem in Brazil in 2014. **Methods:** This is a descriptive study of tuberculosis cases notified at post-mortem. Data resulted from linkage of the Notifiable Health Conditions Information System-TB (SINAN-TB) and the Mortality Information System (SIM), and were described according to underlying cause of death: tuberculosis, AIDS and other. **Results:** In the 2,703 tuberculosis cases notified at post-mortem, a higher proportion was found of people of the male sex (73.5%), aged over 39 (80.8%), <8 years of schooling (66.5%), of Black and brown race/skin color (62.8%), with the pulmonary clinical form of tuberculosis (75.2%); there was also a higher proportion of cases notified by the public health service (57.6%) and in municipalities with HDI-M >0.7 (66.6%). **Conclusion:** The characteristics described of people with post-mortem notification and the magnitude of this outcome suggest weaknesses in tuberculosis care and surveillance services.

Keywords: Tuberculosis; Disease Notification; Epidemiology, Descriptive; Mortality; Information Systems.

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Introduction

Tuberculosis (TB) continues to be the leading cause of death among communicable diseases and one of the ten leading causes of death worldwide. In 2018, there were estimated to have been 10 million cases and 1.4 million deaths directly related to TB.[1]

> *When a TB case is notified at post-mortem it can be considered to be a 'sentinel event' alerting as to failures in individual care and compromising the effectiveness of the TB control service.*

In 2018, the Americas contributed to 3% of the global TB burden, and Brazil was in first place on the continent with 32% of cases, followed by Peru (13%) and Mexico (10%). According to the World Health Organization (WHO), Brazil was the only country on the American continent listed among the world's 30 countries with high TB burdens which account for 87% of all notified cases and have an estimated incidence rate of 45 cases per 100,000 inhabitants.[1] In the same year, the Notifiable Health Conditions Information System-TB (SINAN-TB), controlled by the Brazilian Ministry of Health's Department of Chronic Diseases and Sexually Transmitted Infections (DCCI/MS), recorded 75,717 new TB cases (36.2 cases per 100,000 inhab.), 423 of which were notified at post-mortem.[2]

TB is a compulsorily notifiable disease in Brazil.[3] There is an extensive network for TB surveillance and control which is present in all Brazilian municipalities, which in turn implement different strategies and technologies to prevent new cases and reduce the burden of the disease.[2] However, a situation worthy of concern continues to persist: part of the population with TB is not reached by this network's surveillance and care services.

Non-detection of TB cases is an important challenge to be addressed, because it contributes to maintaining the transmission chain, prevents effective treatment and results in the magnitude of the problem for Public Health being underestimated.[4,5] When a TB case is notified at post-mortem it can be considered to be a 'sentinel event' alerting as to failures in individual care and compromising the effectiveness of the TB control service.

As such, the objective of this study was to characterize TB cases notified at post-mortem in Brazil in 2014.

Methods

This is a descriptive study of TB cases notified at post-mortem, found by linking data for the year 2014 held on two Ministry of Health information systems, namely the SINAN-TB system and the Mortality Information System (SIM).

Brazil is a country of continental dimensions, covering an area of 8,510,820.623km^2 and with an estimated population of 204.2 million inhab. in 2014.[6] There is great social inequality in Brazil, which is particularly unfavorable for the North and Northeast regions, which have the lowest average per capita income and the highest Gini indices among the country's five regions.[7,8] Also in 2014, TB was consider to be one of the most important diseases for Public Health:[9] 67,966 new cases were recorded that year, with the highest incidence coefficients being found in the states of Amazonas (68.4/100,000 inhab.) and Rio de Janeiro (60.9/100,000 inhab.),[10] while nationally the mortality rate was 2.4 deaths per 100,000 inhab.[11]

It is appropriate to recall that the Brazilian National Health System (SUS) is public, free of charge, offers universal coverage and provides care to the greater part of the population.[12] In 2014, jointly the federal, state and municipal public administration networks had some 898,612 health services linked to SUS.[13]

The study population was comprised of all TB cases notified at post-mortem in Brazil in 2014. The case exclusion criteria were: being under 15 years old, in order to prevent considerable heterogeneity among the study population; and missing information on the sex of the cases.

Notification at post-mortem was defined as notification of a TB case exclusively made at the circumstances of death.

The information on the study population was identified by means of a secondary database, derived from linkage between the SINAN-TB and SIM systems, available only for the year 2014. This study added TB cases found on SINAN-TB input as 'post-mortem' cases to TB cases found exclusively on SIM which, for the purposes of this study, were also considered to be 'post-mortem' cases. TB should be registered on SIM as the underlying cause of death or a contributing cause of death – recorded on Part I or Part II of Causes of death on the Death Certificate, using codes A15 to A19 of the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10).

The linked database (SIM + SINAN-TB), was provided by the Ministry of Health following a request made via the Electronic Citizens' Information System (e-SIC), on the website http://esic.cgu.gov.br/sistema/site/index.aspx (Protocol No. 25820.004488/2019-30, issued on June 6th 2019).

The variables of interest to the study were:

a) Individual characteristics
- Sex (male; female);
- Age group (years: 15-19; 20-39; 40-59; 60 or over);
- Schooling (years of study: none; 1-8; more than 8; unknown);
- Race/skin color (White; Black or brown; indigenous; unknown);
- Clinical form of tuberculosis (pulmonary [pulmonary; pulmonary + extrapulmonary]; extrapulmonary or NOS [without mention of bacteriological or histological confirmation]);
- Underlying cause of death (TB; AIDS; other);
- Presence (no; yes) of other diseases mentioned on the Death Certificate – selected chronic diseases (diabetes *mellitus* [E10-14], hypertension [I10-15], respiratory system diseases [J00-99], among others) and diseases most mentioned on post-mortem notifications.

b) Characteristics of municipality of residence
- Human development index (HDI-M) (low [below 0.6]; medium [0.6-0.7]; high [over 0.7]);
- Percentage poverty (low [below 10%]; medium [10-20%], high [20-45%]; very high [over 45%]). Percentage poverty was defined as the proportion of individuals with household per capita income equal to or less than BRL 140 a month in August 2010;
- Population size (number of inhabitants: small [under 20,000]; medium [20-100,000]; large [over 100,000]);
- Brazilian macro-region (North; Northeast; Southeast; South, Midwest);
- Municipality of residence (we described the ten municipalities with most cases of notification at post-mortem).

c) Characteristics of type of service
- Medical care for the disease that caused death (no; yes);
- Type of health service notifying death (public; private; non-profit; not specified);
- Family Health Strategy (FHS) coverage (low [up to 50%]; medium [50-75%]; high [over 75%]) in the municipality of residence;
- Primary Care (PC) coverage (low [up to 50%]; medium [50-75%]; high [over 75%]) in the municipality of residence.

The variables relating to the characteristics of the municipality of residence were obtained from the Brazilian Institute of Geography and Statistics (IBGE) and from the United Nations Development Program (UNDP) (2013), while the variables relating to health service characteristics were retrieved from Tabnet (e-Gestor).[6,14,15] All the other variables were retrieved from SIM.

The DCCI/MS technical team performed the probabilistic linkage using Reclink III free software,[16] applying a multiple-step routine in which each step used a given blocking key.[4] Probabilistic linkage includes a stage intended to standardize files for later use. The following stage, known as the linkage stage, is comprised of two processes, record blocking and record matching, which assist with optimizing the comparison process, dividing the databases into logic blocks, as well as building scores, according to the blocking strategy used. In this study, the linkage parameters were estimated by applying Expectation-Maximization (EM) algorithms. The final stage, data combination, involves the creation of a new file, based on two other files, whereby pairs considered to be "true" are identified according to the score defined, by matching the full name of the person, their mother's name and their date of birth. After each blocking stage, the data are reviewed manually. Doubtful records were classified as 'non-pairs'.

The absolute and relative frequencies of the variables of interest were described with the aid of the Stata version 11.0 and Microsoft Office Excel 2013 computer programs.

The study complied with the ethical principles for conducting research with human beings. As the study only used non-nominal secondary data available for public use, Research Ethics Committee approval was not necessary

Results

A total of 7,268 deaths mentioning TB in 2014 were identified (Figure 1). 4,447 TB cases were excluded because they had been notified before death on SINAN, as well as 59 cases under 15 years old and 59 cases with no information about sex (Figure 1). The post-mortem notifications (2,703) resulted from adding

together 2,506 (93%) cases recorded exclusively on SIM and 197 (7%) retrieved from SINAN-TB input as 'post-mortem'. TB as the underlying cause accounted for 64.9% of all deaths, while AIDS as the underlying cause accounted for 19.7%.

The majority of cases notified at post-mortem as having TB as the underlying cause were male (73.5%), over 39 years old (80.8%), with low schooling (8 years or less, 66.5%), of Black or brown race/skin color (62.8%) and with the pulmonary clinical form of infection (75.2%) (Table 1). Differently to the two other underlying causes highlighted by the study, the proportion of people coinfected with AIDS + TB (AIDS as the underlying cause of death) had 68.6% of males, 53.9% of people over 39 years old, 60.8% of people with low schooling and 57.2% of people with the pulmonary clinical form of TB (Table 1).

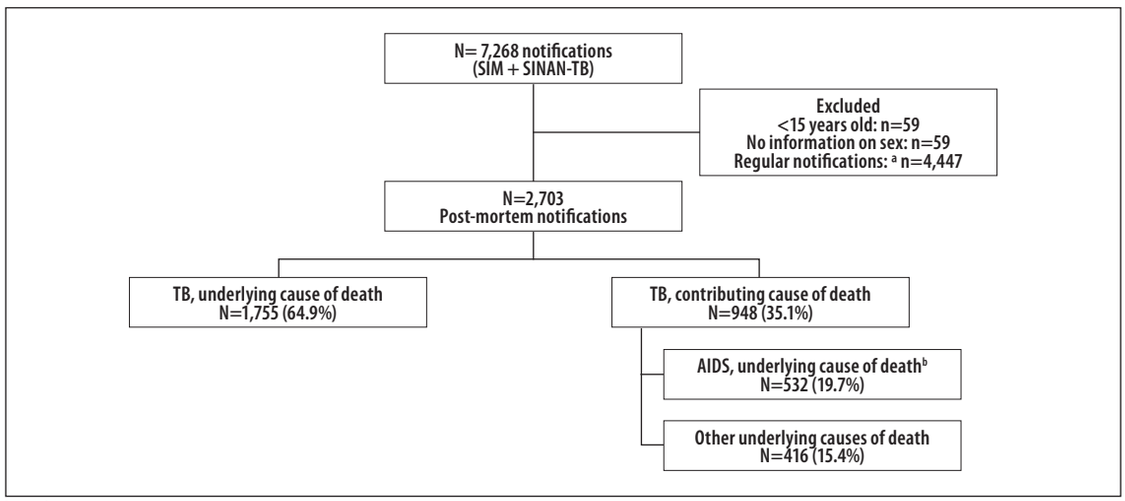
Deaths notified at post-mortem as having TB as the underlying cause mainly occurred among those living in municipalities with high HDI-M (66.6%), large population size (59.6%), low or medium percentage poverty (72.9%), located in the Southeast (46.4%) and Northeast (32.6%) regions of the country (Table 2).

Among the main contributing diseases, when TB was the underlying cause of death, we identified diseases of the respiratory system (52.7%), mental and behavioral disorders caused by used of psychoactive substances (10.0%), circulatory system diseases (8.9%), malnutrition (6.4%), diseases of the digestive system (5.1%), hypertension (4.4%), diabetes *mellitus* (4.0%) and diseases of the genitourinary system (3.9%) (Figure 2). Standing out among respiratory diseases were chronic diseases of the upper respiratory tract. When TB appeared as an associated cause, malignant neoplasms were among the most frequent underlying causes of death, although less frequent as associated causes (2.1%) (Figure 2).

For almost all the cases studied (>90%), it was not possible to identify whether the person had had access to medical care for the condition that resulted in death (Table 3). Cases cared for by the public health service accounted for over half the TB notifications at post-mortem, for all three groups of underlying causes of death (TB; AIDS; other). Finally, more than half the cases were notified in municipalities with low FHS coverage (54.2%), although they had medium (42.1%) or high (35.3%) PC coverage (Table 3).

Discussion

The study found a high number of TB cases identified as only being notified at post-mortem. These were recovered mainly from SIM and were therefore not included in the DCCI/MS official statistics. TB cases notified at post-mortem



Legend:
AIDS: Acquired Immunodeficiency Syndrome.
SIM: Mortality Information System.
SINAN-TB: Notifiable Health Conditions Information System – Tuberculosis.
TB: Tuberculosis.
a) Cases notified before death.
b) AIDS + TB coinfection.

Figure 1 – Flowchart for selection of tuberculosis cases notified at post-mortem, Brazil, 2014

Table 1 – Absolute and relative distribution of individual characteristics and clinical form of cases mentioning tuberculosis notified at post-mortem, by underlying cause, Brazil, 2014

Characteristics	TB, underlying cause of death	TB, contributing cause of death		Total
		Aids, underlying cause of death	Other underlying causes of death	
	N (%)	N (%)	N (%)	N
Sex				
Female	465 (26.5)	167 (31.4)	108 (25.9)	740
Male	1,290 (73.5)	365 (68.6)	308 (74.1)	1,963
Age group (years)				
15-20	19 (1.1)	3 (0.6)	6 (1.4)	28
20-39	317 (18.1)	242 (45.5)	63 (15.2)	622
40-59	676 (38.5)	250 (47.0)	154 (37.0)	1,080
≥60	743 (42.3)	37 (6.9)	193 (46.4)	973
Schooling (years of study)				
00	311 (17.7)	48 (9.1)	59 (14.2)	418
1-8	857 (48.8)	275 (51.7)	221 (53.1)	1,353
>8	212 (12.1)	101 (18.9)	56 (13.5)	369
Unknown	375 (21.4)	108 (20.3)	80 (19.2)	563
Race/skin color				
White	567 (32.3)	173 (32.5)	144 (34.6)	884
Black or brown	1,101 (62.8)	333 (62.6)	253 (60.8)	1,687
Indigenous	18 (1.0)	2 (0.4)	2 (0.5)	22
Unknown	69 (3.9)	24 (4.5)	17 (4.1)	110
Clinical form of tuberculosis				
Pulmonary	1,320 (75.2)	304 (57.2)	280 (67.3)	1,904
NOSa	259 (14.8)	115 (21.6)	100 (24.1)	474
Extrapulmonary	176 (10.0)	113 (21.2)	36 (8.6)	325
Total	**1,755 (100.0)**	**532 (100.0)**	**416 (100.0)**	**2,703**

Legend:
AIDS: Acquired Immunodeficiency Syndrome.
SIM: Mortality Information System.
TB: Tuberculosis.
a) NOS: clinical form of tuberculosis without mention of bacteriological or histological confirmation.

had TB and AIDS as the main underlying causes of death. Among the notifications of TB at post-mortem, we found higher proportions of people of the male sex, over 39 years old, with eight years schooling or less, of Black or brown race/skin color, with the pulmonary clinical form of TB and notified by the public health service. Moreover, their municipalities of residence had higher HDI-M, low poverty rates, large population size, low Family Health Strategy coverage and high or medium Primary Care coverage.

The proportion of AIDS + TB coinfection, whether as underlying cause or associated cause, corroborates previous studies, according to which AIDS appears as the second leading cause of death among all people with TB.[1,17] This result is of concern, given that the protocol adopted in Brazil recommends TB testing for all people with HIV and vice versa.[18]

A higher proportion of males was found among TB cases notified at post-mortem. It is known that men are more affected by TB and die more from this cause, when compared to women, which may be related to the fact of their using health services less, having lower adherence to treatment and having more risk factors, among other reasons.[1,19] Studies indicated that the male sex is also more subject to case underreporting. Pinheiro et al.[20] assessed TB underreporting in a municipality in the state of Rio de Janeiro and identified greater underreporting among the male population.

Greater frequency of people who were 60 years old or over was identified among the TB cases notified at post-mortem, when compared to the other age ranges. Many studies demonstrate that there tends to be higher TB incidence among people of productive age, pointing to greater effectiveness of guidelines on detection of cases in this age group.[4,17,21-23] However, the greater biological vulnerability of the elderly, especially related to the presence of other diseases, increases risk of death from

Table 2 – Absolute and relative distribution of characteristics of municipalities of residence of cases mentioning tuberculosis notified at post-mortem, by underlying cause, Brazil, 2014

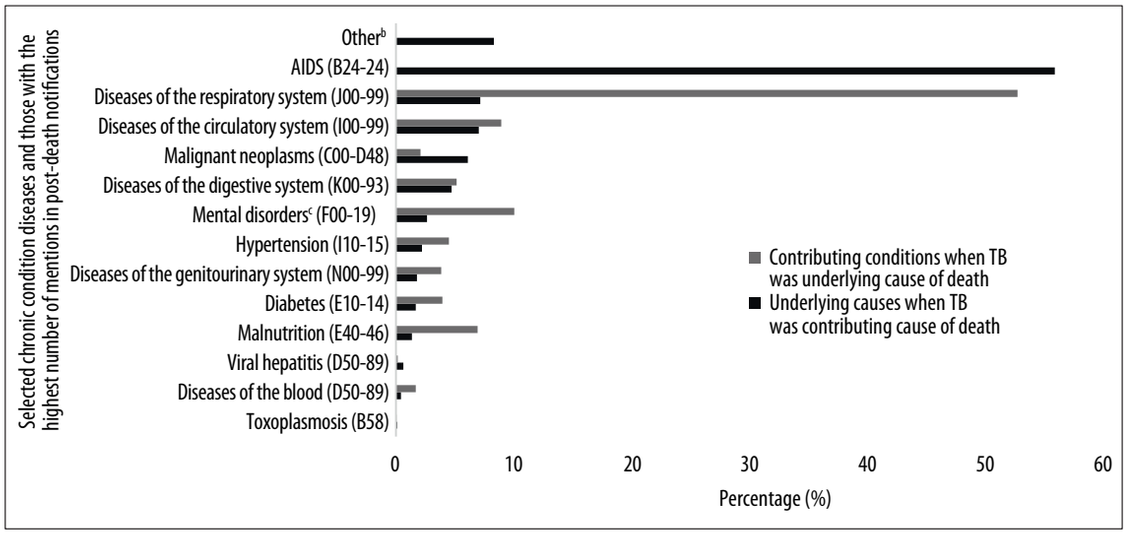
Characteristics	TB, underlying cause of death	TB, contributing cause of death		Total
		Aids, underlying cause of death	Other underlying causes of death	
	N (%)	N (%)	N (%)	N
HDI-M				
Unknown	21 (1.2)	6 (1.1)	2 (0.5)	29
Low (<0.6)	192 (10.9)	22 (4.2)	43 (10.3)	257
Medium (0.6-0.7)	373 (21.3)	105 (19.7)	70 (16.8)	548
High (>0.7)	1,169 (66.6)	399 (75.0)	301 (72.4)	1,869
Poverty (%)				
Unknown	21 (1.2)	6 (1.1)	2 (0.5)	29
Low (<10)	831 (47.4)	307 (57.7)	216 (51.9)	1,354
Medium (10-20)	448 (25.5)	142 (26.7)	108 (25.9)	698
High (20-45)	271 (15.4)	54 (10.2)	49 (11.8)	374
Very high (>45)	184 (10.5)	23 (4.3)	41 (9.9)	248
Population size (per 1,000 inhab.)				
Unknown	21 (1.2)	6 (1.1)	2 (0.5)	29
Small (<20,000)	268 (15.3)	46 (8.6)	61 (14.7)	375
Medium (20-100,000)	420 (23.9)	120 (22.6)	98 (23.5)	638
Large (>100,000)	1,046 (59.6)	360 (67.7)	255 (61.3)	1,661
Region of residence				
North	208 (11.8)	59 (11.1)	40 (9.6)	307
Northeast	572 (32.6)	121 (22.7)	147 (35.4)	840
Southeast	815 (46.4)	244 (45.9)	174 (41.8)	1,233
South	87 (5.0)	78 (14.7)	33 (7.9)	198
Midwest	73 (4.2)	30 (5.6)	22 (5.3)	125
Municipalities of residence				
Rio de Janeiro	199 (11.3)	54 (10.2)	41 (9.9)	294
São Paulo	144 (8.2)	31 (5.8)	25 (6.0)	200
Porto Alegre	–	7 (1.3)	5 (1.2)	12
Recife	21 (1.2)	9 (1.7)	4 (1.0)	34
Manaus	27 (1.5)	9 (1.7)	6 (1.4)	42
Salvador	43 (2.5)	16 (3.0)	15 (3.6)	74
Fortaleza	26 (1.5)	6 (1.1)	20 (4.8)	52
Belém	47 (2.7)	12 (2.3)	10 (2.4)	69
Other capitals/municipalities[a]	96 (5.5)	46 (8.6)	27 (6.5)	169
Other municipalities	1,152 (65.6)	342 (64.3)	263 (63.2)	1,757
Total	**1,755 (100.0)**	**532 (100.0)**	**416 (100.0)**	**2,703**

Legend:
AIDS: Acquired Immunodeficiency Syndrome.
HDI-M: municipal human development index.
TB: Tuberculosis.
a) Other municipalities which are also state capitals.

TB in this age group, conceals symptoms of the disease, reduces awareness of the need for early diagnosis and delays treatment, providing an opportunity for TB underreporting and notification only at post-mortem.

This study found that people of Black or brown race/skin color accounted for over 60% of all TB notifications at post-mortem. In addition to being the biggest ethnic/racial population group in Brazil, the Black or brown race/skin color variable also has important collinearity with schooling and income in Brazil and, therefore, is associated with the pattern of health service use.[6,24,25] People of Black or brown race/skin color are, therefore, more exposed to late diagnosis and treatment, as well as delayed notification of the disease. This result found by the study corroborates this hypotheses and highlights the barriers faced by this population to accessing quality health care in Brazil, one of the world's most unequal countries.[26]

The pulmonary clinical form of TB, which is the most frequent form in Brazil,[5] accounted for the greater part



a) Chronic diseases with greater frequency of notification at post-mortem were chosen.
b) Mortality due to: external causes, ill-defined diseases and unknown causes, and non-chronic diseases.
c) Mental and behavioral disorders due to use of psychoactive substances.
Legend:
AIDS: Acquired Immunodeficiency Syndrome.
TB: Tuberculosis.

Figure 2 – Distribution (%) of selected underlying and associated causes of death[a] of cases mentioning tuberculosis notified at post-mortem, Brazil, 2014

Table 3 – Absolute and relative distribution of health care and health service characteristics in the municipalities of residence de tuberculosis cases notified at post-mortem, by underlying cause, Brazil, 2014

Characteristics	TB, underlying cause of death	TB, contributing cause of death		Total
		Aids, underlying cause of death	Other underlying causes of death	
	N (%)	N (%)	N (%)	N
Individual level				
Medical care[a]				
Yes	68 (3.9)	13(2.4)	5(1.2)	86
No	23 (1.3)	3(0.6)	6(1.4)	32
Unknown	1,664 (94.8)	516(97)	405 (97.4)	2,585
Type of health service notifying death				
Public	1,011 (57.6)	364 (68.4)	204 (49.0)	1,579
Private	85 (4.8)	29 (5.4)	39 (9.4)	153
Non-profit	261 (14.9)	95 (17.9)	81 (19.5)	437
Unknown	398 (22.7)	44 (8.3)	92 (22.1)	534
Municipal level				
FHS coverage[b]				
Low (<50)	952 (54.2)	321 (60.3)	226 (54.3)	1,499
Medium (50-75)	324 (18.5)	91 (17.1)	61 (14.7)	476
High (>75)	479 (27.3)	120 (22.6)	129 (31.0)	728
PC coverage[c]				
Low (<50)	397 (22.6)	228 (42.9)	85 (20.4)	710
Medium (50-75)	739 (42.1)	165 (31.0)	170 (40.9)	1,074
High (>75)	619 (35.3)	139 (26.1)	161 (38.7)	919
Total	**1,755 (100.0)**	**532 (100.0)**	**416 (100.0)**	**2,703**

a) Medical care for the disease that led to death, as notified on Death Certificate.
b) FHS: Family Health Strategy.
c) PC: Primary Health Care.
Legend:
AIDS: Acquired Immunodeficiency Syndrome.
TB: Tuberculosis.

of cases notified at post-mortem. People with pulmonary TB notified only at post-mortem are a further cause of concern due to their potential for transmitting the disease, even though free accurate diagnostic tests and treatment are available nationwide to provide better prognosis than for other clinical forms.[27]

On the other hand, extrapulmonary TB cases were more frequent among people coinfected with HIV/AIDS. There is known to be strong association between extrapulmonary TB and HIV infection.[6,28] In general, it is harder to diagnose this clinical form of TB, even more so in people with HIV, and this favors underdetection of TB in this population and justifies, in part, the results found.

Municipalities with high HDI-M, large population size and low poverty rates, principally those located in the Southeast and Northeast regions, have large populations which explain the greater number of TB cases in all subcategories, including among cases notified at post-mortem.[6,29] It should be remembered that despite their high HDI-Ms, these large municipalities also have large social inequalities and a high level of vulnerable populations, contributing in particular to demands that are not met by health services and, consequently, greater possibility of cases being notified only at post-mortem.

In the population studied, when TB was an associated cause, the main underlying causes identified were AIDS, diseases of the respiratory system, circulatory diseases, malignant neoplasms, diseases of the digestive system, mental and behavioral disorders, hypertension and diabetes *mellitus*, in that order. It is important to note that this list contains diseases that require continuous care and monitoring by health professionals. These findings confirm those of the study conducted by Rocha et al.[17] when characterizing multiple causes of death among a cohort of notified cases, these authors found diseases similar to those mentioned above. This result allows one to infer that there are shortcomings in the comprehensiveness of care, as well as lost opportunities of diagnosing and managing TB cases and their contacts.

People cared for in public health services at the time of their death accounted for the largest proportion of post-mortem TB notification (whether or not TB was the underlying cause). This can be explained by the fact of the public service being free of charge and having national coverage, thus reaching the greater part of the population.[11] Moreover, people attended to in these services are, on average, more socially vulnerable, which may have contributed to the high proportion of TB cases notified only at post-mortem.

Cases resident in municipalities with low Family Health Strategy coverage and high or medium Primary Care coverage accounted for a high proportion of TB notification at post-mortem. This situation may reflect the population exposed to these coverage levels, given that larger municipalities tend to have lower coverage of this kind of health care, especially FHS. In addition, these results may reveal territories where the entry point to SUS does not effectively occur through Primary Health Care, thus compromising the order of care, as well as adequate TB management and surveillance. Strengthening Primary Care as a strategy for ordering health care will contribute to addressing the problem and, possibly, to reducing TB case underdetection and underreporting in the municipalities. Indeed, according to Rasella et al.,[30] municipalities with high FHS and PC coverage have better health indicators.

The main limitation of this study relates to the use of secondary data derived from the health surveillance system routine. Incomplete and inaccurate data and lack of standardization when filling in notification forms and Death Certificates, among other shortcomings, may favor information biases/errors. However, Brazil's SIM is recognized as a robust system, with coverage greater than 95% of estimated deaths.[29] Another limitation of the study lies in having considered as notifications at post-mortem all cases notified on SINAN with this classification and those notified exclusively on SIM, based on probabilistic matching. The process of linking the two information systems may have failed to identify all true pairs, resulting in incorrect classification of cases as being cases notified at post-mortem. This could have contributed to cases being overestimated. Finally, the study population may represent (i) individuals with adequate access to TB diagnosis and treatment, but underreported by SINAN, as well as (ii) individuals with no access to TB care. As such, a further limitation would be the difficulty in distinguishing between these different situations and gaining a better understanding of the findings described. However, the vulnerability profile of the people identified leads us to believe that the second situation is more probable.

The study characterized people for whom TB was notified at post-mortem in Brazil in 2014, their sociodemographic and clinical profile, the characteristics of their municipalities of residence and

other selected variables. Our hypothesis is that people notified only at post-mortem are underreported and, probably, underdetected TB cases, whether because of difficulty in diagnosing them, or because of difficulty in accessing health services. Be that as it may, these situations reveal a weakness in the quality of care received. Despite TB being a treatable and avoidable disease, in 2014, 2,703 people were diagnosed at post-mortem and, probably, their contacts were not reached by the surveillance services. This confers epidemiological relevance on the findings. It is possible that these cases reflect an important loss of opportunity on the part of the health system, given that a relevant part of the TB cases notified at post-mortem had at least one chronic condition which should have required continuous monitoring.

In conclusion and based on the results presented, there is a need to enhance TB surveillance in Brazil. It is important to encourage interest in studying risk factors associated with TB diagnosis and notification at post-mortem, with the aim of identifying how these subjects differ from those with regular notification. This type of approach can assist with the formulation of surveillance strategies and policies, with the aim of increasing timely identification of patients with tuberculosis.

Authors' contributions

Aridja UM and Duarte EC contributed to the study conception and design, analysis and interpretation of the results, drafting and critically reviewing the contents of the manuscript. Oliveira AFM, Silva AWM and Gallo LG contributing to drafting the text, interpreting the results, critically analyzing the intellectual content and reviewing the manuscript. All the authors have approved the final version of the manuscript and are responsible for all aspects thereof, including the guarantee of its accuracy and integrity.

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