Factors Associated with Tuberculosis Outcomes in Children Under 18 Years of Age, 2002-2022

Fatores Associados aos Desfechos da Tuberculose em Menores de 18 Anos, 2002-2022
Factores Asociados a los Resultados de la Tuberculosis en Menores de 18 Años, 2002-2022

RESUMO
Objetivo: Analisar os fatores associados aos desfechos de cura, interrupção do tratamento e óbito por tuberculose em menores de 18 anos no estado do Paraná, Brasil, entre 2002 e 2022. **Método:** Estudo transversal com dados do sistema de informações de agravos de notificação, incluindo 2.832 casos de tuberculose em menores de 18 anos. Foram realizadas análises descritivas, teste Qui-quadrado (p<0,05) e regressão logística multinomial. **Resultado:** Houve associação entre desfechos e faixa etária, raça e macrorregião, tipo de entrada, forma clínica, raio-X e baciloscopia. Diagnóstico na atenção primária, maior idade e residir em municípios de grande porte reduziram o risco para o óbito. Ausência de coinfecção pelo vírus da imunodeficiência humana, consumo de álcool e a realização das baciloscopias diminuíram desfechos negativos. A não realização do tratamento diretamente elevou a interrupção do tratamento. **Conclusão:** A tuberculose persiste entre crianças e adolescentes, exigindo fortalecimento da atenção primária à saúde.
DESCRITORES: Tuberculose; Atenção integral à saúde da criança e do adolescente; Epidemiologia; Estudos transversais; Enfermagem.

ABSTRACT
Objective: To analyze the factors associated with cure, treatment interruption, and death from tuberculosis in children under 18 years of age in the state of Paraná, Brazil, between 2002 and 2022 **Method:** A cross-sectional study was conducted using data from the Notifiable Diseases Information System. The study included 2,832 cases of tuberculosis in children under 18 years of age. Descriptive analyses, a chi-square test (p < 0.05), and a multinomial logistic regression analysis were performed. **Result:** There was a significant association between the outcomes and sociodemographic characteristics, such as age group, race, and macro-region of residence. Epidemiological variables, such as type of admission, clinical form, chest X-ray, and smear microscopy follow-up were also relevant. Diagnosis in primary care was associated with a lower likelihood of treatment interruption and death. Increasing age and residing in large municipalities reduced the risk of death. The absence of comorbidities such as HIV/AIDS and alcoholism, as well as adequate smear microscopy, reduced the likelihood of negative outcomes. Failure to undergo directly observed treatment increased the risk of treatment interruption. **Conclusion:** Tuberculosis persists among children and adolescents in Paraná, underscoring the importance of bolstering primary care.
DESCRIPTORS: Tuberculosis; Comprehensive health care; Epidemiology; Cross-sectional studies; Nursing.

RESUMEN
Objetivo: Analizar los factores asociados a los resultados de cura, interrupción del tratamiento y muerte por tuberculosis en menores de 18 años en el estado de Paraná, Brasil, entre 2002 y 2022. **Método:** Estudio transversal con datos del Sistema de Información de Agravios Notificables, que incluye 2832 casos de tuberculosis en menores de 18 años. Se hicieron análisis descriptivos, pruebas de chi cuadrado (p < 0,05) y regresión logística multinomial. **Resultado:** Se observó una asociación significativa entre los resultados y las características sociodemográficas, como el grupo de edad, la raza y la macrorregión de residencia. También fueron relevantes variables epidemiológicas como el tipo de ingreso, la forma clínica, la radiografía de tórax y el seguimiento de la baciloscopia. El diagnóstico en atención primaria se asoció con una menor probabilidad de interrupción del tratamiento y de muerte. El aumento de la edad redujo el riesgo de muerte, al igual que residir en municipios de gran tamaño. La ausencia

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de comorbilidades, como el VIH/sida y el alcoholismo, y la realización adecuada de baciloscopias redujeron las posibilidades de resultados negativos. La no realización del tratamiento directamente observado aumentó el riesgo de interrupción del tratamiento. **Conclusión:** La tuberculosis persiste entre los niños y adolescentes de Paraná, lo que destaca la importancia de fortalecer la atención primaria.
DESCRITORES: Tuberculosis; Atención integral de salud; Epidemiología; Estudios transversales; Enfermería.

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INTRODUCTION

Tuberculosis (TB), caused by Mycobacterium tuberculosis, remains one of the main global public health challenges, with a significant impact among children and adolescents, especially in contexts of poverty and social inequality[1,2]. Transmission occurs predominantly through the air, from contact with individuals with active TB who expel the bacteria; the disease can be prevented through control strategies, early diagnosis, and appropriate treatment[1].

According to the World Health Organization (WHO), in 2022, approximately 1.25 million children and adolescents under the age of 15 fell ill with TB worldwide, and approximately 200,000 died[2]. In Brazil, data from the Ministry of Health (MS) indicate a proportional increase in cases in children under 15, with 2,703 new cases registered in 2022, representing 3.5% of the total, with a worrying increase in children under five.

The diagnosis of TB in childhood presents challenges, since most cases are paucibacillary and have nonspecific clinical manifestations, making early identification difficult [4]. In adolescents, the picture is similar to that of adults, with greater potential for transmission. The age classification adopted by the Ministry of Health

follows that of the WHO, considering children up to nine years of age and adolescents from 10 to 19 years of age.

To address these challenges, Brazil has implemented the Healthy Brazil Program, which coordinates intersectoral actions for health promotion, prevention, diagnosis, and treatment of TB, with an emphasis on primary health care (PHC). The program's national guidelines include: strengthening epidemiological surveillance, expanding active screening for respiratory symptoms (RS), rapid testing, monitoring supervised treatment, integration with immunization, nutrition, and co-infection control actions, and promoting equity in access to health services[6]. These strategies are aligned with the national plan to end TB as a public health problem and with the Sustainable Development Goals (SDGs), aiming to eliminate TB, especially among vulnerable populations[1,2].

Despite advances, there are still gaps in knowledge about the factors associated with TB outcomes in children and adolescents, especially in regional contexts such as the state of Paraná. Investigating these aspects is essential to guide more effective interventions and contribute to disease control.

Given the above, this study aims to analyze the factors associated with cure, treatment interruption, and death from tuberculosis in children under 18 years of age in the state of Paraná, Brazil, between 2002 and 2022.

METHOD

Type of Study

This is an analytical and cross-sectional study, guided by the STrengthening the Reporting of Observational studies in Epidemiology (STROBE) tool.

Population and sample

The study population included all reported cases of TB in individuals aged 0 to 18 years, residing in the state of Paraná, registered in the Notifiable Diseases Information System (SINAN) between January 2002 and December 2022, according to the ICD-10 [9], totaling 3,583 notifications.9), totaling 3,583 notifications.

All confirmed cases of TB closed in SINAN as cured (2,572), treatment interruption "abandonment + primary abandonment" (231), and deaths from TB (29) were included, totaling 2,832 cases. Cases of people residing in other states (34), discarded cases (121), duplicates (20), cases with typing errors in essential data (34), deaths from other causes (67), transfers (292), drug-resistant tuberculosis (DR-TB) (23), change of regimen (4), treatment failure (1), and unknown closure situations (155).

Study location

The state of Paraná, located in southern Brazil, has 399 municipalities, covering an area of approximately 199,298 km² and an estimated population of 11,824,665 inhabitants, making it the fifth most populous state in the country.(8) Administratively, Paraná is divided into four macro-regional health areas, which are further subdivided into 22 regional health areas (RS)[9].

Data collection

The data were provided by the Paraná State Health Secretariat (SESA) using Microsoft Excel spreadsheet software (version 2016), referring to TB notifications from SINAN for the period proposed for this study. Data collection took place in April 2023. The analyses were performed using IBM Software Statistical Package for the Social Science (SPSS) for Windows, version 22®[10].

Using these sources of information, the sociodemographic profile of the region was analyzed, considering the following independent variables: year of notification (from 2002 to 2022), age group classification: newborn/neonate (0 to 28 days), infant (29 days to 1 year, 11 months, 29 days), preschool (2 to 4 years), school (5 to 10 years), and adolescent (11 to 18 years), sex (male and female), white and non-white race (black, yellow, brown, and indigenous), zone (urban and rural), macro-regional area of residence and institutionalized (non-institutionalized, prison, nursing home, orphanage, psychiatric hospital, and others) [11,12].

Regarding the epidemiological profile of clinical characteristics, the following variables were used : clinical form (pulmonary, extrapulmonary, and pulmonary + extrapulmonary), "type of admission" treatment (new case, recurrence, readmission after abandonment, unknown, transfer, and postmortem), chest X-ray (suspicious, normal, other pathology, and not performed), 1st and 2nd diagnostic smear microscopy (positive, negative, not performed, and not applicable), sputum culture (positive, negative, in progress, and not performed), smear microscopy follow-up (yes, no, and not applicable), and number of smear microscopy follow-ups (only one, two to three, four to six, not performed, and not applicable).

The dependent variables considered were case closure situations (cure, treatment interruption, and death from TB).

Descriptive analysis techniques using simple and relative frequencies were used to characterize the sociodemographic and epidemiological profile, follow-up, and case closure status. To verify the probability of the observed event occurring among the indicators of case closure status with sociodemographic, epidemiological, and follow-up variables, the Chi-square test was performed, considering a statistical significance level of 5%.

To identify the factors associated with treatment interruption and

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death outcomes in relation to cure, explanatory variables related to sociodemographic, clinical, and diagnostic characteristics and information about treatment follow-up were defined.

For this analysis, considering the nominal categorical characteristic of the dependent variable related to TB treatment outcomes, such as cure, treatment interruption, and death from TB, a multinomial logistic regression was defined, whose objective was to estimate the probability of each of the three closures as a function of the independent variables and express the results in terms of odds ratios (OR). To this end, the cure variable was considered the reference for comparison with the other two outcomes in question.

The strategy for constructing the multinomial logistic regression model is similar to that of binary logistics, in which the explanatory variables are initially evaluated univariately. When a p-value of less than 0.1 is presented, the variable is selected for the multivariate model. Next, all selected variables were introduced into the multivariate model, and the procedure of removing variables that did not have a p-value lower than 0.05 was adopted. Finally, these same variables were added again, one by one, to verify the best final model based on the lowest Akaike Information Criterion (AIC) value.

From the final model, which was considered the best possible for the study sample, McFadden's pseudo-coefficient of determination (pseudo-R2) was calculated, which considers the proportion of the total variation of the dependent variable explained by the regression model. This measure demonstrates the explanatory power of the model for the sample analyzed, i.e., an indicator of the quality of the final model.

For the analysis, a significance probability (p-value) of less than 0.05 was considered as the criterion for rejecting the null hypothesis. The analyses were performed using R software, version 4.3.1. The study was approved by the Human Research Ethics Committee of CAAE No. 24963319.1.0000.5393.

RESULTS

Between 2002 and 2022, 2,832 cases of TB in children under 18 years of age were reported in Paraná. Most cases occurred in male adolescents of white race, residing in urban areas in the eastern macro-region and not institutionalized. There was a statistically significant association ($p < 0.05$) between the outcome of the cases (cure, treatment interruption, and death from TB) and the variables age group ($p < 0.001$), race ($p = 0.023$), and macroregion of residence ($p < 0.001$) (Table 1).

Table 1. Distribution of sociodemographic characteristics in children under 18 years of age with tuberculosis associated with case closure status (cure, treatment interruption, and death from tuberculosis). Paraná, Brazil, 2002 to 2022

Sociodemographic variables	Cure	Treatment interruption	Death from tuberculosis	Total	p-value *
	n(%)	n(%)	n(%)	n(%)	
Age group classification (N=2832)					
Adolescent	1773(89,6)	188(9,5)	18(0,9)	1979(100,0)	<0,001
School	332(95,1)	15(4,3)	2(0,6)	349(100,0)	
Infant	241(93,1)	11(4,2)	7(2,7)	259(100,0)	
Preschool	198(93,4)	13(6,1)	1(0,5)	212(100,0)	
Newborn/Neonate	28(84,9)	4(12,1)	1(3,0)	33(100,0)	
Total	2572(90,8)	231(8,2)	29(1,0)	2832(100,0)	
Gender (N=2832)					
Male	1346(90,4)	131(8,8)	12(0,8)	1489(100,0)	0,212
Female	1226(91,3)	100(7,4)	17(1,3)	1343(100,0)	
Total	2572(91,0)	231(8,0)	29(1,0)	2832(100,0)	
Race (N=2635)					
White	1672(91,9)	128(7,1)	19(1,0)	1819(100,0)	0,023
Non-white	725(88,8)	83(10,2)	8(1,0)	816(100,0)	
Total	2397(91,0)	211(8,0)	27(1,0)	2635(100,0)	

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Zone (N=2801)					
Urban	2339(90,7)	212(8,2)	27(1,1)	2578(100,0)	0,584
Rural	206(92,4)	16(7,2)	1(0,4)	223(100,0)	
Total	2545(90,9)	228(8,0)	28(1,1)	2801(100,0)	
Macroregional health of residence (N=2810)					
East	1364(92,7)	90(6,1)	17(1,2)	1471(100,0)	<0,001
West	454(87,1)	63(12,1)	4(0,8)	521(100,0)	
North	402(87,4)	54(11,7)	4(0,9)	460(100,0)	
Northwest	334(93,3)	21(5,9)	3(0,8)	358(100,0)	
Total	2554(90,8)	228(8,1)	28(1,1)	2810(100,0)	
Institutionalized (N=2799)					
No	2479(90,8)	225(8,2)	27(1,0)	2731(100,0)	0,123
Prison	23(92,0)	1(4,0)	1(4,0)	25(100,0)	
Other	23(88,5)	3(11,5)	0(0,0)	26(100,0)	
Orphanage	7(77,8)	1(11,1)	1(11,1)	9(100,0)	
Psychiatric hospital	7(87,5)	1(12,5)	0(0,0)	8(100,0)	
Total	2539(90,7)	231(8,3)	29(1,0)	2799(100,0)	

* Chi-square test $p < 0.05$
Source: Prepared by the authors based on data from SINAN, 2025.

Table 2 shows that most TB cases were new cases, with pulmonary clinical form, suggestive chest X-ray, diagnostic 1st and 2nd smear tests , and no sputum culture performed. Regarding follow-up, there was a predominance of cases without follow-up smear tests and with fewer tests performed.

The Chi-square test analysis showed a statistically significant association ($p < 0.05$) between the closure status of cases (cure, treatment interruption, and death from TB) and the variables: type of admission ($p < 0.001$), clinical form ($p < 0.001$), chest X-ray ($p = 0.003$), 1st diagnostic smear microscopy ($p = 0.032$), smear microscopy follow-up ($p < 0.001$), and number of smear microscopy follow-ups ($p < 0.001$).

Table 2. Distribution of epidemiological and follow-up characteristics of tuberculosis cases in children under 18 years of age asso ciated with case closure (cure, treatment interruption, and death from tuberculosis). Paraná, Brazil, 2002 to 2022.

Epidemiological variables	Cure	Treatment interruption	Death from tuberculosis	Total	p-value *
	n=(%)	n=(%)	n(%)	n= (%)	
Treatment (Type of admission) (N=2832)					
New case	2336(92,3)	173(6,8)	21 (0,9)	253 (100,0)	<0,001
Transfer	105(86,1)	15(12,3)	2 (1,6)	122(100,0)	
Recurrence	44(84,6)	7(13,5)	1 (1,9)	52(100,0)	
Re-entry after dropping out	35(55,6)	28(44,4)	0 (0,0)	63(100,0)	
Don't know	15(83,3)	3(16,7)	0 (0,0)	18(100,0)	
Postmortem	0(0,0)	0(0,0)	1 (100,0)	1(100,0)	
Total	2535(91,0)	226(8,1)	25 (0,9)	2786(100,0)	
Clinical form (N=2786)					
Pulmonary	2027(90,8)	191(8,6)	14 (0,6)	2232(100,0)	0,001
Extrapulmonary	447(92,5)	31(6,4)	5 (1,0)	483(100,0)	
Pulmonary + extrapulmonary	61(85,9)	4(5,6)	6 (8,5)	71(100,0)	
Total	2535(91,0)	226(8,1)	25 (0,9)	2786(100,0)	

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Chest X-ray (N=2775)					
Suspicious	2081(91,4)	181(7,9)	17 (0,7)	2279(100,0)	0,003
Normal	228(95,0)	8(3,3)	4 (1,7)	240(100,0)	
Not performed	199(86,5)	28(12,2)	3 (1,3)	230(100,0)	
Other pathology	21(80,8)	4(15,4)	1 (3,8)	26(100,0)	
Total	2529(91,1)	221(8,0)	25 (0,9)	2775(100,0)	
1st diagnostic smear test (N=2832)					
Not performed	1032(92,4)	73(6,5)	12 (1,1)	1117 (100,0)	0,032
Positive	972(88,7)	113(10,3)	11 (1,0)	1096 (100,0)	
Negative	542(91,7)	44(7,4)	5 (0,8)	591(100,0)	
Not applicable	26(92,9)	1(3,6)	1 (3,6)	28(100,0)	
Total	2572(90,8)	231(8,2)	29 (1,0)	2832(100,0)	
2nd diagnostic smear test (N=1409)					
Not performed	737(91,1)	64(7,9)	8 (1,0)	809(100,0)	0,167
Positive	313(89,7)	32(9,2)	4 (1,1)	349(100,0)	
Negative	234(94,0)	12(4,8)	3 (1,2)	249(100,0)	
Not applicable	1(50,0)	1(50,0)	0 (0,0)	2 (100,0)	
Total	1285(91,2)	109(7,7)	15 (1,1)	1409(100,0)	
Sputum culture (N=2786)					
Not performed	1954(90,9)	176(8,2)	19 (0,9)	2149 (100,0)	0,726
Negative	289(92,9)	20(6,5)	2 (0,6)	311(100,0)	
Positive	270(89,1)	29(9,6)	4 (1,3)	303 (100,0)	
In progress	22(95,7)	1(4,3)	0 (0,0)	23(100,0)	
Total	2535(91,0)	226(8,1)	25 (0,9)	2786(100,0)	
Follow-up variables					
Smear microscopy follow-up (N=2832)					
No	1256(88,6)	142(10,0)	19 (1,4)	1417(100,0)	<0,001
Yes	1121(93,0)	78(6,5)	6 (0,5)	1205(100,0)	
Not applicable	195(92,9)	11(5,2)	4 (1,9)	210(100,0)	
Total	2572(90,8)	231(8,2)	29 (1,0)	2832 (100,0)	
Number of smear tests monitored (N=2832)					
Not performed	1256(88,6)	142(10,0)	19 (1,4)	1417(100,0)	<0,001
2 to 3 smear microscopy	500(93,1)	36(6,7)	1 (0,2)	537(100,0)	
4 to 6 smear microscopy	430(99,1)	4(0,9)	0 (0,0)	434(100,0)	
Not applicable	195(92,9)	11(5,2)	4 (1,9)	210(100,0)	
Only 1 smear test	191(81,6)	38(16,2)	5 (2,2)	234(100,0)	
Total	2572(90,8)	231(8,2)	29 (1,0)	2832(100,0)	

* Chi-square test $p < 0.05$
Source: Prepared by the authors based on data from SINAN, 2025.

In the multinomial logistic regression model, independent variables with a p-value < 0.1 were selected. In the multiple modeling, 18 variables were included, as shown in Table 3.

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Table 3. Variables selected for the multivariate model using univariate multinomial logistic regression

Independent variables	Variable selected for multiple model
Year of diagnosis	Not selected
Micro-region of notification	Not selected
Micro-region of residence	Not selected
Diagnostic unit	Not selected
Age	Selected
Gender	Not selected
Race/color	Selected
Education	Selected
City of residence	Selected
Area of residence	Not selected
Type of entry	Selected
Institutionalization	Not selected
X-ray exam result	Selected
Tuberculin test	Selected
Clinical form	Selected
Associated condition	Selected
AIDS*	Selected
Alcoholism	Selected
DM**	Selected
Mental illness	Selected
Illegal drugs	Selected
Sputum smear test result	Selected
Sputum culture result	Not selected
Histopathology result	Not selected
TDO***	Selected
Follow-up sputum smear microscopy	Selected
Number of follow-up sputum smears performed	Selected
PPL****	Not selected
PSR*****	Not selected
Healthcare professional	Not selected
Immigrant	Not selected
Beneficiary of government income redistribution policy	Not selected

Legend:*AIDS (Acquired Immune Deficiency Syndrome); ** DM (Diabetes Mellitus); ***TDO (Directly Observed Treatment); **** PPL (Population Deprived of Liberty); *****PSR (Homeless Population)
Source: Prepared by the authors based on data from SINAN, 2025.

The final multinomial logistic regression model, presented in Table 4, included 15 variables, of which 12 showed a significant association with treatment outcomes. A normal chest X-ray was associated with a higher chance of treatment discontinuation. It is noteworthy that diagnosis made in PHC or other services, compared to hospitals, was associated with a lower chance of treatment discontinuation and death. Age was a factor associated with an increased risk of death. Living in large municipalities was also associated with a lower risk of death.

The absence of associated conditions, such as alcoholism, was related to a lower chance of treatment interruption, and death and illicit drug use were related to a lower chance of

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treatment interruption. On the other hand, not performing TDO increased the risk of treatment interruption in children and adolescents. Performing two (02) to three (03) follow-up smear tests reduced the chances of treatment interruption and death, and four (04) to six (06) tests were a protective factor against death.

The final model had an AIC of 744.8 and a McFadden pseudo-R2of 0.34, meaning that the independent variables explained 34% of the variability in the treatment outcomes analyzed.

The lack of information on some variables, such as race/color and mental illness, influenced the results found for the outcomes. Finally, cases of extrapulmonary TB ( ) had a lower chance of treatment interruption compared to the pulmonary form.

Table 4. Final multinomial logistic regression model for outcomes cure, treatment interruption, and death from tuberculosis in children under 18 years of age. Paraná, Brazil, 2002 to 2022

Explanatory variable	Outcomes related to cure			
	OR treatment interruption	p-value	OR death	p-value
Diagnostic unit				
Hospital unit	-	-	-	-
APS*	0,1	<0,01*	0,21	<0,01*
Others	0,19	<0,01*	0,25	<0,01*
Age (in years)	1,02	0,503	0,93	<0,01*
Race/color				
White	-	-	-	-
Not white	1,19	0,715	0,99	0,977
No information	1,81	0,489	3,99	<0,01*
Size of municipality of residence				
Small	-	-	-	-
Medium	2,62	0,259	1,69	0,339
Large	1,25	0,644	0,44	0,01*
No information	7,59	0,136	0,8	0,85
X-ray results				
Suspicious	-	-	-	-
Normal	4,53	0,041*	1,83	0,179
Not realized	3,32	0,098	1,57	0,399
Other pathology or no information	2,6	0,42	1,38	0,667
Associated condition				
Yes	-	-	-	-
No	0,16	<0,01*	0,15	<0,01*
No information	0,38	0,392	0,11	<0,01*
AIDS				
Yes	-	-	-	-
No	21,2	0,91	0,63	0,425
No information	91,4	0,88	0,34	0,115
Alcoholism				
Yes	-	-	-	-
No	15,6	0,95	0,18	0,017*
No information	21,8	0,81	0,32	0,324

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Illegal drugs				
Yes	-	-	-	-
No	0,09	0,035*	0,6	0,686
Diabetes mellitus				
Yes	-	-	-	-
No	1,14	0,92	18,5	0,91
No information	0,9	0,987	46,1	0,88
Mental illness				
Yes	-	-	-	-
No	72,8	0,91	0,57	0,442
No information	20,4	0,92	0,06	0,002*
TDO				
Yes	-	-	-	-
No	4,13	0,021*	0,53	0,103
No information	2,54	0,115	0,89	0,752
Number of follow-up sputum smears performed				
Only 1 smear test	-	-	-	-
2 to 3 smears	0,04	0,006*	0,09	0,009*
4 to 6 smears	0,01	0,88	0,06	0,014*
Not performed, not applicable, no information	0,46	0,181	0,84	0,735
Tuberculin test				
Non-reactive	-	-	-	-
Weak or strong reactor	0,1	0,061	0,46	0,154
Not performed or no information available	1,28	0,737	1,66	0,235
Clinical form				
Pulmonary or Pulmonary + extrapulmonary	-	-	-	-
Extrapulmonary or no information	0,21	0,025*	1,32	0,467

Legend: *PHC (Primary Health Care); **AIDS (Acquired Immune Deficiency Syndrome); ***DOT (Directly Observed Treatment); AIC: 744.8. *significant value (p-value<0.05)
Source: Prepared by the authors based on data from SINAN, 2025

DISCUSSION

The results of this study highlight sociodemographic, clinical, and follow-up factors associated with cure, treatment interruption, and death from TB in children under 18 years of age in Paraná between 2002 and 2022. The findings corroborate national and international literature by pointing to the vulnerability of male adolescents, white race, and residents of urban areas, which are predominant among reported cases[2,3,14-16].

The significant association between age group, race, and macro-region of residence with TB outcomes highlights the importance of strategies targeting specific population subgroups. Studies indicate that adolescents are at greater risk of treatment interruption, possibly due to behavioral issues and difficulties in accessing health services [2,17].

The predominance of cases in urban areas may be related to higher population density and easier access to diagnosis, but it also reflects social inequalities present in these territories [3,4,18].

The data show that most cases were pulmonary, with diagnosis based on suggestive X-rays and smear tests, but with low rates of follow-up tests. The literature emphasizes that adequate monitoring through smear tests is essential to ensure adherence and therapeutic success, reducing the risk of resistance and death [2,4].

The low frequency of laboratory follow-up identified in this study points to weaknesses in the conduct of treatment, especially in children under 18 years of age, a group for which the collection of respiratory control samples is difficult to obtain

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and, therefore, rigorous follow-up is even more crucial [4,19,20].

Multivariate analysis identified that diagnosis made in PHC was associated with better outcomes, reinforcing the importance of strengthening PHC as the gateway and coordinator of care. The national literature highlights that PHC, when well structured, contributes to early detection, close monitoring, and reduced losses in the follow-up of pediatric cases. In addition, the role of nursing within PHC is fundamental in this scenario. These professionals play a crucial role in the detection, monitoring, and control of the disease, contributing significantly to good treatment outcomes over the years [4,17,21].

Another relevant finding was the association between the absence of conditions such as alcoholism and illicit drug use and better outcomes, which is consistent with studies that point to the negative impact of comorbidities on the progression of TB.2,4In addition, performing two or more follow-up smear tests was a protective factor against treatment interruption and death, highlighting the importance of continuous monitoring [22,23].

Finally, the lack of information on variables such as race/color and mental illness reinforces the need to improve data collection in health information systems, ensuring epidemiological surveillance and equity in access to treatment[2,4].

Therefore, the results of this study point to the need to strengthen primary care, improve laboratory follow-up, and enhance epidemiological surveillance to optimize TB treatment outcomes in children and adolescents, in line with the guidelines of the Healthy Brazil program and international recommendations.

This study has some limitations that should be considered when interpreting the results. As this is a cross-sectional study, it is not possible to establish causal relationships between the factors analyzed and TB treatment outcomes. The cross-sectional design is also subject to temporality bias, since exposure and outcome are assessed simultaneously. 24

In addition, the study was based on secondary data from SINAN, which are subject to possible inconsistencies, underreporting, and failure to fill in relevant variables, such as race/color and presence of comorbidities. The incompleteness and quality of the data may limit the accuracy of the analyses and influence the results, as pointed out in other studies using secondary databases.

Another limitation refers to the absence of detailed information on socio- factors, access to health services, and adherence to treatment, which could contribute to a more comprehensive understanding of the determinants of the outcomes analyzed[2].

Finally, the results should be generalized with caution, since the context of the state of Paraná may not reflect the reality of other regions of Brazil, especially those with different epidemiological and structural profiles of health services.

CONCLUSION

It is concluded that TB in children and adolescents aged 0 to 18 years remains an important public health challenge in the state of Paraná. This study identified and analyzed the factors associated with TB case outcomes: cure, treatment interruption, and death in this population over the last 20 years.

The results showed that sociodemographic characteristics (such as age group, race/color, and health macro-region) and epidemiological characteristics (type of admission, clinical form, chest X-ray, smear microscopy follow-up, and number of follow-up tests) significantly influence treatment outcomes. There was a predominance of cases among male adolescents of white race, residing in urban areas and, mainly, in the eastern macro-region of the state. There was a predominance of new cases of the pulmonary form of the disease.

It is noteworthy that children and adolescents diagnosed in PHC or other health services were less likely to discontinue treatment and die from TB, indicating the importance of access to these services and early diagnosis. On the other hand, age was a factor associated with an increased risk of death, while living in large municipalities was related to a reduced risk compared to small municipalities. In addition, the absence of comorbidities associated with TB contributed to better outcomes, with a lower probability of treatment interruption and death.

The study also identified that not performing TDO was y determining factor for an increased chance of treatment interruption among children and adolescents.

This study makes relevant contributions to the improvement of public health practices, especially in the context of combating TB in children and adolescents. The findings highlight the importance of strengthening PHC as a gateway and privileged space for early diagnosis and adequate follow-up of cases, which is directly related to better treatment outcomes. Investing in the training of PHC teams, actively seeking SR, and integrating surveillance and care actions are fundamental strategies for expanding access and the effectiveness of interventions.

It is worth noting that strengthening the nursing team in the control, prevention, and treatment of childhood TB is of great importance in PHC. In addition, the continuous training of these professionals is essential, as it ensures that they are always up to date and prepared to act

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effectively in combating this disease.

The identification of more vulnerable groups, such as male adolescents, white individuals, and residents of urban areas, allows for the targeting of specific actions, such as educational campaigns, closer monitoring, and psychosocial support, promoting equity in care. Furthermore, the identification of weaknesses in treatment monitoring, evidenced by the low rate of follow-up smear tests, indicates the need to improve collection, supervision, and recording routines, ensuring adherence and therapeutic success.

The integration of the actions proposed by the study with the Healthy Brazil program is essential, as this program aims to strengthen the Brazilian health system's response to communicable diseases, with an emphasis on promoting equity and reducing regional inequalities. The study results reinforce the relevance of the Healthy Brazil guidelines by pointing to the need for intersectoral interventions, qualified epidemiological surveillance, and public policies that ensure universal and comprehensive access to TB diagnosis and treatment, especially for vulnerable populations.

Finally, improving data collection and use in information systems is highlighted as a key element for planning, monitoring, and evaluating actions , contributing to more efficient and evidence-based management. Thus, the findings of this study support the development of more effective practices and policies, aligned with national and international recommendations, and contribute to advances in the control and elimination of TB as a public health problem in Brazil.

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