BMC Infectious Diseases

RESEARCH

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Factors associated with unsuccessful tuberculosis treatment outcome in children in four provinces of Mozambique: a retrospective cohort study, 2018–2021

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Abstract

Background Tuberculosis (TB) remains a significant global public health challenge. Childhood TB treatment outcomes in Mozambique remain poorly understood. This retrospective cohort study aims to identify factors associated with unsuccessful outcomes in children.

Methods We analysed children (0–14 years) treated for TB between 2018 and 2021 in 16 selected health facilities. Logistic regression was undertaken to identify factors associated with unsuccessful outcomes reported as Odds ratios (ORs) with 95% confidence intervals.

Results During the study period, a total of 1,421 children were included (211 in 2018, 380 in 2019, 600 in 2020 and 230 in 2021). Of these, 33.7% (479) were aged 0–4 years, 37.1% (527) 5–9 years, and 29.2% (415) 10–14 years. Females accounted for 50.3% (715), and 25.8% (367) were HIV positive. Pulmonary tuberculosis was the predominant form, representing 96.1% (1,366), while Extrapulmonary Tuberculosis (EPTB) comprised 3.9% (55). Unsuccessful outcome occurred in 5.6% (79) children. In multivariable regression model, several factors were independently associated with unsuccessful treatment outcome. Children aged 5–9 years had significantly lower odds of unsuccessful outcomes compared with those aged 0–4 years (model 1: aOR: 0.49 95% CI: 0.27–0.88; $p=0.017$ and model 2: aOR: 0.44 95% CI: 0.24–0.80; $p=0.007$). PTB was also associated with lower odds of unsuccessful outcome (model 1: aOR 0.33; 95% CI 0.14–0.78; $p=0.011$ and model 2: aOR 0.39; 95% CI 0.16–0.96; $p=0.039$). Compared to children treated in Maputo city, those in Maputo province (aOR 0.29; 95% CI 0.14–0.60; $p=0.01$), Nampula (aOR 0.16; 95% CI 0.07–0.36; $p<0.01$) and Zambézia (aOR 0.06; 95% CI 0.02–0.15; $p<0.01$) had significantly lower odds of an unsuccessful outcome.

Conclusions Young children and those with EPTB were associated with unsuccessful treatment. Provincial disparities suggest inequities in pediatric TB care. Strengthening prevention, early diagnosis, management in young children, and service equity are needed to improve outcomes.

Keywords Tuberculosis, Children, Treatment outcomes, Mozambique

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Introduction

Background

Tuberculosis remains a significant global health challenge, particularly in low and middle-income countries (LMICs), where resources for diagnosis and treatment are often limited. In 2024, TB was one of the top ten causes of mortality worldwide, with an estimated 10 million people falling ill with the disease and 1.23 million dying from it [1]. Among these, children accounted for a substantial portion of the cases (12%), with nearly 200,000 childhood deaths due to TB, highlighting the critical need to address TB in this vulnerable population [2, 3].

Mozambique, located in southern Africa, is one of the 30 high-burden TB countries, with an estimated incidence rate of 361 cases per 100,000 population [1]. The country also faces a high burden of HIV, with approximately 12.5% of adults aged 15–49 years old living with HIV, in addition to a significant burden of drug-resistant TB [1, 4, 5].

Paediatric TB presents unique challenges compared to TB in adults. Children often have paucibacillary disease, meaning they carry a lower bacillary load. As a result, diagnostic tests that detect TB bacilli tend to be less sensitive in children compared to adolescents and adults, leading to lower rates of bacteriological confirmation [6]. Additionally, young children struggle to produce sputum samples for TB testing. This, combined with the non-specific symptoms of TB in children, can result in delays, underdiagnosis and failure to treatment initiation [7, 8]. Furthermore, children are more likely to develop severe forms of TB, such as TB meningitis and miliary TB, which can be life-threatening if not diagnosed and treated promptly. Accurate and timely diagnosis of paediatric TB is critical to prevent morbidity and mortality [9–11]. However, diagnosing TB in children can be particularly challenging in resource-limited settings where access to diagnostic tools such as GeneXpert and chest radiography, as well as consumables for sample collection, may be restricted. Although no single clinical finding can confirm TB, certain clinical signs and symptoms are highly suggestive and can aid in decision-making, as TB diagnoses are frequently missed [12].

Despite the challenges, Mozambique has made considerable progress in the diagnosis and treatment of TB in children. In 2011, the country adopted the use of GeneXpert for TB diagnosis, which has improved the sensitivity and specificity of TB diagnosis compared to traditional methods such as smear microscopy [4, 13, 14]. Furthermore, the introduction of paediatric formulations for drug-sensitive TB (DS-TB) in 2015, can improve adherence and treatment outcomes among children [12].

According to Mozambique's guidelines, paediatric TB diagnosis is established through a standardized clinical algorithm or bacteriological confirmation. The clinical algorithm requires at least two symptoms such as prolonged cough, fever, weight loss, or fatigue, combined with recent TB contact. The presence of chest X-ray findings suggestive of TB further supports a clinical diagnosis. For bacteriological confirmation, Xpert MTB/RIF Ultra is the preferred test due to its superior sensitivity in paucibacillary samples. Where this technology is unavailable, smear microscopy is performed, with samples referred for molecular testing at the nearest facility [13].

All patients completing TB treatment in Mozambique are classified into standardized outcome categories following the WHO recommendations: "Cured" (bacteriological confirmation at diagnosis with subsequent negative results), "Treatment Completed" (finished without failure but lacking final bacteriological proof), "Treatment Failed" (persistently positive bacteriology after month 5, "Died" (patient who dies from any cause during the course of tuberculosis treatment) or "Lost to Follow-up" (treatment interruption ≥ 2 months). Treatment success is collectively defined as the combination of patients who are cured and those who have completed treatment [12, 13].

There are still gaps in the diagnosis and treatment of paediatric TB in Mozambique. Limited access to healthcare facilities, inadequate healthcare infrastructure, and a shortage of healthcare workers trained in TB prevention, diagnosis and management remain significant challenges. These challenges contribute to no diagnosis or delays in diagnosis, treatment initiation and its monitoring which can result in poor treatment outcomes and the development of drug-resistant TB strains [9, 15].

There is limited information on TB treatment outcomes in children [1]. In Mozambique, there is limited literature on the subject. A study conducted at the Hospital Carmelo, Gaza Province, using a cohort of children less than 15 years treated for drug-sensitive TB from 2006 to 2017, showed that 83.6% of children had a favourable outcome (cure or completed treatment). Predictors of unsuccessful outcomes included age under 5 years [16]. Another study in the Manhiça district, Maputo Province, in the period 2011–2012 involving 1957 patients (children and adults), revealed a different reality from that found in Gaza Province, with 73,8% of treatment success, 15.1% of children dying during treatment, 10% lost to follow-up, and 1.1% experiencing treatment failure. Factors associated with unsuccessful outcomes included HIV co-infection, female sex, and lack of bacteriological confirmation [17].

The geographical diversity of Mozambique, with its varying landscapes, climates, and population densities, presents unique challenges and opportunities for TB control and healthcare delivery. Understanding the TB burden and treatment outcomes in children in different regions of Mozambique is crucial for developing targeted

interventions and improving TB management nationwide. This retrospective cohort study aims (1) to describe the demographic characteristics and clinical profile of children treated for TB and (2) to analyse the treatment outcomes and identify factors associated with unsuccessful treatment outcomes among children with TB in Mozambique. By identifying these factors, we can inform policy and practice to improve the TB control strategies of paediatric TB and reduce the impact of the disease on children in Mozambique.

Methods

Study design and period

In this retrospective cohort study, we retrieved routinely collected data from selected health facilities across Mozambique for the period from 2018 to 2021.

Setting

The study was conducted in sixteen primaries public health facilities across four provinces of Mozambique: Maputo City and Maputo Province (southern region), Zambézia (central region), and Nampula (northern region). These provinces were selected to capture geographic diversity and variation in urban–rural contexts. Health facilities were non-randomly selected, using a convenience sampling approach based on the highest reported pediatric TB notification rates prior to the study period (between 2016 and 2017). Within each province, the two districts with the highest number of pediatric TB cases were identified using National TB Program (NTP) surveillance data. From each selected district, two primary public health facilities providing TB treatment services were included, resulting in a total of sixteen facilities.

In Mozambique, TB treatment and outcome recording are coordinated under the NTP and are primarily delivered in public health facilities. Non-public institutions, including private for-profit clinics, perform initial TB diagnosis but refer patients to public facilities for treatment registration and follow-up. Treatment outcomes are recorded within the NTP registry at the treating public facility. Because TB treatment and outcome classification follow standardized WHO definitions within the NTP, outcome reporting procedures were consistent across included facilities.

Participants/study population

The study included children aged 0–14 years who were initiated on TB treatment between 2018 and 2021. Patients with a confirmed TB diagnosis, based on either bacteriological confirmation (e.g., positive smear microscopy, culture, or molecular testing) or clinical criteria (e.g., symptoms, radiological findings, or histopathological evidence), were included. The study excluded children with DR-TB, incomplete medical records (defined as those with missing information on either the primary treatment outcome or the child age), had transferred to another health facility, or had been diagnosed with TB but had not initiated treatment.

Data sources and variables

Data were collected from medical records and national routine TB registers including demographic information (age, sex), clinical details (referral source, TB category, TB lesion localization, comorbidities, resistance profile), diagnostic test results (smear microscopy, GeneXpert, culture), radiological findings (X-ray), treatment details (regimen, duration), and treatment outcomes (cure, completion, death, loss to follow-up, treatment failure).

Treatment outcomes were categorized as successful (cured or treatment completion) and unsuccessful (lost to follow-up, death, treatment failure, transfer out) in alignment with WHO TB definition: "Cured" (bacteriological confirmation at diagnosis with subsequent negative results), "Treatment Completed" (finished without failure but lacking final bacteriological proof), "Treatment Failed" (persistently positive bacteriology after month 5), "Died," (patient who dies from any cause during the course of tuberculosis treatment), or "Lost to Follow-up" (treatment interruption ≥ 2 months). Treatment success was defined as the combination of patients who are cured and those who have completed treatment [12].

Bias

Medical records or data collection processes may be incomplete or inconsistent, especially if data are manually recorded. Missing or inaccurate data on treatment outcomes, diagnostic results, or patient characteristics could lead to misclassification or underreporting of cases.

Sample size

All eligible pediatric TB cases recorded in selected facilities during the study period were included. Because this was a retrospective analysis of routinely collected programmatic data, no a priori sample size calculation was performed.

Data collection

Data were retrieved from routinely collected records by trained research assistants using a standardized tool. All eligible pediatric TB records during the study period were abstracted. No quota sampling or case selection was applied.

Statistical methods/ data analysis

Descriptive statistics summarized frequencies of categorical variables, including age groups, sex, type of institution where the children were diagnosed, type of

TB (pulmonary or extrapulmonary), HIV status, and treatment outcomes. Chi-square or Fisher's exact tests were used to analyse differences in TB case distribution, TB type, HIV status, diagnostic methods, and treatment outcomes. To identify factors associated with unsuccessful treatment outcomes, we performed univariate and multivariable logistic regression analyses. The model included variables such as sex, age, institution type, TB type, HIV status, and diagnostic results. Variables with a p-value < 0.20 in univariate analysis, as well as clinically relevant variables (age and sex), were included in the multivariable logistic regression model. The final model included sex, age group, type of institution at diagnosis (public vs. non-public), TB type (pulmonary vs. extrapulmonary), HIV status, previous treatment status, and province. We estimated both crude and adjusted odds ratios (ORs) with their respective 95% confidence intervals (CIs). For all statistical tests we used a 5% significance level. Data were entered using Excel and analysed using *SPSS software version 28.0.*

Ethics statement

Ethical approval for this study was obtained from the National Bioethics Committee for Health, Mozambique (CNBS), IRB00002657, on July 1, 2021 (Reference: 388/NBS/21). Informed consent was not required as the study involved secondary analysis of existing data collected during routine medical care. No direct interaction occurred with the participants, and data extraction was performed on de-identified records. Each patient was assigned a unique study ID. To ensure confidentiality, participant names were excluded from the data sheet. Information obtained from the study participants data is kept confidential. The study adhered to the principles of the Declaration of Helsinki.

Results

Study population

A total of 1,453 eligible children under the age of 15 years, who were receiving treatment for all forms of tuberculosis, were identified across 16 health facilities. From this initial cohort, we excluded children with drug-resistant TB ($n = 6$), as their treatment regimens and follow-up modalities differ substantially from those with drug-susceptible TB, which could introduce clinical heterogeneity and bias in the analysis of treatment outcomes. We also excluded children with unevaluable treatment outcomes ($n = 26$), defined as those who were transferred out, had an unknown outcome, or for whom outcome data were missing from medical records. After applying these exclusion criteria, a total of **1,421** children were included in the final descriptive analysis (Fig. 1). This cohort represents the study population for whom complete data were available to assess factors associated with unsuccessful TB treatment outcomes.

Demographic and clinical characteristics

Among the total of 1,421 children, 33.7% (479) were aged 0–4 years, 37.1% (527) 5–9 years, and 29.2% (415) 10–14 years. Females accounted for 50.3% (715). Regarding geographic origin, the majority of children came from Zambézia province, representing 36.8% (523). In terms of place of diagnosis 70.3% (999) were initially diagnosed in public health facilities, while the remaining 29.7% (422**)** were referred from the private sector.

Most cases were new diagnoses, accounting for 97.4% (1,384) of the study population. HIV testing was positive in 25.8% (367) and was not performed in 1.1% (16). Among those who tested positive for HIV, 95.1% (349) initiated antiretroviral therapy (ART). Regarding TB laboratory investigation, among the 1,421 children included

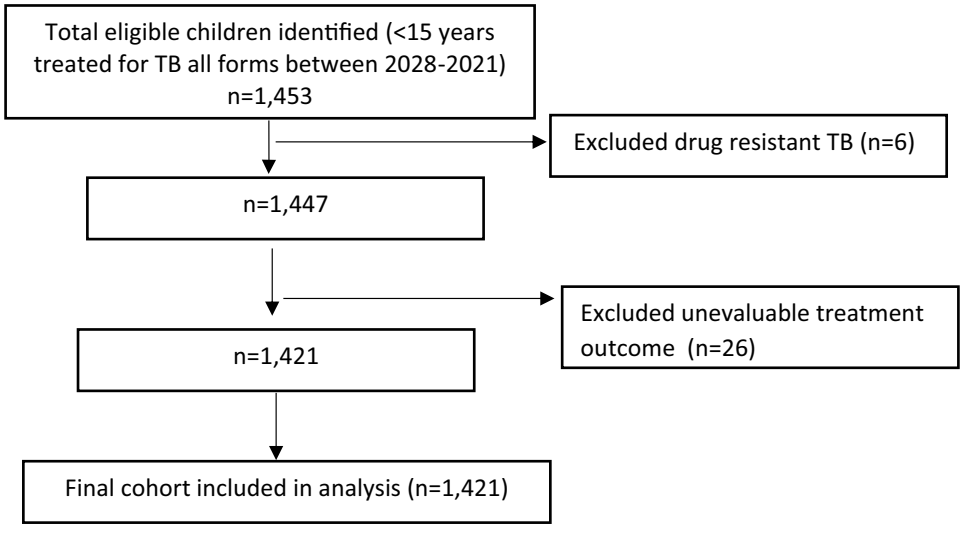

Fig. 1 Pediatric TB case selection flowchart

in the final analysis, only 479 (33.7%) underwent bacteriological testing for TB confirmation. Of these, 263 were tested using Xpert MTB-RIF and 216 using microscopy. The remaining 942 children (66.3%) did not have a laboratory confirmation recorded.

Chest X-ray was performed in only 78 children (5.5%). The majority of cases were diagnosed clinically (90.4%, $n = 1{,}284$), while 9.6% (137) were bacteriologically confirmed. Bacteriological confirmation was more frequent among children aged 5–14 years (Table 1).

Pulmonary tuberculosis was the predominant form, accounting for 96.1% (1,366). Among the extrapulmonary TB cases, lymphadenitis was the most frequent presentation accounting for 44.6% (25). Other EPTB forms included abdominal (10.7%, $n = 6$), pleural (7.1%, $n = 4$), and bone (5.4%, $n = 3$). Meningeal, pericardial, peritoneal, and vertebral TB each accounted for 1.7% of EPTB

Table 1 Demographic and clinical characteristics of children with TB

Characteristic	Total ($N = 1{,}421$)	(%)	0–4 years ($n = 479$)	(%)	5–9 years ($n = 527$)	(%)	10–14 years ($n = 415$)	(%)
Sex								
Male	704	(49.5)	237	(49.5)	276	(52.4)	191	(46.0)
Female	715	(50.3)	242	(50.5)	251	(47.6)	222	(53.5)
Missing	2	(0.1)					2	(0.5)
Province								
Maputo City	228	(16.0)	55	(11.5)	87	(16.5)	86	(20.7)
Maputo Province	371	(26.1)	121	(25.3)	140	(26.6)	110	(26.5)
Nampula	299	(21.0)	96	(20.0)	120	(22.8)	83	(20.0)
Zambezia	523	(36.8)	207	(43.2)	180	(34.2)	136	(32.8)
TB Location								
Pulmonary TB	1366	(96.1)	472	(98.5)	502	(95.3)	392	(94.5)
Extrapulmonary TB	55	(3.9)	7	(1.5)	25	(4.7)	23	(5.5)
TB classification								
New cases	1384	(97.4)	476	(99.4)	512	(97.2)	396	(95.4)
Previously treated	37	(2.6)	3	(0.6)	15	(2.8)	19	(4.6)
Institution of diagnosis								
Public	999	(70.3)	367	(76.6)	374	(71.0)	258	(62.2)
Non-public (Private)	422	(29.7)	112	(23.4)	153	(29.0)	157	(37.8)
HIV status								
Negative	1038	(73.0)	391	(81.6)	378	(71.7)	269	(64.8)
Positive	367	(25.8)	81	(16.9)	142	(26.9)	144	(34.7)
Not done	16	(1.1)	7	(1.5)	7	(1.3)	2	(0.5)
HIV positive on ART								
No	9	(2.5)	4	(4.9)	3	(2.1)	2	(1.4)
Yes	349	(95.1)	74	(91.4)	137	(96.5)	138	(95.8)
Missing	9	(2.5)	3	(3.7)	2	(1.4)	4	(2.8)
TB test								
Smear microscopy	216	(15.2)	45	(9.4)	65	(12.3)	106	(25.5)
Xpert MTB RIF	263	(18.5)	40	(8.4)	112	(21.3)	111	(26.7)
Not done	942	(66.3)	394	(82.3)	350	(66.4)	198	(47.7)
TB test results ($n = 479$)								
MTB Detected	329	(68.7)	72	(84.7)	129	(72.9)	128	(59.0)
MTB not detected	137	(28.6)	11	(12.9)	42	(23.7)	84	(38.7)
Missing	13	(2.7)	2	(2.4)	6	(3.4)	5	(2.3)
Type of diagnosis								
Bacteriologically confirmed	329	(23.2)	72	(15.0)	129	(24.5)	128	(30.8)
Clinically diagnosed	1092	(76.8)	407	(85.0)	398	(75.5)	287	(69.2)
Chest X-ray results								
Not suggestive	3	(0.2)	1	(0.2)	1	(0.2)	1	(0.2)
Suggestive of TB	75	(5.3)	28	(5.8)	31	(5.9)	16	(3.9)
Not done	1343	(94.5)	450	(93.9)	495	(93.9)	398	(95.9)

Abbreviation: ARV: antiretroviral treatment, PTB: pulmonary tuberculosis; EPTB: extrapulmonary tuberculosis

Table 2 Location of extrapulmonary tuberculosis

	Total		0–4 years		5–14 years	
	n	**(%)**	***n***	**(%)**	***n***	**(%)**
Lymph node	25	(45.5)	6	(85.7)	19	(39.6)
Abdominal	6	(10.9)	1	(14.3)	5	(10.4)
Pleural	4	(7.3)	0	(0.0)	4	(8.3)
Bone	3	(5.5)	0	(0.0)	3	(6.3)
Meningeal	1	(1.8)	0	(0.0)	1	(2.1)
Pericardial	1	(1.8)	0	(0.0)	1	(2.1)
Peritoneal	1	(1.8)	0	(0.0)	1	(2.1)
Vertebral	1	(1.8)	0	(0.0)	1	(2.1)
Missing	13	(23.6)	0	(0.0)	13	(27.1)
Total	55	(100.0)	7	(100.0)	48	(100.0)

Table 3 Treatment outcomes by age groups

Outcome (*n* = 1421)	**Total**		**0–4 Years old**		**5–9 Years old**		**10–14 Years old**		***P* value**
		(%)	***n* = 479**	**(%)**	***n* = 527**	**(%)**	***n* = 415**	**(%)**	
Cure or completion	1342*	(94.4)	447	(93.3)	507	(96.2)	388	(93.5)	0.083
LFU	40	(2.8)	19	(4.0)	10	(1.9)	11	(2.7)	0.136
Death	26	(1.8)	7	(1.5)	6	(1.1)	13	(3.1)	0.058
Treatment failure	13	(0.9)	6	(1.3)	4	(0.8)	3	(0.7)	0.634

*Total Cured = 74 (5,2%); Completed treatment = 1268 (88.2%);

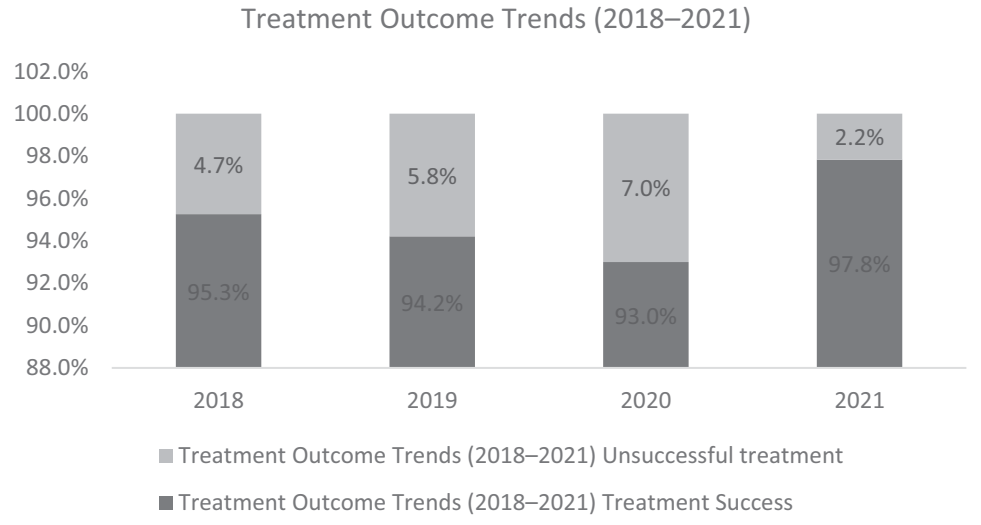

Fig. 2 Trend in TB treatment outcome, 2018–2021

cases. Data on the specific anatomical site was missing for 23.6% (13) of EPTB cases (Table 2).

Treatment outcomes of children with TB

Among the 1,421 children included, 5.2% (74) were cured and 89.2% (1,268) completed treatment, resulting in an overall treatment success rate (cure and treatment completion) of 94.4% (1,342). Unsuccessful outcomes occurred in 5.6% (79) children. Among those with unsuccessful treatment, loss to follow-up (LFU) accounted for 2.8% (40), death 1.8% (26) and treatment failure 0.9% (13). To assess the strength of these associations, we used the chi-square test. There were no significant differences in the treatment outcomes rates between the age groups (Table 3).

Treatment outcomes remained consistently high throughout the study period, with success rates remaining above 90% from 2018 to 2021 (Fig. 2).

Unsuccessful treatment outcome differed across provinces, with 6.2% (23) in Maputo Province, 1.5% (8) in Zambézia, 3.3% (10) in Nampula and 16.7% (38) in Maputo City (Table 4).

Table 4 Treatment outcomes by provinces

Treatment outcome	Maputo		Zambézia		Nampula		Maputo City	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Success	348	(93.8)	515	(98.5)	289	(96.7)	190	(83.3)
Unsuccessful	23	(6.2)	8	(1.5)	10	(3.3)	38	(16.7)

Table 5 Factors associated with unsuccessful TB treatment in children

Variable	Crude OR (95% CI)	*p*-value	Adjusted OR Model 1* (95% CI)	*p*-value	Adjusted OR Model 2† (95% CI)	*p*-value
Sex (Female vs. male)						
Male	0.84 (0.53–1.33)	0.460	0.84 (0.52–1.33)	0.450	0.89 (0.55–1.44)	0.633
Age group (0–4 years vs. 5–9 years; 0–4 years vs. 10–14 years)						
5–9 years	0.55 (0.31–0.98)	0.041	0.49 (0.27–0.88)	**0.017**	0.44 (0.24–0.80)	**0.007**
10–14 years	0.97 (0.57–1.65)	0.917	0.74 (0.42–1.30)	0.296	0.65 (0.36–1.17)	0.152
HIV status (Negative vs. positive)						
Positive	1.45 (0.89–2.35)	0.138	1.57 (0.95–2.59)	0.079	1.12 (0.65–1.91)	0.686
Institution of diagnosis (Private sector vs. public)						
Public health facility	0.48 (0.30–0.76)	0.002	0.44 (0.27–0.71)	**0.001**	1.18 (0.61–2.30)	0.624
Localization (EPTB vs. PTB)						
Pulmonary TB	0.38 (0.17–0.87)	0.023	0.33 (0.14–0.78)	**0.011**	0.39 (0.16–0.96)	**0.039**
Province (Maputo City vs. other provinces)						
Maputo	0.33 (0.19–0.57)	< 0.001	–	–	0.29 (0.14–0.60)	**0.001**
Nampula	0.17 (0.08–0.36)	< 0.001	–	–	0.16 (0.07–0.36)	**< 0.001**
Zambézia	0.08 (0.04–0.17)	< 0.001	–	–	0.06 (0.02–0.15)	**< 0.001**

In bold p-value < 0.05

Factors associated with unsuccessful treatment

Bivariate analysis

In the bivariate logistic regression analysis, age group, TB type, HIV status, TB classification, institution of diagnosis, and province were associated with unsuccessful treatment outcomes at a significance level of $p < 0.20$ and were therefore included in the multivariable model.

Multivariable analysis

In multivariable regression model, several factors were independently associated with unsuccessful treatment outcomes. Two multivariable logistic regression models were fitted (Table 5). Model 1 included demographic and clinical variables without adjusting for province. In this model, children aged 5–9 years had significantly lower odds of unsuccessful outcomes compared with those aged 0–4 years (aOR: 0.49 95% CI: 0.27–0.88; $p = 0.017$). Diagnosis public institutions had significantly lower odds of unsuccessful outcomes (aOR 0.44; 95% CI 0.27–0.71; $p = 0.001$). In addition, children with pulmonary TB had lower odds of unsuccessful outcome (aOR 0.33; 95% CI 0.14–0.78; $p = 0.011$).

Model 2 included demographic and clinical variables adjusting for province. After this adjustment, children aged 5–9 years had significantly lower odds of unsuccessful outcomes compared with those aged 0–4 years (aOR: 0.44 95% CI: 0.24–0.80; $p = 0.007$). PTB was also associated with lower odds of unsuccessful outcome (aOR 0.39; 95% CI 0.16–0.96; $p = 0.039$).

Furthermore, compared to children treated in Maputo city, those in Maputo province (aOR 0.29; 95% CI 0.14–0.60; $p = 0.01$), Nampula (aOR 0.16; 95% CI 0.07–0.36; $p < 0.01$) and Zambézia (aOR 0.06; 95% CI 0.02–0.15; $p < 0.01$) had significantly lower odds of an unsuccessful outcome.

Discussion

This multicenter retrospective cohort study evaluated factors associated with tuberculosis treatment outcomes among children using routinely collected programmatic data. The study found a high overall treatment success rate of 94.4%, exceeding the WHO-recommended threshold of 90% [12] and aligning with the national treatment success rate (for all ages), which is also above 90% [18]. The overall treatment success rate observed in our study is higher than those reported in earlier regional studies from Maputo and Gaza provinces that reported success rates of 71.2% and 83.6%, respectively [16, 19]. This difference may reflect variations in study populations, time periods, health system contexts, or geographic coverage, rather than a direct indication of national progress over time. Our findings should therefore be interpreted within the context of the selected high-incidence facilities included in this study.

Furthermore, Mozambique's performance compares favorably with rates reported in other sub-Saharan African countries, including Ghana, Botswana, and Ethiopia, where pediatric TB treatment success rates range from

78.9% to 93.1% [16, 20–22]. This suggests that Mozambique has made notable strides in enhancing the management of pediatric TB, marking a positive shift in national TB control efforts.

Despite this encouraging overall performance, our findings reveal a small but important proportion of children (5.6%) experienced unsuccessful outcomes. The rate of unsuccessful treatment outcome was 2.8% for loss to follow-up, 1.8% for death, and 0,9% for treatment failure, which is consistent with the recommended WHO threshold of < 5% [12]. These findings are comparable to those reported in a study conducted in Cameroon, which documented a loss to follow-up rate of 2.4% and a mortality rate of 1% [10]. However, other studies have reported divergent results. For instance, a study in Pakistan reported a mortality rate of 1.6% alongside a loss to follow-up rate of 9.3% [23], while data from Zambia indicated a mortality rate of 9.2% and a loss to follow-up rate of 1.5% [24].

A key finding of our study was the identification of factors associated with unsuccessful treatment outcomes. First, children aged 5–9 years had significantly lower odds of unsuccessful outcomes compared with those aged 0–4 years (model 1: aOR: 0.49 95% CI: 0.27–0.88; $p = 0.017$ and model 2: aOR: 0.44 95% CI: 0.24–0.80; $p = 0.007$). This observation is consistent with previous studies [11, 23, 25]. Several interrelated factors likely contribute to this increased risk. Biologically, their immature immune systems render them less capable of containing *Mycobacterium tuberculosis* infection, leading to higher rates of severe and disseminated disease [8, 10, 26]. Compounding this vulnerability are the well-documented diagnostic challenges in this age group. Young children often present with non-specific symptoms that mimic common childhood illnesses, and they experience difficulties producing sputum for bacteriological confirmation [10, 26]. This non-specificity in clinical presentation can result in diagnostic delays, late initiation of treatment, and more advanced disease at presentation, all of which contribute to the higher risk of unsuccessful outcomes observed in this age group [8, 26].

Second, children with PTB were also associated with lower odds of unsuccessful outcome (model 1: aOR 0.33; 95% CI 0.14–0.78; $p = 0.011$ and model 2: aOR 0.39; 95% CI 0.16–0.96; $p = 0.039$). This finding aligns with research from other African settings, where EPTB in children is associated with higher mortality and loss to follow-up [20].

In the unadjusted analysis, children diagnosed in public institutions appeared to have lower odds of unsuccessful treatment outcomes. However, this association disappeared after adjustment for province, suggesting that the initial finding was likely confounded by geographic differences in health service utilization and programmatic conditions. Further examination of the data showed that diagnoses in non-public institutions were disproportionately concentrated in Maputo City. Because Maputo City also exhibited higher proportions of unsuccessful outcomes, the apparent institutional effect observed in the unadjusted analysis was likely driven by geographic variation rather than by the type of diagnosing institution itself. This finding highlights the importance of accounting for contextual factors such as regional differences in health system organization, patient pathways, and access to care when interpreting programmatic data.

The most striking disparities, however, were geographic. The strong association between province and treatment outcomes suggests that geographic disparities may play an important role in pediatric TB outcomes in Mozambique. Compared to Maputo City, children treated in Maputo Province (aOR: 0.29; 95% CI: 0.14–0.60), Nampula (aOR: 0.16; 95% CI: 0.07–0.36), and Zambezia (aOR: 0.06; 95% CI: 0.02–0.15) had significantly lower odds of unsuccessful outcomes. This finding is counterintuitive, as Maputo City, the capital, typically has better access to specialized pediatric care and diagnostic infrastructure. Several factors could contribute to these differences, including variations in health system capacity, referral pathways, diagnostic practices, and follow-up mechanisms. Urban settings such as Maputo City may also experience more complex patient flows, including referrals between public and private providers, which could influence treatment continuity and outcome reporting [27–29]. Further research is needed to understand the underlying drivers of these geographic disparities. Understanding the specific drivers of these geographic differences will be important for improving pediatric TB care and ensuring equitable treatment outcomes across the country. Therefore, the higher odds of unsuccessful outcomes in Maputo should be interpreted cautiously, as they likely represent a combination of referral patterns, disease severity, and unmeasured social or health-system determinants, rather than poorer quality of TB care alone.

Contrary to previous studies in Mozambique and other countries as South Africa, Botswana, Ethiopia, Cameroon, Zambia and Pakistan we did not find male sex, recurrent TB, or HIV co-infection to be significantly associated with unsuccessful outcomes [10, 11, 20–22, 30]. This may reflect improvements in HIV care and integration of TB/HIV services in Mozambique, including expanded access to antiretroviral therapy for children living with HIV [5, 18]. Continued strengthening of integrated TB/HIV services remains essential to sustain these gains.

Limitation

This study has several important limitations. First, its retrospective design, reliant on existing medical records, inherently carries risks of information bias due to incomplete or inconsistent documentation. For instance, treatment outcomes may have been affected by underreporting or misclassification, and critical social determinants of health such as household socioeconomic status, parental education, nutritional status, and comorbidities were not systematically recorded for analysis.

Finally, the observational nature of this analysis precludes the establishment of causality; it can only identify associations between risk factors and outcomes. Future prospective studies designed to systematically collect detailed clinical, social, and behavioral data are needed to confirm these associations and provide a more comprehensive understanding of the drivers behind pediatric TB treatment outcomes in Mozambique.

Conclusions

In conclusion, our findings have important implications for policy and practice. The high overall treatment success rate is commendable and suggests that Mozambique's National TB Programme is making progress toward global targets. However, the persistent disparities by age, clinical presentation, and geography indicate that additional efforts are needed to ensure equitable access to high childhood TB quality care. Specifically, interventions should focus on: (1) strengthening prevention, early case finding and diagnostic capacity for TB in young children and those with EPTB; (2) enhancing treatment support mechanisms for younger children and their caregivers; and (3) investigating and addressing the specific barriers to successful treatment outcomes in Maputo City and other high-risk areas. By targeting these high-risk groups and addressing geographic inequities, Mozambique can build on its recent successes and move closer to eliminating TB among children.

Abbreviations

DS-TB	Drug-sensitive TB
EPTB	Extrapulmonary Tuberculosis
HIV	Human Immunodeficiency Virus
MDR-TB	Multi-Drug-Resistant Tuberculosis
ODs	Odds ratios
PTB	Pulmonary Tuberculosis
TB	Tuberculosis
WHO	World Health Organization

Acknowledgements

This study was partially funded by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., under the R&D unit Global Health and Tropical Medicine (UID/04413/2025) and the Associated Laboratory in Translation and Innovation Towards Global Health REAL (LA/P/0117/2020). We extend our sincere gratitude to the dedicated staff who made this work possible. The findings and conclusions expressed in this article are solely those of the authors and do not necessarily represent the official position of the National Tuberculosis Program.

Author contributions

Conceptualization: CMM, EN, MRM. Data curation: CMM, IM; JMR-R, MRM. Investigation: CMM, IM; EN, JMR-R, BJ, MRM. Resources: CMM. Supervision: EN, MRM.Writing the original draft: CMM. Writing review & editing: CMM, IM; EN, JMR-R, BJ, MRM. Approval for publication: All the authors.

Funding

The authors declare that no funds or grants were received.

Data availability

All the data have been incorporated into the manuscript and are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the National Bioethics Committee for Health, Mozambique (CNBS), IRB00002657, on July 1, 2021 (Reference: 388/NBS/21). Informed consent was not required as the study involved secondary analysis of existing data collected during routine medical care.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 16 January 2026 / Accepted: 6 April 2026
Published online: 13 April 2026

References

1. Global tuberculosis report 2025. Geneva: World Health Organization; 2025. Licence: CC BY-NC-SA 3.0 IGO https://www.who.int/publications/i/item/9789240116924
2. Verkuijl S, Bastard M, Brands A, Viney K, Masini T, Mavhunga F, et al. Global reporting on TB in children and adolescents: how far have we come and what remains to be done? IJTLD Open. 2023.
3. Yerramsetti S, Cohen T, Atun R, Menzies NA. Global estimates of paediatric tuberculosis incidence in 2013–19: a mathematical modelling analysis. Lancet Global Health. 2022;10:e207–15. https://doi.org/10.1016/S2214-109X(21)00462-9.
4. Mutemba CM, Schindele A, Munyangaju I, Ramanlal N, Manhiça I, José B, et al. Contribution of Xpert® MTB/RIF to pediatric TB diagnosis in Mozambique. Int J Tuberc Lung Dis. 2023;27:419–21. https://doi.org/10.5588/ijtld.22.0479.
5. UNAIDS. UNAIDS|Countries. UNAIDS 2024. https://www.unaids.org/en/regionscountries/countries (accessed August 13, 2021).
6. Silva JB, Santos JC, Barbosa L, Carvalho I. Tuberculosis in the paediatric age group: a reflection on transmission. Pediatr (English Version) (Barc). 2021;94:403–11. https://doi.org/10.1016/j.anpede.2020.12.002.
7. Moore BK, Graham SM, Nandakumar S, Doyle J, Maloney SA. Pediatric Tuberculosis: A Review of Evidence-Based Best Practices for Clinicians and Health Care Providers. Pathogens. 2024;13:467. https://doi.org/10.3390/pathogens13060467.
8. Gunasekera KS, Vonasek B, Oliwa J, Triasih R, Lancioni C, Graham SM, et al. Diagnostic Challenges in Childhood Pulmonary Tuberculosis—Optimizing the Clinical Approach. Pathogens. 2022;11:382. https://doi.org/10.3390/pathogens11040382.

9. Fernandes Q, Augusto O, Machai H, Pfeiffer J, Carone M, Pinto N, et al. Scrutinizing human resources for health availability and distribution in Mozambique between 2016 and 2020: a subnational descriptive longitudinal study. Hum Resour Health. 2023;21:33. https://doi.org/10.1186/s12960-023-00815-7.
10. Vukugah TA, Akoku DA, Tchoupa MM, Lambert E. Epidemiology of Pediatric Tuberculosis and Factors Associated with Unsuccessful Treatment Outcomes in the Centre Region of Cameroon: A Three-Year Retrospective Cohort Study. Interdisciplinary Perspect Infect Dis. 2022;2022:1–10. https://doi.org/10.1155/2022/2236110.
11. Ahmad R, Syed Sulaiman SA, Muttalif AR, Ahmad N, Yaghi ARA, Goh KW, et al. Treatment Outcomes of Childhood TB Patients in Four TB High Burden States of Malaysia: Results from a Multicenter Retrospective Cohort Study. Antibiotics. 2022;11:1639. https://doi.org/10.3390/antibiotics11111639.
12. World Health Organization. WHO consolidated guidelines on tuberculosis: module 5: management of tuberculosis in children and adolescents: web annex 5: overview of consolidated WHO recommendations. World Health Organization; 2022.
13. Ministério da Saúde (Moçambique). Manual para o manejo da Tuberculose na criança, adolescente e mulher grávida. Maputo: Ministério da Saúde; 2019.
14. Nacarapa E, Muchiri E, Moon TD, Charalambous S, Verdu ME, Ramos JM, et al. Effect of Xpert MTB/RIF testing introduction and favorable outcome predictors for tuberculosis treatment among HIV infected adults in rural southern Mozambique. A retrospective cohort study. PLoS ONE. 2020;15:e0229995. https://doi.org/10.1371/journal.pone.0229995.
15. Weldegebreal F, Teklemariam Z, Mitiku H, Tesfaye T, Abrham Roba A, Tebeje F et al. Treatment outcome of pediatric tuberculosis in eastern Ethiopia. Front Pediatr. 2022;10. https://doi.org/10.3389/fped.2022.966237.
16. Moon TD, Nacarapa E, Verdu ME, Macuácua S, Mugabe D, Gong W, et al. Tuberculosis Treatment Outcomes Among Children in Rural Southern Mozambique: A 12-Year Retrospective Study. Pediatr Infect Dis J. 2019;38:999–1004. https://doi.org/10.1097/INF.0000000000002435.
17. García-Basteiro AL, Respeito D, Augusto OJ, López-Varela E, Sacoor C, Sequera VG, et al. Poor tuberculosis treatment outcomes in Southern Mozambique (2011–2012). BMC Infect Dis. 2016;16:214. https://doi.org/10.1186/s12879-016-1534-y.
18. Ministério da Saúde (Moçambique). Relatório anual do Programa Nacional de Controlo da Tuberculose. Maputo: Ministério da Saúde; 2024.
19. López-Varela E, Augusto OJ, Guerra L, Respeito D, Sacoor C, Sacarlal J, et al. Low paediatric tuberculosis case detection rate in Southern Mozambique. Eur Respir J. 2016;47:1003–5. https://doi.org/10.1183/13993003.01454-2015.
20. Belay GM, Wubneh CA. Childhood tuberculosis treatment outcome and its association with HIV co-infection in Ethiopia: a systematic review and meta-analysis. Trop Med Health. 2020;48:7. https://doi.org/10.1186/s41182-020-00195-x.
21. Ohene S-A, Fordah S, Dela Boni P. Childhood tuberculosis and treatment outcomes in Accra: a retrospective analysis. BMC Infect Dis. 2019;19:749. https://doi.org/10.1186/s12879-019-4392-6.
22. Siamisang K, Rankgoane-Pono G, Madisa TM, Mudiayi TK, Tlhakanelo JT, Mubiri P, et al. Pediatric tuberculosis outcomes and factors associated with unfavorable treatment outcomes in Botswana, 2008–2019: a retrospective analysis. BMC Public Health. 2022. https://doi.org/10.1186/s12889-022-14477-y. ;22:2020.
23. Hamid M, Brooks MB, Madhani F, Ali H, Naseer MJ, The Childhood Tuberculosis Karachi Group. Risk factors for unsuccessful tuberculosis treatment outcomes in children. PLoS ONE. 2019;14:e0222776. https://doi.org/10.1371/journal.pone.0222776.
24. Ngosa D, Lupenga J. Childhood tuberculosis outcomes and factors associated with unsuccessful treatment outcomes in selected public hospitals of Lusaka Zambia from 2015 to 2019. PLOS Glob Public Health. 2024;4:e0002591. https://doi.org/10.1371/journal.pgph.0002591.
25. Brooks MB, Malik A, Khan S, Ahmed JF, Siddiqui S, Jaswal M, et al. Predictors of unsuccessful tuberculosis treatment outcomes in children from a prospective cohort study in Pakistan. J Glob Health. 2021;11:04011. https://doi.org/10.7189/jogh.11.04011.
26. Götzinger F, Caprile AA, Noguera-Julian A, Lo Vecchio A, Baquero-Artigao F, Rosal TD, et al. Clinical presentation, diagnostics, and outcomes of infants with congenital and postnatal tuberculosis: a multicentre cohort study of the Paediatric Tuberculosis Network European Trials Group (ptbnet). Lancet Reg Health - Europe. 2025;53:101303. https://doi.org/10.1016/j.lanepe.2025.101303.
27. Boffa J, Mhlaba T, Chibi B, Naidoo M, Lutchminarain K, Swe Swe-Han K, et al. Improving tuberculosis diagnosis in South Africa's private sector: The results of a pilot public-private mix intervention in eThekwini health district. PLOS Glob Public Health. 2025;5:e0004233. https://doi.org/10.1371/journal.pgph.0004233.
28. Borde E, Manjate ES, Zandamela NN, Navarro MG-Z, Martínez-Herrera E, Dula J et al. Satisfação e percepção dos utentes de serviços de saúde em Maputo sobre a qualidade do cuidado. 2023.
29. Gironés LA, Belvis F, Julia M, Benach J. Health care inequalities in Mozambique: needs, access, barriers and quality of care. Barcelona: Medicus Mundi; 2018.
30. Osman M, Lee K, Du Preez K, Dunbar R, Hesseling AC, Seddon JA. Excellent Treatment Outcomes in Children Treated for Tuberculosis Under Routine Operational Conditions in Cape Town, South Africa. Clin Infect Dis. 2017;65:1444–52. https://doi.org/10.1093/cid/cix602.

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