

Prevalence and factors associated with HIV among children with tuberculosis in ten high-burden regions of Tanzania, 2018–2023: a retrospective analysis of national surveillance data

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Abstract

Background Children living with HIV who develop tuberculosis (TB) have higher case fatality and lower treatment success than their HIV-negative peers. Tanzania's routine surveillance reports pediatric TB-HIV co-infection descriptively, without formal trend testing or modelling of associated factors, leaving the National Tuberculosis and Leprosy Programme without evidence to target HIV testing and TB preventive therapy. We determined the prevalence of TB-HIV co-infection, described its pattern by year, age group, sex and region of registration, and identified associated factors among children aged below 15 years registered with TB in Tanzania.

Methods We conducted a retrospective analysis of Tanzania's national electronic TB surveillance system (DHIS2-eTL). The analysis included all children aged below 15-years with documented HIV status registered with TB across ten high-burden regions between January 2018 and December 2023. HIV positivity was confirmed at TB registration. We tested the annual trend with the chi-square test for linear trend and estimated adjusted prevalence ratios (aPR) by modified Poisson regression with robust variance.

Results Of 25,449 children registered with TB and having a documented HIV status, 3,667 were HIV-positive (14.4%, 95% CI:14.0–14.8). Prevalence fell in every successive year, from 28.5% (95% CI:26.8–30.2) in 2018 to 8.9% (95% CI:8.1–9.8) in 2023 ($\chi^2_1=719.7$, $p<0.001$). It rose across age groups, from 9.0% (95% CI:8.5–9.5) below 5 years to 17.7% (95% CI:16.8–18.6) at 5–9 years and 22.6% (95% CI 21.6–23.7) at 10–14 years ($\chi^2_1=684.3$, $p<0.001$) and did not differ by sex ($p=0.814$). It was highest in Njombe (29.7%) and lowest in Ruvuma (6.7%) ($p<0.001$). In the adjusted model, co-infection was independently associated with age 10–14 years (aPR=2.40, 95% CI:2.22–2.59), registration in Njombe (aPR=1.46, 95% CI:1.30–1.64) and relapse TB (aPR=2.30, 95% CI:1.92–2.76).

Conclusions TB-HIV co-infection affected approximately one-in-seven children notified with TB and declined by two-thirds between 2018 and 2023, but remained concentrated in older children, in previously treated children

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and in Njombe, Mbeya and Iringa. The NTLP should prioritize repeat HIV testing for all children aged 5 years and above presenting with TB and for all retreatment cases, with geographic intensification in these three regions.

Keywords TB-HIV co-infection · TB · HIV · Child · Surveillance · Tanzania

Background

Tuberculosis (TB) remains a leading infectious cause of death worldwide, and children carry a substantial and frequently underestimated share of that burden. The World Health Organization (WHO) estimates that 10.7 million people fell ill with TB in 2024, of whom 1.2 million were children and young adolescents aged below 15 years. An estimated 174,300 children died of TB in that year, accounting for 14.2% of all TB deaths, and case detection in this age group remains poor: approximately 43% of children who developed TB were never diagnosed or notified [1]. The WHO African Region carries a disproportionate share of this burden, and sub-Saharan Africa, which accounts for approximately two thirds of the global HIV burden, contains most of the countries in which pediatric TB and pediatric HIV overlap. In Tanzania, a WHO-designated high TB and high TB/HIV burden country, children aged below 15 years accounted for 17% of all notified TB cases in 2022 [2]. Where pediatric TB and pediatric HIV overlap, the consequences for the child are considerably more severe.

HIV is the single strongest risk factor for progression from TB infection to TB disease in childhood: children and adolescents living with HIV are 8 to 20 times more likely to develop TB disease than their HIV-negative peers [3]. Once TB develops, co-infected children fare considerably worse. TB accounts for approximately one third of deaths among children and adolescents living with HIV, and co-infected children experience higher case fatality, lower cure rates, more frequent loss to follow-up and more frequent recurrent disease than children with TB alone, reflecting accelerated immune deterioration, more complex treatment and an amplified risk of drug resistance [3, 4]. TB also remains the leading single cause of death among people living with HIV: approximately 161,000 people living with HIV died of TB in 2023, accounting for roughly one quarter of all HIV-related deaths worldwide (WHO, 2025; Chen et al., 2025). Tanzania has responded through the National TB and Leprosy Programme (NTLP), whose guidelines require that every child registered with TB be offered HIV testing and that every co-infected child be linked to antiretroviral therapy (ART) [2, 5]. Routine surveillance records co-infection among notified pediatric TB cases and reports it by age and region, but whether that policy is translating into measurable change over time, and for which children it is not, requires analysis that routine descriptive reporting does not perform.

Tanzania's HIV epidemic is geographically heterogeneous. The Tanzania HIV Impact Survey (THIS) 2022–2023 estimated adult HIV prevalence at 4.4% nationally and 4.5% in Mainland Tanzania, with marked regional variation across the mainland, from 1.7% in Kigoma to 12.7% in Njombe; prevalence exceeded 9.0% in three regions; Mbeya, Iringa and Njombe [6]. Because most children acquire HIV vertically, this heterogeneity is expected to propagate into pediatric HIV exposure. Since the introduction of the Option B+ strategy in October 2013, lifelong ART for all pregnant women living with HIV has substantially reduced vertical transmission, but the cascade remains incomplete: only 34.6% to 44.2% of HIV-exposed infants return for the 18-month confirmatory test, leaving a residual population of children with undiagnosed HIV who remain unprotected against TB [5, 7]. How large that residual population is, where it is concentrated and which children within it are most affected has not been described.

Evidence on the prevalence, temporal pattern, geographical distribution and determinants of TB-HIV co-infection among Tanzanian children remains limited [8]. Single-facility studies provide clinical detail but cannot inform regional prioritization. Routine national reporting is descriptive and annual: it counts co-infected children by age and region but does not test whether the observed decline is statistically significant, and it does not model which characteristics are independently associated with co-infection. The NTLP therefore lacks an analytic evidence base on which to target HIV testing, TB preventive therapy and integrated service delivery.

We conceptualized HIV positivity among notified pediatric TB cases as arising from three domains of factors. Individual-level factors comprise age, sex, TB disease classification and treatment history. Health-system and programmatic factors comprise calendar year of registration, HIV testing practice, TB diagnostic practice and treatment regimen. Geographic and contextual factors comprise region of registration, regional HIV prevalence, healthcare access and socioeconomic conditions. This framework guided variable selection and the two-model analytical strategy described below. This study therefore set out to: (i) determine the prevalence of TB-HIV co-infection among children aged below 15 years registered with TB in ten high TB-HIV burden regions of Tanzania between 2018 and 2023; (ii) describe the pattern of co-infection by year, age group, sex and region of registration; and (iii) identify factors independently associated with co-infection. We hypothesized that TB-HIV co-infection prevalence among notified pediatric TB cases declined significantly over this period following the scale-up of prevention of mother-to-child transmission (PMTCT), pediatric ART and TPT services, and that residual co-infection is concentrated among older children, among children with a history of previous TB treatment, and in regions with the highest background HIV burden.

Methods

Design and data source

We conducted a cross-sectional study and abstracted records of children aged below 15 years from the District Health Information System 2 Electronic TB and Leprosy (DHIS2-eTL) for the period January 2018 to December 2023, using a standardized and approved data extraction form. The DHIS2-eTL is the official national TB surveillance system and provides standardized facility-level records across all registered health facilities in Tanzania. As standard care, children diagnosed with TB were initiated on a WHO-recommended first-line regimen according to the NTLP guideline in force at the time of registration: 2HRZE/10RH for TB meningitis and osteoarticular TB, 2RHZE/4RH using adult formulations, or 2RHZE/4RH-KID using pediatric dispersible formulations [9]. Children found to be HIV-positive were referred to a Care and Treatment Clinic (CTC) for initiation of antiretroviral therapy, and co-trimoxazole preventive therapy was provided in accordance with national guidelines [5].

Study setting

The ten regions were purposively selected using the NTLP high TB-HIV burden priority classification, defined *a priori* as regions falling in the highest national tertile of pediatric TB case notifications recorded in the DHIS2-eTL during 2018–2023 and, simultaneously, having an adult HIV prevalence above the national average of 4.4% estimated in THIS 2022–2023. Regions meeting both criteria were Njombe, Iringa, Mbeya, Songwe, Kagera, Tabora, Shanyanga, Mara, Ruvuma and Geita. Across these ten regions, adult HIV prevalence ranged from 4.9% in Geita and Ruvuma to 12.7% in Njombe, against a national average of 4.4% [6].

All ten are administrative regions, each comprising urban municipal or city councils together with predominantly rural district councils; nationally, 65.1% of Tanzania's population is classified as rural (NBS, 2022). The DHIS2-eTL records the region and district of the registering facility but does not record whether an individual child resides in an urban or a rural setting. TB diagnosis and treatment are delivered through NTLP-registered public, faith-based and private health facilities; nationally, of 9,366 registered health facilities, 6,988 (74.6%) are public, 1,299 (13.8%) private, 998 (10.6%) faith-based and 81 (1.0%) parastatal [9, 10]; all of which report into the DHIS2-eTL, so the dataset is not restricted to the public sector.

The selected regions together account for approximately 21.6 million people, of whom about 44% are children aged below 15 years [11]. The operative denominators for this study, however, are facility-based: the numbers of children aged below 15 years notified with TB in each region during 2018–2023. The study population is facility-based. It comprises children aged below 15 years who were notified and registered with TB at an NTLP-registered

facility in one of the ten study regions during the study period. It is not a community sample of children at risk of TB or HIV, and the estimates presented are not community prevalence estimates.

Study population and eligibility

Eligible participants were children aged below 15 years registered with TB, whether bacteriologically confirmed or clinically diagnosed and whether pulmonary or extra-pulmonary, with a documented HIV status, notified in the DHIS2-eTL in one of the ten study regions between January 2018 and December 2023. The cut-off of 15 years aligns with WHO and NTLP definitions of pediatric TB [1, 2, 9, 12]. Both newly diagnosed and previously treated (retreatment) children who were registered and initiated on TB treatment during this period were eligible. Bacteriological confirmation was not required for eligibility, because it is achieved in only a minority of young children and restricting the cohort to confirmed cases would have introduced substantial selection bias. Children registered but not initiated on TB treatment are not captured in the DHIS2-eTL treatment register and are therefore not represented. Age below 15 years was an eligibility criterion rather than an exclusion; records for persons aged 15 years or above were not part of the study population. Among children aged below 15 years, records with unknown or missing HIV status, or with missing age, were excluded.

Measurements

Data were abstracted onto a standardized extraction form approved by the NTLP. The form captured the date and facility of TB registration, region and district, age in completed years, sex, referral source, method of diagnosis, TB disease classification, treatment history category, drug-susceptible TB (DSTB) regimen, HIV status, ART and co-trimoxazole preventive therapy status, and collaborative TB-HIV services received. The records abstracted were generated through routine clinical care. At presentation, each child underwent symptom screening and physical examination by the attending clinician, with chest radiography performed where pulmonary TB was suspected. Bacteriological confirmation was sought by GeneXpert, smear microscopy and/or culture, in accordance with national NTLP diagnostic guidelines. Children in whom bacteriological confirmation was not obtained were classified as clinically diagnosed based on symptoms, examination findings, chest radiography, or histology and imaging for extra-pulmonary disease. HIV testing followed the national serial rapid test algorithm, with DNA polymerase chain reaction testing for infants aged below 18 months [5].

Variables and operational definitions

TB-HIV co-infection, the outcome of this study, was defined as a documented HIV-positive status recorded in the DHIS2-eTL for a child aged below 15 years registered with TB. HIV status was a laboratory-confirmed result obtained through the national serial rapid test algorithm, or by DNA polymerase chain reaction for infants aged below 18 months and recorded at the time of TB registration; self-reported status was not accepted. Age was recorded in completed years at registration and categorized as below 5, 5–9 and 10–14 years. Sex was recorded as female or male. Region of TB registration refers to the region of the health facility at which the child was registered. Geographic zone grouped the ten regions as Southern Highlands (Njombe, Iringa, Mbeya, Songwe), Lake (Kagera, Mara, Geita, Shinyanga), Western (Tabora) and Southern (Ruvuma). TB disease classification was recorded as pulmonary, extra-pulmonary, or both pulmonary and extra-pulmonary. Treatment history followed WHO and NTLP definitions: new (no previous TB treatment, or less than one month of anti-TB drugs); relapse (previously treated, declared cured or treatment completed, now diagnosed with a recurrent episode); treatment after loss to follow-up (previously treated, treatment interrupted for two or more consecutive months, now re-registered); and other previously treated (previously treated, but the outcome of the most recent course unknown or undocumented). DSTB regimen was recorded as 2HRZE/10RH, 2RHZE/4RH or 2RHZE/4RH-KID. Regimen availability was calendar-period dependent, with pediatric dispersible formulations introduced through a national

roll-out during 2019–2020 and progressively replacing adult formulations, and 2HRZE/10RH reserved throughout for tuberculous meningitis and osteoarticular TB.

Sample size

All eligible records held in the DHIS2-eTL for the ten study regions during 2018–2023 were included, so the study used exhaustive (census) sampling rather than a sample of records. For reference, the minimum sample required to estimate an expected co-infection prevalence of approximately 15%, based on published Tanzanian estimates, with 5% absolute precision at 95% confidence, using the Kish–Leslie formula $n = Z^2 P(1 - P)/e^2$ with $Z = 1.96$, $P = 0.15$ and $e = 0.05$, is 196 records; inflating this by 10% to allow for incomplete records gives 216. The number of records analyzed exceeds this minimum by more than a hundredfold.

Data management

Records were exported from the DHIS2-eTL, and all data cleaning, validation and analysis were performed in R version 4.5.1. Cleaning comprised de-duplication on the registration identifier, range and logic checks on age and registration dates, and standardization of categorical labels.

Statistical analysis

Categorical variables were summarized as frequencies and percentages. Associations between HIV serostatus and participant characteristics were assessed using Pearson's chi-square test. Prevalence estimates are presented with 95% Wilson score confidence intervals.

Published estimates of HIV prevalence among children with TB in Tanzania and comparable settings exceed 10%. Where the outcome is common, odds ratios overstate relative associations in a cross-sectional design. We therefore estimated prevalence ratios using modified Poisson regression with a log link and robust (Huber–White sandwich) variance estimation, reporting crude and adjusted prevalence ratios with 95% confidence intervals. Adjusted odds ratios from binary logistic regression are presented alongside the prevalence ratios so that the divergence between the two measures is explicit.

Variables were screened by bivariate comparison of HIV serostatus across each characteristic and by unadjusted prevalence ratios. Those reaching $p < 0.20$, together with sex, which was retained as a standard demographic adjustment, entered the multivariable model: age group, sex, region of TB registration, calendar period, DSTB regimen, TB disease classification and treatment history. Reference categories were age below 5 years, female sex, Geita, the pre-COVID period, 2HRZE/10RH, both pulmonary and extra-pulmonary tuberculosis, and new TB case; the COVID-19 period was defined as 2020–2023 and the pre-COVID period as 2018–2019. DSTB regimen is potentially downstream of clinical and programmatic processes, including HIV status itself, and its estimate is therefore reported as a clinical and programmatic correlate rather than as a determinant of HIV status. Referral source was screened but excluded from the model, because children referred from a Care and Treatment Clinic are already known to be HIV-positive, making referral source a consequence of the outcome rather than a determinant of it.

Trends in prevalence across ordered categories were assessed using the chi-square test for linear trend in proportions. For the annual series, the Mann–Kendall test for monotonic trend was additionally applied with the exact p-value reported, and a segmented regression was fitted to the annual proportions with an intercept, a pre-existing slope term, a level-change term and a slope-change term at a change point in 2020.

Analyses were conducted on complete cases; no imputation was performed. Of the 25,599 children aged below 15 years, 150 (0.6%) were excluded for incomplete records; 146 with unknown or missing HIV status and 4 with missing age. Among the 25,449 children analyzed, 294 had no DSTB regimen recorded and 12 no disease classification. All tests were two-sided and statistical significance was set at 0.05.

Ethical considerations

This study involved secondary analysis of de-identified, routinely collected national tuberculosis surveillance data; no experiments were conducted on human participants and no human samples were used. All methods were performed in accordance with relevant guidelines and regulations, including the Declaration of Helsinki. Ethical approval was granted by the National Institute for Medical Research (NIMR) through the National Health Research Ethics Committee (NatHREC), Dodoma, Tanzania (reference NIMR/HQ/R.8a/Vol.IX/4988). Administrative clearance was obtained from the Cavendish University Uganda (CUU) School of Postgraduate Studies, and permission to use programmatic data was granted by the Ministry of Health of the United Republic of Tanzania through the National Tuberculosis and Leprosy Programme (reference GA.154/425/05/111/9). Because the study involved secondary analysis of de-identified, routinely collected programmatic data, the requirement for individual informed consent was waived by the National Health Research Ethics Committee (NatHREC) of the National Institute for Medical Research, Tanzania. Patient names, registration numbers and facility identifiers were removed at the point of extraction by the NTLP data manager, so the analytic dataset contained no direct or indirect identifiers, and no attempt was made to re-identify any individual.

Results

Participant selection

Of 163,476 TB records notified in the ten study regions between January 2018 and December 2023, 25,599 (15.7%) were for children aged below 15 years. Of these, 150 (0.6%) were excluded because of incomplete records; 146 with unknown or missing HIV status and 4 with missing age; leaving 25,449 (99.4%) children in the analysis, of whom 3,667 (14.4%) were HIV-positive and 21,782 (85.6%) HIV-negative (Fig. 1). Both HIV-positive and HIV-negative children contributed to all analyses. Children who were excluded did not differ significantly from those included with respect to age group, sex or region of registration (all $p > 0.05$).

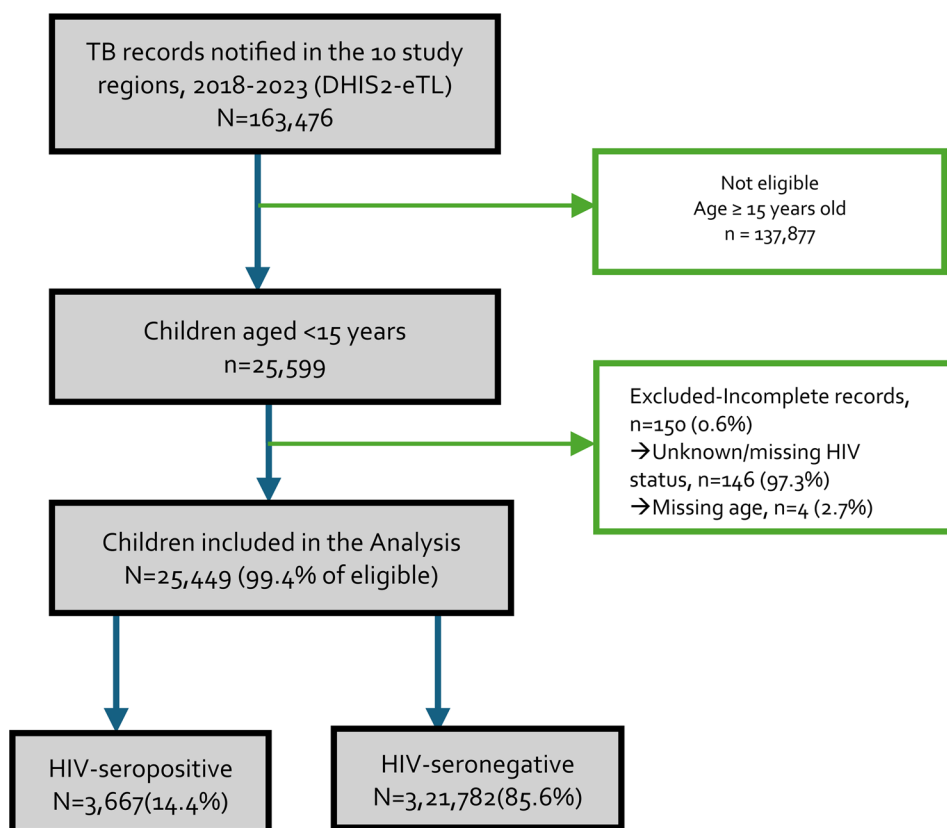
Characteristics of notified pediatric TB cases

Just over half of the cohort were aged below 5 years (13,047; 51.3%), while 6,325 (24.9%) were aged 5–9 years and 6,077 (23.9%) were aged 10–14 years. Males accounted for 13,315 (52.3%). The largest contributing regions were Tabora (3,845; 15.1%), Mara (3,661; 14.4%) and Kagera (3,632; 14.3%), and the smallest were Songwe (871; 3.4%) and Njombe (1,112; 4.4%). Annual notifications rose from 2,688 in 2018 to a peak of 5,421 in 2022 before falling to 4,493 in 2023. Most children received the adult-formulation regimen 2RHZE/4RH (15,201; 60.4%), while 9,477 (37.7%) received the pediatric dispersible formulation 2RHZE/4RH-KID and 477 (1.9%) received 2HRZE/10RH. Full characteristics, by HIV serostatus, are presented in Table 1.

Annual HIV positivity

The overall prevalence of TB-HIV co-infection was 14.4% (95% CI:14.0–14.8). Prevalence declined in every successive year, from 28.5% (95% CI:26.8–30.2) in 2018 to 21.6% (95% CI:20.2–23.0) in 2019, 15.3% (95% CI:14.3–16.4) in 2020, 10.7% (95% CI:9.9–11.6) in 2021, 10.0% (95% CI:9.3–10.9) in 2022 and 8.9% (95% CI:8.1–9.8) in 2023 (Table 2; Fig. 2). The decline was statistically significant on the chi-square test for linear trend in proportions ($\chi^2_1 = 719.7$, $p < 0.001$) and on the Mann–Kendall test for monotonic trend ($S = -15$, Kendall's $\tau = -1.00$, exact two-sided $p = 0.0028$). These estimates describe HIV positivity within the notified pediatric TB cohort and are not population HIV prevalence estimates among Tanzanian children.

Fig. 1 Flow of records through the study, ten high TB-HIV burden regions of Tanzania, 2018–2023



Regional variation

Co-infection prevalence rose monotonically across age groups, from 9.0% (95% CI:8.5–9.5) in children aged below 5 years to 17.7% (95% CI:16.8–18.6) at 5–9 years and 22.6% (95% CI:21.6–23.7) at 10–14 years (chi-square test for trend, $p < 0.001$). Prevalence did not differ by sex (female 14.5%, 95% CI:13.9–15.1; male 14.4%, 95% CI:13.8–15.0; $p = 0.814$). Prevalence varied markedly by region of registration ($p < 0.001$), being highest in Njombe (29.7%, 95% CI: 27.0–32.4), Mbeya (25.9%, 95% CI:23.7–28.1) and Iringa (23.5%, 95% CI:21.3–25.7), and lowest in Ruvuma (6.7%, 95% CI: 5.8–7.6), Mara (7.4%, 95% CI:6.6–8.2) and Kagera (8.2%, 95% CI:7.3–9.1) (Table 1; Fig. 3).

Factors associated with HIV positivity

Three patterns emerged from the adjusted analysis (Table 3). Prevalence rose steeply and monotonically with age, more than doubling between children under 5 and those aged 10–14 (aPR=2.40, 95% CI: 2.22–2.59), and the gradient was unchanged after adjustment for region, period, regimen, disease classification and treatment history. Regional variation was wide, spanning a more than threefold difference between the highest adjusted estimate in Njombe (aPR=1.46, 95% CI: 1.30–1.64) and the lowest in Mara (aPR=0.41, 95% CI: 0.36–0.47), with the three highest all in the southern highlands and the three lowest all in the Lake zone. Any history of previous TB treatment carried a similar excess regardless of category (aPR=2.23 to 2.45), suggesting that prior treatment itself, rather than the reason for it, marks the higher-prevalence subgroup. Prevalence did not differ by sex, and was lower during the COVID-19 period than before it (aPR=0.52, 95% CI: 0.49–0.55).

Because the outcome prevalence was 14.4%, these estimates were compared with adjusted odds ratios from the same covariate specification (Table 4). Odds ratios exceeded the corresponding prevalence ratios for every

Table 1 Sociodemographic and clinical characteristics of children aged below 15 years registered with TB, by HIV serostatus, ten high TB-HIV burden regions of Tanzania, 2018–2023

Characteristic	Total <i>N</i> =25,449	HIV-seronegative <i>n</i> =21,782	HIV-seropositive <i>n</i> =3,667	HIV positivity % (95% CI)	<i>p</i> -value
Age group					<0.001
<5 years	13,047 (51.3)	11,873 (91.0)	1,174 (9.0)	9.0 (8.5–9.5)	
5–9 years	6,325 (24.9)	5,207 (82.3)	1,118 (17.7)	17.7 (16.8–18.6)	
10–14 years	6,077 (23.9)	4,702 (77.4)	1,375 (22.6)	22.6 (21.6–23.7)	
Sex					0.814
Female	12,134 (47.7)	10,379 (85.5)	1,755 (14.5)	14.5 (13.8–15.1)	
Male	13,315 (52.3)	11,403 (85.6)	1,912 (14.4)	14.4 (13.8–15.0)	
Region of TB registration					<0.001
Geita	3,102 (12.2)	2,532 (81.6)	570 (18.4)	18.4 (17.1–19.8)	
Iringa	1,381 (5.4)	1,056 (76.5)	325 (23.5)	23.5 (21.4–25.8)	
Kagera	3,632 (14.3)	3,335 (91.8)	297 (8.2)	8.2 (7.3–9.1)	
Mara	3,661 (14.4)	3,391 (92.6)	270 (7.4)	7.4 (6.6–8.3)	
Mbeya	1,472 (5.8)	1,091 (74.1)	381 (25.9)	25.9 (23.7–28.2)	
Njombe	1,112 (4.4)	782 (70.3)	330 (29.7)	29.7 (27.1–32.4)	
Ruvuma	2,777 (10.9)	2,592 (93.3)	185 (6.7)	6.7 (5.8–7.7)	
Shinyanga	3,596 (14.1)	3,090 (85.9)	506 (14.1)	14.1 (13.0–15.2)	
Songwe	871 (3.4)	745 (85.5)	126 (14.5)	14.5 (12.3–17.0)	
Tabora	3,845 (15.1)	3,168 (82.4)	677 (17.6)	17.6 (16.4–18.8)	
Year of registration					<0.001
2018	2,688 (10.6)	1,922 (71.5)	766 (28.5)	28.5 (26.8–30.2)	
2019	3,404 (13.4)	2,670 (78.4)	734 (21.6)	21.6 (20.2–23.0)	
2020	4,536 (17.8)	3,840 (84.7)	696 (15.3)	15.3 (14.3–16.4)	
2021	4,907 (19.3)	4,380 (89.3)	527 (10.7)	10.7 (9.9–11.6)	
2022	5,421 (21.3)	4,877 (90.0)	544 (10.0)	10.0 (9.3–10.9)	
2023	4,493 (17.7)	4,093 (91.1)	400 (8.9)	8.9 (8.1–9.8)	
DSTB regimen					<0.001
2HRZE/10RH	477 (1.9)	435 (91.2)	42 (8.8)	8.8 (6.6–11.7)	
2RHZE/4RH	15,201 (60.4)	12,728 (83.7)	2,473 (16.3)	16.3 (15.7–16.9)	
2RHZE/4RH-KID	9,477 (37.7)	8,369 (88.3)	1,108 (11.7)	11.7 (11.1–12.4)	
Total	25,449 (100)	21,782 (85.6)	3,667 (14.4)	14.4 (14.0–14.8)	

CI= confidence interval; DSTB= drug-susceptible tuberculosis; H=isoniazid; R=rifampicin; Z=pyrazinamide; E=ethambutol; 2RHZE/4RH-KID=pediatric dispersible formulation. Values are *n* (%). *p*-values are from Pearson's chi-square test. Confidence intervals are Wilson score intervals for the proportion HIV-seropositive within each stratum. The mean-age row has been removed, and age is presented in categories only

Table 2 Annual HIV positivity among children aged below 15 years notified with TB, ten high TB-HIV burden regions of Tanzania, 2018–2023

Year	HIV-positive (<i>n</i>)	Children with documented HIV status (<i>N</i>)	HIV positivity	95% CI
2019	734	3,404	21.6%	20.2–23.0
2018	766	2,688	28.5%	26.8–30.2
2020	696	4,536	15.3%	14.3–16.4
2021	527	4,907	10.7%	9.9–11.6
2022	544	5,421	10.0%	9.3–10.9
2023	400	4,493	8.9%	8.1–9.8
Total	3,667	25,449	14.4%	14.0–14.8

Cochran–Armitage test for linear trend in proportions, $p < 0.001$; Mann–Kendall test for monotonic trend, $S = -15$, Kendall's $\tau = -1.00$, exact two-sided $p = 0.0028$. Confidence intervals shown are Wald approximations and should be regenerated as exact Wilson intervals before submission

covariate, by 10–25% for most but by approximately 100% for the treatment-history categories, where the estimate for relapse was aOR=4.68 (95% CI 3.04–9.45) against aPR=2.30 (95% CI: 1.92–2.76). The two measures were concordant in direction throughout but differed for one covariate at the 5% level: registration in Tabora reached significance as an odds ratio (aOR=1.15, 95% CI 1.01–1.30, $p=0.038$) but not as a prevalence ratio (aPR=1.10, 95% CI 1.00–1.22, $p=0.061$).

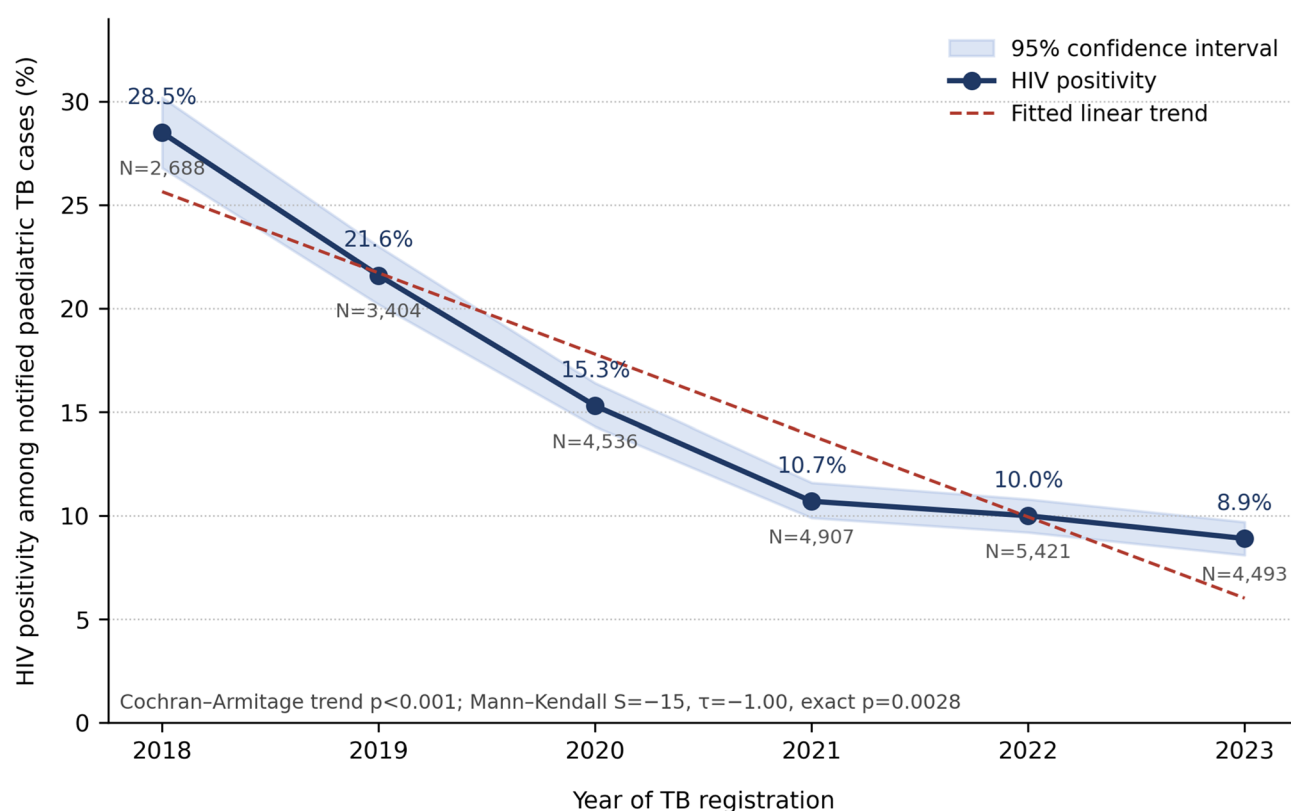


Fig. 2 Annual HIV positivity among children aged below 15 years notified with TB, with 95% confidence intervals and fitted trend, 2018–2023

Discussion

Among 25,449 children registered with TB across ten high-burden regions of Tanzania between 2018 and 2023, 14.4% had a documented HIV-positive status, approximately one in seven notified children. Prevalence declined in every successive year, falling by roughly two thirds from 28.5% in 2018 to 8.9% in 2023; formal trend testing confirmed this decline rather than leaving it to inference from the annual counts. Yet co-infection did not recede uniformly. After mutual adjustment, it remained independently concentrated in three groups: older children, among whom prevalence more than doubled from the under-five level to reach 22.6% at 10–14 years; children with any history of previous TB treatment, elevated across every retreatment category; and children registered in the southern highlands, peaking in Njombe (aPR 1.46) and extending to Mbeya and Iringa. Prevalence did not differ by sex.

The observed overall prevalence of 14.4% sits toward the lower end of the range the World Health Organization (WHO) has estimated for children with TB in settings of moderate-to-high HIV prevalence (10% to 60%) [13–15]. Higher prevalence, 29.2%, was reported by researchers in Lagos State, Nigeria [13], and in Lubumbashi, Democratic Republic of Congo (21.0%) [14]. Although regional variations will always persist (even within the present study), earlier studies were within the context of a period of pre-expansion [2, 5, 7, 16, 17] and maturation of pediatric ART and PMTCT programmes [13, 14]. This also could partly explain the higher prevalence rates observed in the earlier years by the present study. That co-infection prevalence declined in every successive year, from 28.5% in 2018 to 8.9% in 2023 despite an increase in pediatric TB notifications is an achievement of from the Tanzania programme efforts. Moreover, this finding is also collaborated a decline in adult HIV prevalence in mainland Tanzania from 4.9% in 2016–2017 to 4.4% in 2022–2023 [6, 18].

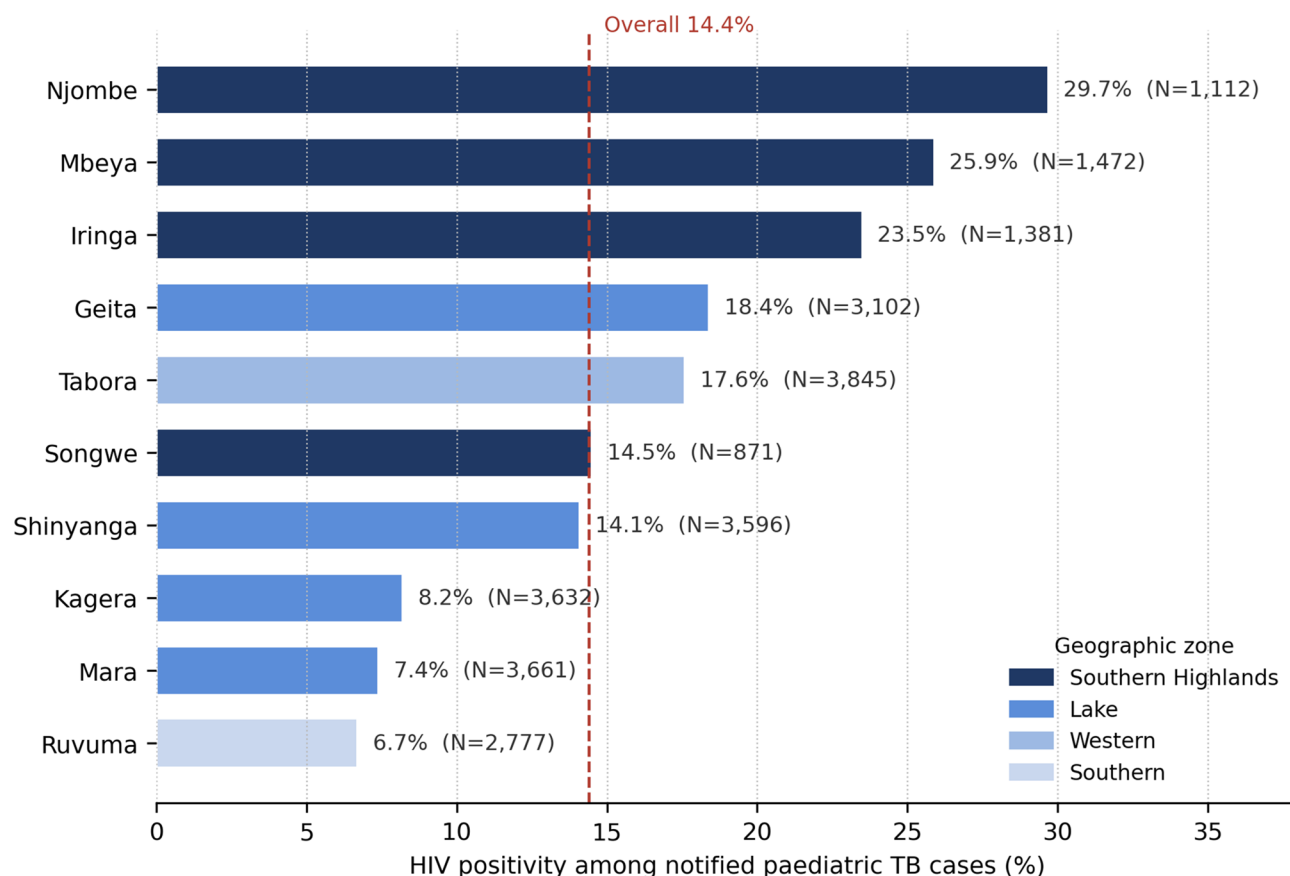


Fig. 3 HIV positivity among children aged below 15 years notified with TB, by region of registration

Co-infection prevalence rose monotonically with age, reaching more than twice the under-five level among children aged 10–14 years. Such observations have been linked to severe immunosuppression rather than age itself [19]. ART reduces TB notification in children living with HIV by 70–92% [20, 21]. Therefore, this observation is consistent with children experiencing interrupted or late ART carrying higher residual risk. Our gradient fits an ageing-up effect, in which children infected perinatally survive into adolescence and present later with TB [22]. Children aged 10–14 years in this cohort were largely born before or during Tanzania’s October 2013 Option B+ rollout, when lifelong maternal ART was not yet universal [5]. Moreover, it fits delayed diagnosis equally well, since only 34.6–44.2% of HIV-exposed infants in Tanzania return for the 18-month confirmatory test [7]. In addition, also fits acquisition routes not captured by PMTCT surveillance, which studies from neighboring countries have documented alongside breakthrough infections and gaps in the PMTCT cascade [23, 24]. Individually and taken together, each point of these point to the same action, that is, older children presenting with TB warrant HIV testing irrespective of their previously documented status.

Co-infection prevalence varied substantially across regions of registration and peaked in Njombe, Mbeya and Iringa. The Tanzania HIV Impact Survey (THIS) 2022–2023 identified these same three regions as the only ones in mainland Tanzania with adult HIV prevalence above 9.0%, at 12.7%, 9.6% and 11.1% respectively [6]. This correspondence is logical, a high HIV prevalence among adults will often result in a high HIV prevalence among children. However, PMTCT programs are meant to prevent this exact outcome, therefore, the study findings highlight that despite a well performing PMTCT program in Tanzania, there is still a challenge in high-burden regions. More efforts are needed in understanding this further as other factors could be at play. For instance, whether high community HIV prevalence raises pediatric co-infection through perinatal exposure, through delayed diagnosis, or through differential access to testing remains untestable here.

Table 3 Factors associated with co-infection (HIV infection with TB) among children aged below 15 years registered with TB, ten high TB-HIV burden regions of Tanzania, 2018–2023

Characteristic	Crude PR (95% CI)	<i>p</i> -value	Adjusted PR (95% CI)	<i>p</i> -value
Age group				
<5 years	1		1	
5–9 years	1.96 (1.82–2.12)	<0.001	2.00 (1.85–2.15)	<0.001
10–14 years	2.51 (2.34–2.70)	<0.001	2.40 (2.22–2.59)	<0.001
Sex				
Female	1		1	
Male	0.99 (0.94–1.05)	0.814	0.99 (0.94–1.05)	0.760
Region of TB registration				
Geita	1		1	
Iringa	1.28 (1.14–1.44)	<0.001	1.25 (1.11–1.41)	<0.001
Kagera	0.45 (0.39–0.51)	<0.001	0.51 (0.44–0.58)	<0.001
Mara	0.40 (0.35–0.46)	<0.001	0.41 (0.36–0.47)	<0.001
Mbeya	1.41 (1.26–1.58)	<0.001	1.35 (1.21–1.51)	<0.001
Njombe	1.62 (1.44–1.82)	<0.001	1.46 (1.30–1.64)	<0.001
Ruvuma	0.36 (0.31–0.42)	<0.001	0.45 (0.38–0.53)	<0.001
Shinyanga	0.77 (0.69–0.85)	<0.001	0.85 (0.76–0.95)	0.004
Songwe	0.79 (0.66–0.94)	0.008	0.95 (0.80–1.14)	0.602
Tabora	0.96 (0.87–1.06)	0.407	1.10 (1.00–1.22)	0.061
Period				
Pre-COVID	1		1	
During COVID	0.45 (0.43–0.48)	<0.001	0.52 (0.49–0.55)	<0.001
DSTB regimen				
2HRZE/10RH	1		1	
2RHZE/4RH	1.85 (1.38–2.47)	<0.001	1.46 (1.09–1.96)	0.010
2RHZE/4RH-KID	1.33 (0.99–1.78)	0.059	1.56 (1.16–2.10)	0.003
Disease classification				
Both pulmonary and extra-pulmonary	1		1	
Extra-pulmonary	1.78 (1.01–3.16)	0.047	1.86 (1.02–3.41)	0.044
Pulmonary	2.07 (1.17–3.67)	0.012	2.05 (1.12–3.75)	0.020
History of treatment				
New	1		1	
Other previously treated	3.44 (2.47–4.80)	<0.001	2.23 (1.63–3.05)	<0.001
Relapse	3.47 (2.86–4.21)	<0.001	2.30 (1.92–2.76)	<0.001
Treatment after loss to follow-up	2.83 (2.10–3.82)	<0.001	2.45 (1.75–3.41)	<0.001

PR=prevalence ratio, estimated by modified Poisson regression with a log link and robust (Huber–White sandwich) variance; CI=confidence interval; DSTB=drug-susceptible tuberculosis; 1 denotes the reference category. The adjusted estimates are from a single multivariable model including age group, sex, region of TB registration, calendar period, DSTB regimen, TB disease classification and treatment history. Treatment history follows WHO and NTLP definitions: new, no previous TB treatment or less than one month of anti-TB drugs; relapse, previously treated and declared cured or treatment completed, now diagnosed with a recurrent episode; treatment after loss to follow-up, previously treated with treatment interrupted for two or more consecutive months and now re-registered; other previously treated, previously treated but the outcome of the most recent course unknown or undocumented. Regimens are 2HRZE/10RH (isoniazid, rifampicin, pyrazinamide and ethambutol for two months, then rifampicin and isoniazid for ten), 2RHZE/4RH (adult formulation) and 2RHZE/4RH-KID (paediatric dispersible formulation). The pre-COVID period is 2018–2019 and the COVID period 2020–2023. Referral source was excluded from the model, because children referred from a Care and Treatment Clinic are already known to be HIV-positive (crude PR 12.3, 95% CI 11.5–13.1), making referral source a consequence of the outcome rather than a determinant of it. All tests were two-sided with statistical significance set at 5%

Children registered with a previous history treatment carried a markedly higher prevalence and risk of co-infection than new cases. Mandalakas et al. (2020) reported worse TB outcomes among co-infected children in a multi-country sub-Saharan African cohort, and Mukuku et al. (2019) reported case fatality of 47.7% among co-infected children in Lubumbashi against 17.0% in HIV-uninfected children, a pattern that would arise if HIV-related immunosuppression precedes recurrent disease [19]. The reverse ordering is equally consistent the present study's findings, as are differences in referral pathways, health-system factors and unmeasured socioeconomic

Table 4 Comparison of adjusted prevalence ratios and adjusted odds ratios for factors associated with TB-HIV co-infection among children aged below 15 years registered with tuberculosis, ten high TB-HIV burden regions of Tanzania, 2018–2023

Characteristic	Adjusted PR (95% CI)	Adjusted OR (95% CI)	OR/PR
Age group			
<5 years	1	1	
5–9 years	2.00 (1.85–2.15)	2.32 (2.11–2.55)	1.16
10–14 years	2.40 (2.22–2.59)	2.99 (2.72–3.29)	1.25
Sex			
Female	1	1	
Male	0.99 (0.94–1.05)	0.99 (0.92–1.07)	1.00
Region of TB registration			
Geita	1	1	
Iringa	1.25 (1.11–1.41)	1.37 (1.17–1.61)	1.10
Kagera	0.51 (0.44–0.58)	0.45 (0.38–0.52)	0.88
Mara	0.41 (0.36–0.47)	0.35 (0.30–0.41)	0.85
Mbeya	1.35 (1.21–1.51)	1.53 (1.31–1.78)	1.13
Njombe	1.46 (1.30–1.64)	1.73 (1.46–2.04)	1.18
Ruvuma	0.45 (0.38–0.53)	0.40 (0.33–0.48)	0.89
Shinyanga	0.85 (0.76–0.95)	0.82 (0.72–0.94)	0.96
Songwe	0.95 (0.80–1.14)	0.95 (0.76–1.18)	1.00
Tabora	1.10 (1.00–1.22)	1.15 (1.01–1.30)	1.05
Period			
Pre-COVID (2018–2019)	1	1	
During COVID (2020–2023)	0.52 (0.49–0.55)	0.42 (0.39–0.46)	0.81
DSTB regimen			
2HRZE/10RH	1	1	
2RHZE/4RH	1.46 (1.09–1.96)	1.62 (1.17–2.29)	1.11
2RHZE/4RH-KID	1.56 (1.16–2.10)	1.76 (1.37–2.51)	1.13
Disease classification			
Both pulmonary and extra-pulmonary	1	1	
Extra-pulmonary	1.86 (1.02–3.41)	2.10 (1.14–4.35)	1.13
Pulmonary	2.05 (1.12–3.75)	2.37 (1.29–4.91)	1.16
History of treatment			
New	1	1	
Other previously treated	2.23 (1.63–3.05)	4.50 (2.16–9.45)	2.02
Relapse	2.30 (1.92–2.76)	4.68 (3.04–9.45)	2.03
Treatment after loss to follow-up	2.45 (1.75–3.41)	3.75 (2.18–6.35)	1.53

PR=prevalence ratio; OR=odds ratio; CI=confidence interval; DSTB=drug-susceptible tuberculosis; OR/PR=ratio of the adjusted odds ratio to the adjusted prevalence ratio; 1 denotes the reference category. Prevalence ratios were estimated by modified Poisson regression with a log link and robust (Huber–White sandwich) variance; odds ratios by binary logistic regression. Both models included the same covariates: age group, sex, region of TB registration, calendar period, DSTB regimen, TB disease classification and treatment history. Treatment history follows WHO and NTLP definitions: new, no previous TB treatment or less than one month of anti-TB drugs; relapse, previously treated and declared cured or treatment completed, now diagnosed with a recurrent episode; treatment after loss to follow-up, previously treated with treatment interrupted for two or more consecutive months and now re-registered; other previously treated, previously treated but the outcome of the most recent course unknown or undocumented. Regimens are 2HRZE/10RH (isoniazid, rifampicin, pyrazinamide and ethambutol for two months, then rifampicin and isoniazid for ten), 2RHZE/4RH (adult formulation) and 2RHZE/4RH-KID (pediatric dispersible formulation). The two measures coincide only when the outcome is rare; as prevalence rises the odds ratio moves further from the null in both directions, and the OR/PR column quantifies that divergence

factors. The present study recorded HIV status at registration for the current TB episode; after the previous treatment course had already occurred; so, it cannot order HIV acquisition and previous treatment in time. Whatever the mechanism, a documented history of previous TB treatment marks a subgroup with substantially higher co-infection prevalence, and it is a practical trigger for intensified or repeat HIV testing at registration. Clinical presentation offers a further, weaker signal.

The risk of co-infection was higher among children with pulmonary TB and among those with extra-pulmonary TB compared to those with both types. Only a small number of children were recorded as having both forms, and both confidence intervals are correspondingly wide, making these the least precise estimates in the analysis; they should be interpreted with caution. Extra-pulmonary TB is a recognized AIDS-defining illness and a marker of severe immunosuppression [3]. While direct testing of this expectation was constrained by the reference category, the overall decline warrants separate consideration as a distinct period-specific trend.

Despite the COVID-19 pandemic, co-infection prevalence continued to fall through 2020–2023. Studies from Malawi, Ghana and Zambia document 20–45% drops in TB notifications and HIV testing during the pandemic, with disproportionate under-detection of HIV-positive TB cases [25–28], and diagnostic disruption is therefore a plausible contributor. The present study's findings differ from those studies in one respect that warrants careful consideration. The prevalence was already falling by 24.3% per year between 2018 and 2019, before the pandemic. In a segmented analysis of the annual series with a change point at 2020, there was a significant one-off drop in prevalence beyond that pre-existing trend ($PR = 0.80$), but the annual rate of decline after 2020 did not differ significantly from the rate before it (PR for slope change = 1.11, $p = 0.072$). The pandemic, therefore, possibly had very little to do with the decline in the prevalence which is also another testament to the efforts of the Tanzanian TB and HIV programs.

This study analyses six years of national surveillance data as a census rather than a sample, covering 25,449 children across ten regions that account for a substantial share of Tanzania's pediatric TB notifications. It is the first analysis to test the temporal trend formally across six years and to model the characteristics independently associated with co-infection, moving beyond the descriptive counts that routine reporting provides, and it does so at a scale single-facility studies cannot reach. For the reader, this means the age and geographic gradients are precise enough to guide programmatic targeting rather than merely indicating a direction of effect: a district or regional TB coordinator can identify which age groups and which regions to prioritize for HIV testing and preventive therapy. Because staff recorded the data routinely at registration, recall and interviewer bias do not operate. However, several limitations should be considered. The study experienced inherent constraints of its design approach being retrospective, cross-sectional and use of existing data. Such included missing records and incompleteness among other challenges. Also, DHIS2-eTL does not record CD4 count, viral load, ART status, maternal HIV status, PMTCT history or socioeconomic position. This limited immunological interpretation and prevented any individual-level test of the mechanisms. Future studies could use the age, regional gradient and explore, an interrupted time-series or cohort designs aligned to intervention roll-out timelines to test some causal hypotheses raised here. The trend analysis rests on only six annual observations, which limited inference about the shape of the decline; with six time points the Mann–Kendall test has limited power, and its smallest attainable exact two-sided p -value is 0.0028. Finally, the study selected the ten regions purposively based on TB and HIV burden, so the estimates may not generalize to lower-burden regions of Tanzania.

Conclusion

Among children registered with TB in ten high TB-HIV burden regions of Tanzania between 2018 and 2023, the prevalence of TB-HIV co-infection was 14.4%. The pattern varied by time, age and place: prevalence fell in each successive year from 28.5% to 8.9%, rose steadily across age groups, showed no difference by sex, and was highest in Njombe, Mbeya and Iringa. After adjustment, age 10–14 years, any history of previous TB treatment, and registration in Njombe, Mbeya or Iringa were independently associated with co-infection. These findings describe HIV positivity within the notified pediatric TB cohort and identify three subgroups in which co-infection now concentrates. Co-infection was most prevalent among older children and among retreatment cases, so clinicians should offer HIV testing at TB registration to every child aged 5 years and above and to every child registered as a retreatment case, regardless of any previously documented negative result. This concentration is visible in routine counts but has not been tested analytically, and the NTLP should therefore incorporate periodic trend testing and

multivariable analysis of surveillance data into routine programme review, and prioritize Njombe, Mbeya and Iringa for intensification of integrated TB-HIV services. Older children with undiagnosed HIV remain the group in which co-infection persists, and PMTCT and early infant diagnosis services should strengthen tracing of HIV-exposed infants to the 18-month confirmatory test. This study identifies who is affected without establishing why and linking TB surveillance data to maternal and CTC records would be needed to identify modifiable predictors of co-infection.

Abbreviations

Abbreviation	Full term
aOR	adjusted odds ratio
aPR	adjusted prevalence ratio
ART	Antiretroviral therapy
CI	Confidence interval
COVID-19	Coronavirus disease 2019
CTC	Care and Treatment Clinic
DHIS2-eTL	District Health Information System 2 Electronic TB and Leprosy
DSTB	Drug-susceptible tuberculosis
HIV	Human immunodeficiency virus
LTFU	Lost to follow-up
NaTHREC	National Health Research Ethics Committee
NIMR	National Institute for Medical Research
NTLP	National Tuberculosis and Leprosy Programme
OR	Odds ratio
PMTCT	Prevention of mother-to-child transmission
PR	Prevalence ratio
RECORD	Reporting of studies Conducted using Observational Routinely collected health Data
SD	Standard deviation
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
TB	Tuberculosis
THIS	Tanzania HIV Impact Survey
TPT	Tuberculosis preventive therapy
WHO	World Health Organization

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Author contributions ENM: Conceptualization, methodology, analysis, writing, original draft, project administration. STW: Data review, analysis, and interpretation. DN, DK, and FSK: Technical oversight throughout study development, analysis, interpretation, writing, and review. DK, OGO, AR, JK, KMR, PS, RFB, and GAS: Critical review and editing of the manuscript. All authors read and approved the final manuscript.

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Data availability The individual-level dataset analyzed in this study cannot be shared publicly. It is the property of the Ministry of Health of the United Republic of Tanzania, access is governed by the National Tuberculosis and Leprosy Programme, and the terms of the data-sharing authorization under which it was obtained do not permit onward release. Requests for access to the individual-level data should be directed to the NTLP. The aggregated dataset necessary to interpret and replicate the findings reported in this article is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate See Ethical Considerations in the Methods. Ethical approval was granted by NIMR/Nather (Reference: NIMR/HQ/R.8a/Vol.IX/4988); permission to use programmatic data was granted by the Ministry of Health through the NTLP (Reference: GA.154/425/05/111/9); and the requirement for individual informed consent was waived by the ethics committee.

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Competing interests The authors declare no competing interests.

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References

1. World Health Organization (WHO). Global tuberculosis report 2025 [Internet]. 2025 [cited 2026 Aug 27]. Available from: <https://www.who.int/teams/global-programme-on-tuberculosis-and-lung-health/tb-reports/global-tuberculosis-report-2025>.
2. National TB, and Leprosy Programme (NTLP). epi-review_january_2023_-_united_republic_of_tanzania_-_final_report [Internet]. 2023 [cited 2026 Jun 16]. Available from: https://ntlp.go.tz/site/assets/files/1196/epi-review_january_2023_-_united_republic_of_tanzania_-_final_report.pdf.
3. Fry SHL, Barnabas SL, Cotton MF. Tuberculosis and HIV—An Update on the Cursed Duet in Children. *Front Pediatr*. 2019;7:159. <https://doi.org/10.3389/fped.2019.00159>.
4. Wondmeneh TG, Mekonnen AT. The incidence rate of tuberculosis and its associated factors among HIV-positive persons in Sub-Saharan Africa: a systematic review and meta-analysis. *BMC Infect Dis*. 2023;23(1):613. <https://doi.org/10.1186/s12879-023-08533-0>.
5. National AIDS. STIs and Hepatitis control programme (NASHCOP), Tanzania. National Integrated guidelines for management Of HIV, STIs and viral hepatitis [Internet]. 2024 [cited 2026 Aug 28]. Available from: <https://nacp.go.tz/re-sources/guidelines>.
6. National Bureau of Statistics (NBS). Tanzania, Office of the chief government statistician (OCGS), Zanzibar. THIS2022-2023_Summary_Sheet [Internet]. 2024 [cited 2025 Aug 3]. Available from: https://www.nbs.go.tz/nbs/takwimu/THIS2022-2023/THIS2022-2023_Summary_Sheet.pdf.
7. Morris BM, Nyamhagata M, Tarimo E, Sunguya B. Eliminating mother-to-child transmission of HIV in Tanzania calls for efforts to address factors associated with a low confirmatory test. Wagner AL, editor. *PLOS Glob Public Health*. 2023;3(3):e0001218. <https://doi.org/10.1371/journal.pgph.0001218>.
8. Masoja TS, Rwezaura R, Msanga DR, Chami N, Kabirigi J, Ambrose E, et al. Prevalence and outcome of HIV infected children admitted in a tertiary hospital in Northern Tanzania. *BMC Pediatr*. 2022;22:101. <https://doi.org/10.1186/s12887-022-03105-8>. PubMed PMID: 35189841; PubMed Central PMCID: PMC8860281.
9. National TB, and Leprosy Programme (NTLP). Manual for management of TB Leprosy in Tanzania.pdf [Internet]. Dodoma, Tanzania: Ministry of health, community development, Gender, Elderly Children; 2020 [cited 2026 Jul 25]. Available from: https://ntlp.go.tz/site/assets/files/1081/ntlp_manual_2020_2021_1.pdf.
10. Ministry of Health (MoH). Tanzania. Tanzania Health Facilities Atlas 2023 [Internet]. 2024 [cited 2026 Aug 28]. Available from: <https://www.moh.go.tz/storage/app/uploads/public/674/eb8/6d6/674eb86d688d4542845162.pdf>.
11. National Bureau of Statistics (NBS). Tanzania. Age_and_Sex_Distribution_Key_Finding_Report_Tanzania. [Internet]. 2022 [cited 2026 Aug 28]. Available from: https://www.nbs.go.tz/nbs/takwimu/Census2022/Age_and_Sex_Distribution_Key_Finding_Report_Tanzania.pdf.
12. World Health Organization (WHO). Global tuberculosis report 2024 [Internet]. 2024 [cited 2026 Jun 4]. Available from: <https://iris.who.int/server/api/core/bitstreams/7292c91e-fb0-4cef-ac39-0200f06961ea/content>.
13. Daniel OJ, Adejumo OA, Gidado M, Abdur-Razzaq HA, Jaibesimi EO. HIV-TB co-infection in children: associated factors and access to HIV services in Lagos. *Nigeria public health action*. 2015;5(3):165–9. <https://doi.org/10.5588/pha.15.0027>.

14. Mukuku O, Mutombo AM, Kakisingi CN, Musung JM, Wembonyama SO, Luboya ON. Tuberculosis and HIV co-infection in Congolese children: risk factors of death. *Pan Afr Med J*. 2019;33. <https://doi.org/10.11604/pamj.2019.33.326.18911>.
15. Venturini E, Turkova A, Chiappini E, Galli L, De Martino M, Thorne C. Tuberculosis and HIV co-infection in children. *BMC Infect Dis*. 2014;14(S1):S5. <https://doi.org/10.1186/1471-2334-14-S1-S5>.
16. Chaudhury S, Hertzmark E, Muya A, Sando D, Ulenga N, Machumi L, et al. Equity of child and adolescent treatment, continuity of care and mortality, according to age and gender among enrollees in a large HIV programme in Tanzania. *J Int AIDS Soc*. 2018;21(Suppl 1):e25070. <https://doi.org/10.1002/jia2.25070>. PubMed PMID: 29485735; PubMed Central PMCID: PMC5978660.
17. Nuwagaba-Biribonwoha H, Kilama B, Antelman G, Khatib A, Almeida A, Reidy W, et al. Reviewing progress: 7 year trends in characteristics of adults and children enrolled at HIV care and treatment clinics in the United Republic of Tanzania. *BMC Public Health*. 2013;13:1016. <https://doi.org/10.1186/1471-2458-13-1016>. PubMed PMID: 24160907; PubMed Central PMCID: PMC3937235.
18. National Bureau of Statistics (NBS). Tanzania, Office of the Chief Government Statistician (OCGS), Zanzibar. FINAL_ THIS 2016 2017_Final Report__02.28.19_EnglishCover.pdf [Internet]. 2018 [cited 2026 Jun 4]. Available from: https://www.nbs.go.tz/nbs/takwimu/this2016-17/THIS_2016-2017_Final_Report.pdf.
19. Mandalakas AM, Kay AW, Bacha JM, Devezin T, Golin R, Simon KR, et al. Tuberculosis among Children and Adolescents at HIV Treatment Centers in Sub-Saharan Africa. *Emerg Infect Dis*. 2020;26(12):2933–43. <https://doi.org/10.3201/eid2612.202245> PubMed PMID: 33219815; PubMed Central PMCID: PMC7706926.
20. Lawn SD, Myer L, Edwards D, Bekker LG, Wood R. Short-term and long-term risk of tuberculosis associated with CD4 cell recovery during antiretroviral therapy in South Africa. *AIDS*. 2009;23(13):1717–25. <https://doi.org/10.1097/QAD.0b013e32832d3b6>. PubMed PMID: 19461502; PubMed Central PMCID: PMC3801095.
21. Pettit AC, Mendes A, Jenkins C, Napravnik S, Freeman A, Shepherd BE, et al. Timing of Antiretroviral Treatment, Immunovirologic Status, and TB Risk: Implications for Testing and Treatment. *JAIDS J Acquir Immune Defic Syndr*. 2016;72(5):572–8. <https://doi.org/10.1097/QAI.0000000000001018>.
22. Eaton JW, Garnett GP, Takavarasha FR, Mason PR, Robertson L, Schumacher CM, et al. Increasing Adolescent HIV Prevalence in Eastern Zimbabwe – Evidence of Long-Term Survivors of Mother-to-Child Transmission? *PLoS ONE*. 2013;8(8):e70447. <https://doi.org/10.1371/journal.pone.0070447>. PubMed PMID: 23950938; PubMed Central PMCID: PMC3737189.
23. Okello B, Nyana H, Luwukya R, Odongkara M, Kibone W, Bongomin F. Breakthrough mother-to-child transmission of HIV in a low-health facility in Uganda. *IJID Reg*. 2023;8:153–6. <https://doi.org/10.1016/j.ijregi.2023.07.009>.
24. Pegurri E, Konings E, Crandall B, Haile-Selassie H, Matinhure N, Naamara W, et al. The Missed HIV-Positive Children of Ethiopia. *PLoS ONE*. 2015;10(4):e0124041. <https://doi.org/10.1371/journal.pone.0124041>.
25. Chanda-Kapata P, Ntouni F, Kapata N, Lungu P, Mucheleng'anga LA, Chakaya J, et al. Tuberculosis, HIV/AIDS and Malaria Health Services in sub-Saharan Africa - A Situation Analysis of the Disruptions and Impact of the COVID-19 Pandemic. *Int J Infect Dis*. 2022;124(Suppl 1):S41–6. PubMed PMID: 35341998; PubMed Central PMCID: PMC8949686.
26. Flanagan CF, McCann N, Stover J, Freedberg KA, Ciaranello AL. Do not forget the children: a model-based analysis on the potential impact of COVID-19-associated interruptions in paediatric HIV prevention and care. *J Int AIDS Soc*. 2022;25(1):e25864. <https://doi.org/10.1002/jia2.25864>. PubMed PMID: 35048515; PubMed Central PMCID: PMC8771146.
27. Lungu P, Kerkhoff A, Muyoyeta M, Kasapo C, Nyangu S, Kagujje M, et al. Interrupted time-series analysis of active case-finding for tuberculosis during the COVID-19 pandemic, Zambia. *Bull World Health Organ*. 2022;100(03):205–15. <https://doi.org/10.2471/BLT.21.286109>.
28. Osei E, Amu H, Kye-Duodu G, Kwabla MP, Danso E, Binka FN et al. Impact of COVID-19 pandemic on Tuberculosis and HIV services in Ghana: An interrupted time series analysis. Atalell KA, editor. *PLoS ONE*. 2023;18(9):e0291808. <https://doi.org/10.1371/journal.pone.0291808>.

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