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Missed opportunity for tuberculosis screening and prevention and the associated factors among child contacts in rural southwestern Uganda

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Abstract

Background Tuberculosis (TB) treatment and control guidelines recommend screening of contacts of bacteriologically confirmed TB cases and prompt initiation of preventive therapy. However, many children exposed to TB in high-burden settings like Uganda remain unscreened. The extent of the missed opportunity for screening TB-exposed children in Ugandan rural settings remains largely unknown. We determined the burden and associated factors of missed opportunity for TB screening and prevention in rural southwestern Uganda.

Methods We conducted a cross-sectional study in four high-volume TB treatment centers in Kanungu District, southwestern Uganda. Using consecutive sampling, we included children aged 0–14 years who were household contacts of bacteriologically-confirmed persons with TB. We defined a missed opportunity as not being screened for TB or not receiving preventive TB treatment despite being eligible. We used modified Poisson regression to identify factors associated with the missed opportunities.

Results Among 279 children enrolled from 79 households, 119 (42.7%) were aged < 5 years, 103 (36.9%) were 5–10 years, and 57 (20.4%) were 11–14 years. Overall, 140 (50.2%) were never screened. Of the 139 screened, 25 (18.0%) reported TB symptoms and 6 (24.0%) of these received TB treatment; among the 19 symptomatic but untreated, 3 (15.8%) missed isoniazid preventive therapy (IPT) initiation. Of 114 asymptomatic contacts, 60 were IPT-eligible, yet 34 (56.7%) were not initiated on IPT. Overall, 177/279 (63.4%; 95% CI: 67.6–68.9%) experienced a missed screening or prevention opportunity. Factors independently associated with missed opportunity were living in a household below the poverty line (adjusted prevalence ratio [aPR] = 1.62, 95% CI: 1.19–2.21), lack of formal education among index patients (aPR = 1.41, 95% CI: 1.09–1.83), and being a contact aged < 5 years (aPR = 1.45, 95% CI: 1.12–1.88).

Conclusion Our study revealed a high burden of missed opportunity for TB screening and prevention among child contacts in this rural setting, driven by socio-economic disadvantages, including household poverty, lack of formal education, and younger age for household TB contacts (< 5 years). Interventions should target socio-economically disadvantaged households to improve access to TB screening and preventive care.

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Keywords Tuberculosis, Contact tracing, Pulmonary, Child, Uganda

Introduction

Despite being preventable and treatable, tuberculosis (TB) remains a major global health challenge, particularly in low- and middle-income countries, where approximately 1.2 million pediatric cases are reported annually [1]. Children who develop TB usually acquire the infection from an adult contact in the community, often living within the same household [2]. Pediatric TB cases are often underdiagnosed due to diagnostic challenges hence contributing to high morbidity and mortality, especially in resource-limited settings [3]. At the 2018 United Nations (UN) high-level meeting on TB, member states committed to providing tuberculosis preventive therapy (TPT) to 30 million people, including 4 million children < 5 years; however, these targets were not met by 2022 [1]. Despite WHO recommendations, global uptake of TPT remains low, with only 27% of the 1.3 million eligible children < 5 years starting treatment in 2018, most of whom (76%) were in Africa [4].

Missed opportunity for screening and preventing TB among exposed children represent a critical gap in TB control efforts globally [5]. Inadequate health system infrastructure, limited access to preventive services, and insufficient knowledge among caregivers and healthcare workers contribute to these missed opportunities [5–8]. Despite WHO guidelines that emphasize the importance of contact tracing and preventive treatment for children exposed to TB, many high-burden countries, including Uganda, face challenges in fully implementing these measures [9].

Uganda is among the 30 high-burden countries for TB, with children accounting for 12% of all TB cases [10]. Despite the national TB control program's efforts, many children exposed to TB through household contacts go unscreened [11]. The Uganda Ministry of Health recommends the following strategies to enhance the identification of TB household contacts: (1) scheduling home visits for index patients diagnosed with TB as soon as possible; (2) conducting these visits by physically reaching the residences of index patients; (3) screening all household contacts; and (4) ensuring that all symptomatic and high-risk contacts undergo comprehensive TB evaluation [12]. Furthermore, all children living with HIV who are exposed to TB and children under 5 years of age who are contacts of bacteriologically confirmed TB cases should be provided with TB preventive therapy [12]. Nevertheless, the implementation of these guidelines remains sub-optimal [11]. In most of rural Uganda, the frequency of missed opportunities for TB screening among exposed children remains largely unstudied. Identifying these missed opportunities and the factors contributing to

them is crucial to improving TB prevention efforts in rural Uganda and similar settings elsewhere. Therefore, the purpose of this study was to determine the prevalence of missed opportunity for TB screening and prevention, and identify the associated factors in rural Uganda.

Methods

Study design and setting

We conducted a cross-sectional study design with a quantitative approach in Kanungu, a rural district in southwestern Uganda. The district is located at the Ugandan border with Democratic Republic of Congo, approximately 420 km from Kampala, the capital city. With a population of 277,300 people across an area of 1,271 square kilometers, the primary source of income for residents is agriculture. Healthcare services related to TB are delivered through 18 diagnostic and treatment centers, organized under two health sub-districts, which represent county-level administrative units in the Ugandan health system.

Data were collected from November 3, 2023 to February 20, 2024. We collected data from four TB treatment sites in Kanungu District, which we purposively selected as they contributed the highest patient load in the district. These sites comprised Kambuga Hospital also the main district hospital, Kihiihi Health Centre IV (county level) and two health facilities (Katete and Nyamirama) at the sub-county level. The TB preventive therapy (TPT) regimen that was offered at these study sites involved administration of isoniazid treatment daily for six months. TB screening is typically conducted at health facilities, and the guidelines recommend home visits for index patients to identify household contacts and initiate TB screening and preventive treatment. Each health facility has a TB Focal Person trained in TB contact investigation and TPT practices.

Study population and eligibility

The study included children aged 0–14 years who were household contacts of TB patients receiving treatment at the four selected TB treatment sites. We defined a household TB contact as a child who shared an enclosed living space with the index TB case-patient for one or more nights within the past three months prior to the start of TB treatment [12]. Persons with TB that was not bacteriologically confirmed pulmonary TB or those transferred to other treatment sites were excluded.

Sampling and sample size calculation

We conducted a census of all eligible households with a bacteriologically confirmed persons with TB receiving

treatment at the four selected TB treatment sites in Kanungu District. According to the Kanungu District TB registry, there were 120 patients undergoing treatment at these sites. Based on Uganda Bureau of Statistics (UBOS) data, the average household size in Kanungu District is 4.7 people, with children aged 0–14 years comprising 45.9% of household members. Thus, we estimated an average of 2.15 children aged 0–14 years per household [13]. Using this estimation, we expected approximately 258 children from the households of these 120 persons with TB. As it was logistically possible to reach all these children, we did not calculate a formal sample size. We aimed to recruit all the eligible children aged 0–14 years who were household contacts of bacteriologically confirmed persons with TB. An ad hoc power analysis indicated that with a fixed sample of about 258 children, the study would have 80% power to detect a prevalence ratio of 0.67 for the association between proximity to the health facility (≤ 5 km vs. > 5 km) and missed opportunities for TB screening and prevention, assuming a 95% confidence level. We hypothesized that children in households closer to the health facility (≤ 5 km) would be less likely to experience a missed opportunity compared to those living farther away [14]. These calculations were performed using OpenEpi Version 3 (PowerCross module). Other key assumptions included a two-sided confidence interval of 95%, a missed opportunity of 40% among those living proximal or less than 5 km, 60% among those living more than 5 km [15], and an expected prevalence difference of -20% . We used a consecutive sampling approach to include all eligible persons with TB, thereby reaching their household contacts.

Data collection procedures

We identified bacteriologically confirmed persons with TB on treatment during the study period using TB registers and contact tracing records at the four selected treatment sites. Household contacts, specifically children aged 0–14 years, were identified through these registers, Village Health Teams (VHTs), clinic visits for medication refills, or direct communication with persons with TB via phone calls or home visits. Once eligible households were identified, we conducted home visits to collect data. Written informed consent was obtained from legal guardians, and assent was sought from children aged 7 years and older before participation. Trained research assistants used a semi-structured questionnaire (Appendix 1) to collect information from caregivers on individual and household socio-demographic characteristics, TB-related factors such as ever having symptoms, and access to healthcare. Children identified as TB contacts were screened for TB symptoms using the WHO pediatric TB diagnostic algorithm [16]. Data collected included

their TB screening history, preventive treatment status, and TB diagnosis outcomes.

Study variables

The dependent variable was the missed opportunity for TB screening and prevention among children aged 0–14 years. We defined a missed opportunity as not being screened for TB or not receiving preventive TB treatment despite being eligible.

We focused on health system factors (e.g., level of health facility for the index patient, distance to the health facility), sociodemographic factors (e.g., age, sex, education levels, and income level), and clinical factors (e.g., HIV status) as independent variables. Households or individuals with a weekly income of $\leq 25,000$ Ugandan Shillings, equivalent to earning < 1 USD per day, were considered to be living below the poverty line. For the assessment of malnutrition, we used the mid-upper arm circumference (MUAC) as the measurement tool. Children were classified into categories based on their MUAC values: moderate malnutrition was defined as a MUAC between 11.5 cm and 12.5 cm, while severe malnutrition was indicated by a MUAC of less than 11.5 cm, consistent with the World Health Organization (WHO) thresholds for malnutrition [17]. Household ventilation was assessed through direct observation, focusing on the presence of windows, ventilation openings, and airflow. Households were classified as “poorly ventilated” if they lacked a window or a ventilator on a room.

Data management and analysis

Data were entered into REDCap and analyzed using STATA version 15.1 (StataCorp, Texas, USA). The prevalence of missed opportunity for TB screening and/or prevention was calculated as the proportion of child contacts with missed opportunities out of all child contacts of bacteriologically confirmed persons with TB, expressed with 95% confidence intervals. Prevalence ratios (PRs) with corresponding 95% confidence intervals were used to assess associations between missed opportunity and potential factors. The primary outcome variable, missed opportunity, was binary. Given the high prevalence of missed opportunities, we used modified Poisson regression with robust standard errors to estimate prevalence ratios, as this approach avoids the overestimation of effect sizes obtained using logistic regression [18]. To identify factors associated with missed opportunity, we performed bivariate and multivariable analyses using multi-level mixed-effects generalized linear models. Independent variables were treated as categorical fixed effects, nested within household identifiers to account for clustering at the household level. Variables with a p -value < 0.2 in bivariate analyses were included in the

multivariable model, with statistical significance set at $p < 0.05$.

Results

During the study period, 124 persons with TB from four treatment sites were screened. Among these, 97 patients had positive sputum samples, and of these, 82 had children aged 0–14 years in their households. Six patients were lost to follow-up, and three (3.7%) declined to enroll in the study, resulting in a total of 79 patients (96.3%) being enrolled. From the 79 consenting households, a total of 279 children aged 0–14 years were included in the study (Fig. 1).

Missed opportunities for TB screening and treatment

Of the 279 children aged 0–14 years, 140 (50.2%) were not screened for symptoms of TB disease. Of the 139 screened children, 25 (18.0%) had a history of TB symptoms. Of the 25 children with history of TB symptoms, 6 (24.0%) were initiated on TB treatment, and among the 19 ever-symptomatic children who remained untreated, 3 (15.8%) were not initiated on IPT, despite being eligible. The remaining 16/19 untreated children were not eligible for IPT and had alternative diagnoses. For the 114 children with no history of TB symptoms, 60 children were eligible for IPT; however, 34 (56.7%) of these eligible children did not receive IPT (Fig. 2).

Overall, missed opportunities for screening and treatment occurred among 177 out of 279 children for a prevalence of 63.4% (95% CI: 57.6–68.9%).

Characteristics of contacts to persons with tuberculosis enrolled into the study

Of 279 TB-exposed children, 119 (42.7%) were under 5 years old, 103 (36.9%) were aged 5–10 years, and 57 (20.4%) were aged 11–14 years. Of the participants, 155 (55.6%) were female, and 119 (42.7%) had attained primary education. Slightly more than half (54.8%) lived in poorly-ventilated houses, and 219 (78.5%) were not malnourished. HIV status was known for 152 (54.5%) of the children, only one (0.8%) of whom tested positive (Table 1).

The proportion of children under 5 years was significantly higher in the missed opportunities group (49.2%) compared to the non-missed opportunity group (31.4%) ($p = 0.012$). Educational level differed significantly ($p = 0.011$): 66/177 (37.3%) of the missed-opportunity group had primary schooling versus 53/102 (52.0%) of the non-missed group. Known HIV status was less common among those with missed opportunities (26.0%) compared to those without (79.4%; $p < 0.001$). Poor household ventilation was also more frequent in the missed-opportunity group (69.5%) than in the non-missed group (29.4%; $p < 0.001$) (Table 1).

Index patient-related characteristics

Notably, 66.7% of the child contacts in the no missed opportunity group were linked to index patients who had a weekly income exceeding 25,000 UGX, compared to 26.5% in the missed opportunity group ($p < 0.001$). Additionally, 89.2% of index patients in the non-missed opportunities group had their TB treatment initiated by

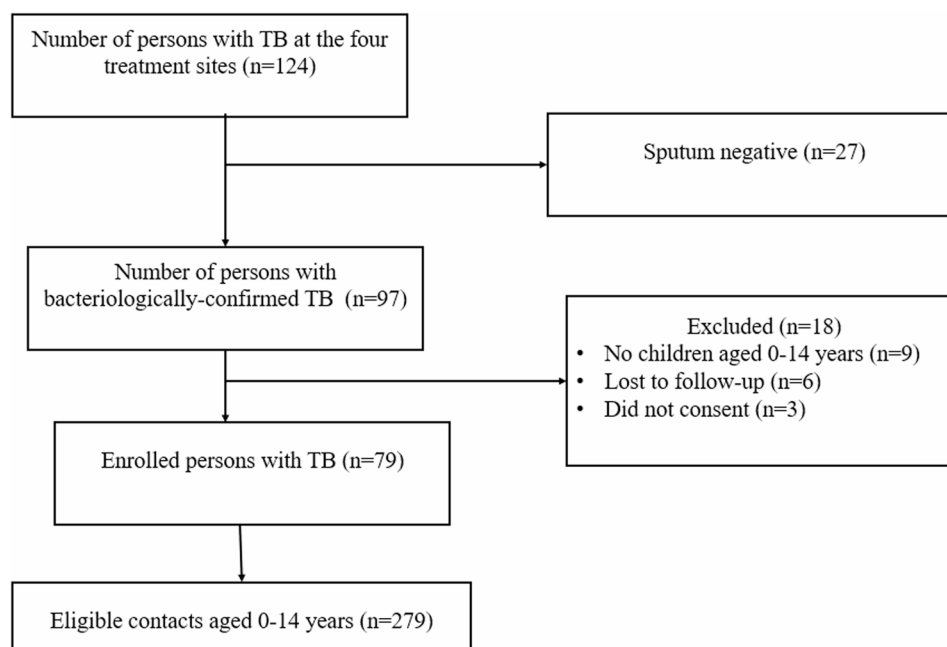


Fig. 1 Flowchart of participant enrollment and reasons for exclusion, Kanungu District, Uganda, November 2023 to February 2024

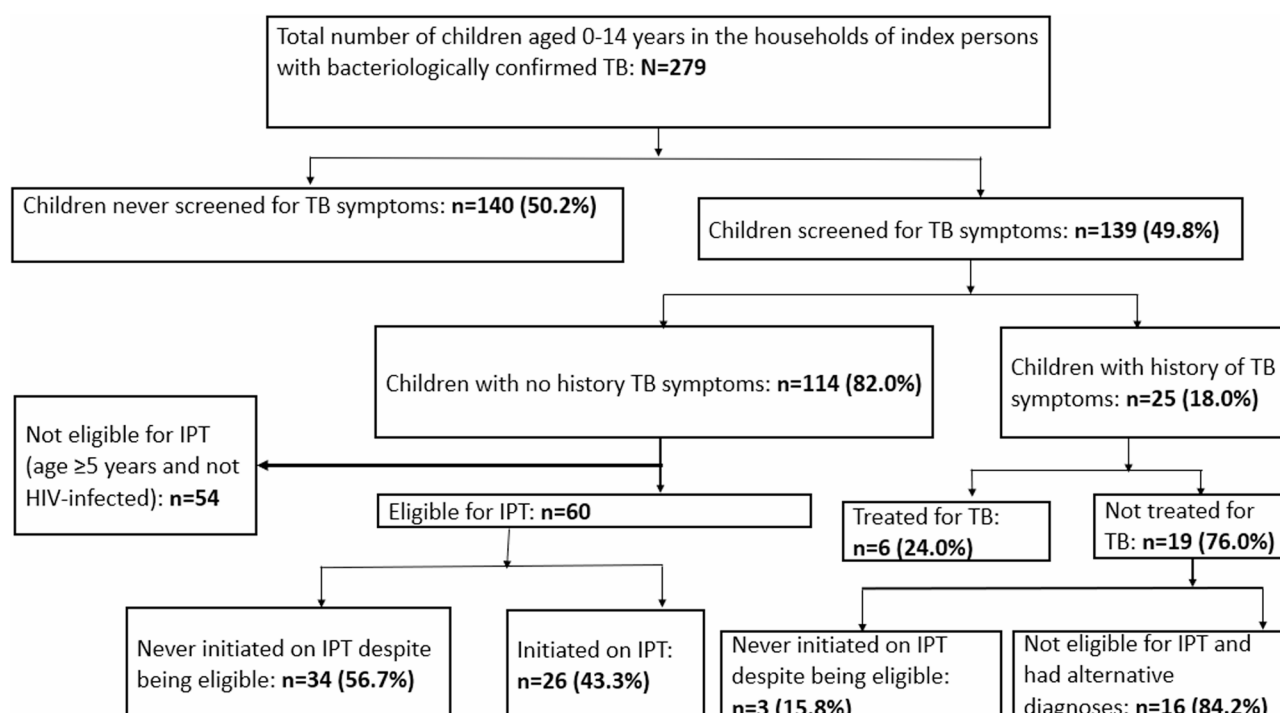


Fig. 2 Missed opportunities for TB screening and prevention among exposed children aged 0–14 years, Kanungu District, Uganda, November 2023 to February 2024 ($n=279$); TB: Tuberculosis, IPT: Isoniazid preventive therapy

a nurse, compared to 59.9% in the missed opportunity group ($p<0.001$) (Table 2). A significant difference was observed in education level: 26.0% of contacts in the missed opportunity group were linked to index patients who had no formal education, compared to 9.8% in the no missed opportunity group ($p=0.005$). Compared with contacts without missed opportunities, those with missed opportunities were more likely to be linked to index patients living ≥ 5 km from a health facility (75.7% vs. 55.9%; $p=0.001$) and to index patients attending HC IIIs (37.9% vs. 24.5%; $p=0.022$). Other characteristics, including age, sex, and TB status disclosure, showed no significant differences between the two groups (all $p>0.05$) (Table 2).

Factors associated with missed opportunity for TB prevention and treatment

Missed opportunity for TB investigation was significantly associated with the age of the household TB contact, household income, and the education level of the index TB case. Household TB contacts aged <5 years were more likely to experience missed opportunities compared to those aged 11–14 years (aPR=1.45, 95%CI: 1.12–1.88, $p=0.005$). Households earning $\leq 25,000$ Ugandan shillings per week (equivalent to <1 USD per day) were more likely to experience missed opportunities compared to those earning $>25,000$ UGX (aPR=1.62, 95% CI: 1.19–2.21, $p=0.002$). Furthermore, contacts of index patients

with no formal education had a higher prevalence of missed opportunities compared to those with primary education (aPR=1.41, 95% CI: 1.09–1.83, $p=0.008$) (Table 3).

Discussion

This study aimed to assess the burden of missed opportunity for TB screening and prevention and the associated factors among children aged 0–14 years. The study conducted in a rural setting of southwestern Uganda revealed that nearly two-thirds of child contacts experienced missed opportunity. Living below the poverty line, lack of formal education, and being a household contact aged under 5 years were significantly associated with missed opportunity for TB screening and prevention.

This study identified a high frequency of missed opportunity for TB screening among children aged 0–14 years, with 63% of child contacts not receiving appropriate preventive interventions. This substantial gap in pediatric TB care aligns with findings from other settings. For example, a retrospective study in South Africa reported that 86% of children with an indication for treatment did not receive latent TB infection (LTBI) prophylaxis [19]. This is expected to contribute significantly to the childhood TB burden. An Alabama cohort reported that 21% of preventable TB cases were attributable to failures in contact tracing, delays in initial assessment, or noncompliance with preventive therapy [20].

Table 1 Characteristics of TB-exposed children aged 0–14 years, Kanungu district, uganda, November 2023 to February 2024 (N = 279)

Characteristic	Overall (N = 279)		Missed opportunity (n = 177)		No missed opportunity (n = 102)		p value
	n	(%)	n	(%)	n	(%)	
Age of contact (Years)							0.012
< 5	119	(42.7)	87	(49.2)	32	(31.4)	
5–10	103	(36.9)	60	(33.9)	43	(42.2)	
11–14	57	(20.4)	30	(16.9)	27	(26.5)	
Sex of contact							0.505
Female	155	(55.6)	101	(57.1)	54	(52.9)	
Male	124	(44.4)	76	(42.9)	48	(47.1)	
Education level							0.011
Nursery	71	(25.5)	43	(24.3)	28	(27.5)	
Preschool	87	(31.2)	66	(37.3)	21	(20.6)	
Primary	119	(42.7)	66	(37.3)	53	(52.0)	
Secondary	2	(0.7)	2	(1.1)	0	(0.0)	
HIV status							< 0.001
Known	127	(45.5)	46	(26.0)	81	(79.4)	
Unknown	152	(54.5)	131	(74.0)	21	(20.6)	
HIV serostatus ^a							0.449
Negative	126	(99.2)	46	(100)	80	(98.8)	
Positive	1	(0.8)	0	(0.0)	1	(1.2)	
Nutrition status using MUAC							0.089
Moderate	43	(15.4)	26	(14.7)	117	(16.7)	
Normal	219	(78.5)	136	(76.8)	83	(81.4)	
Severe	17	(6.1)	15	(8.5)	2	(2.0)	
Household condition							< 0.001
Well ventilated	126	(45.2)	54	(30.5)	72	(70.6)	
Poorly ventilated	153	(54.8)	123	(69.5)	20	(29.4)	

MUAC Mid Upper Arm Circumference

^aAnalysed among those with known HIV serostatus (n = 127)

Global data further illustrate the persistent challenges in preventing pediatric TB. According to UNICEF, more than half of children who die from TB were not notified, indicating they were neither screened nor linked to care [21]. In Brazil, only 17% of children with indications for LTBI treatment received appropriate care [22]. Evidence from low-incidence countries also highlights substantial gaps [5]. In the United States, one study found that 40% of children under 5 years with TB disease identified through contact tracing experienced delays or failures in their evaluation or management [23]. Another U.S. study identified deficiencies in contact tracing and preventive management for 16% of children under 14 years [24]. A study in Germany revealed that among children under 5 years identified through contact tracing, only 32% were screened in accordance with guidelines, and just 20% received prophylactic or preventive treatment [25]. These findings underscore the critical need to enhance TB prevention strategies for pediatric populations globally. Strengthening contact tracing, ensuring timely and comprehensive screening, and improving adherence to preventive treatment protocols are critical steps toward reducing missed opportunities for TB prevention [5, 26]. Addressing these gaps may require a concerted effort

to optimize existing health systems, implement robust policies—including a willingness to accept some level of over-treatment to close the persistent case detection gap in young children—and ensure equitable access to TB care, particularly in resource-limited settings [27].

The association between being a younger contact (<5 years) and an increased prevalence of missed opportunities for TPT initiation in this study highlights significant gaps in providing timely TB prevention, particularly given that all children in this age group were eligible for TPT. These gaps are often attributed to factors such as failure to visit health facilities, which is a common issue in TB-endemic settings [28]. Additional barriers identified in similar studies include a lack of parental risk perception, knowledge gaps among healthcare workers, and limited access to treatment [29]. To address these challenges, it is essential to enhance patient-centered care, improve healthcare worker training, increase community education, and ensure a stable supply of medications to effectively deliver TPT [30]. Furthermore, previous research has shown that a community-based approach, leveraging the role of community health workers, can significantly improve contact investigation coverage and

Table 2 Index patient-related characteristics, Kanungu district, uganda, November 2023 to February 2024 (N = 279)

Characteristic	Overall (N = 279)		Missed opportunity (n = 177)		No missed opportunity (n = 02)		p value
	N	(%)	n	(%)	n	(%)	
Age (Years)							0.102
< 25	18	(6.5)	8	(4.5)	10	(9.8)	
25–50	172	(61.7)	116	(65.5)	56	(54.9)	
> 50	89	(31.9)	53	(29.9)	36	(35.3)	
Sex							0.813
Female	96	(34.4)	60	(33.9)	36	(35.3)	
Male	183	(65.6)	117	(66.1)	66	(64.7)	
Weekly income ^a							< 0.001
≤ 25k	164	(58.8)	130	(73.5)	34	(33.3)	
> 25k	115	(41.2)	47	(26.5)	68	(66.7)	
TB status disclosure							0.524
No	23	(8.2)	16	(9.0)	7	(6.9)	
Yes	256	(91.8)	161	(91.0)	95	(93.1)	
Cadre that initiated TB treatment							< 0.001
Nurse	197	(70.6)	106	(59.9)	91	(89.2)	
Medical officer or clinical officer	82	(29.4)	71	(40.1)	11	(10.8)	
Distance to nearest health facility							0.001
< 5 km	88	(31.5)	43	(24.3)	45	(44.1)	
≥ 5 km	191	(68.5)	134	(75.7)	57	(55.9)	
Health facility level of index patient							0.022
Hospital or HC IV	187	(67.0)	110	(62.1)	77	(75.5)	
HCIII	92	(33.0)	67	(37.9)	25	(24.5)	
Education level							0.005
None	56	(20.1)	46	(26.0)	10	(9.8)	
Primary	167	(59.8)	97	(54.8)	70	(68.6)	
Secondary or tertiary	56	(20.1)	34	(19.2)	22	(21.6)	

1k 1,000 Ugandan shillings, 1USD 3,600 shillings, HC Health Centre

^amedian weekly income = 20,000 (IQR: 10, 000 to 42,000 shillings)

increase TPT completion rates among child contacts in TB-endemic regions [31].

Living below the poverty line was significantly associated with missed opportunity for TB screening and prevention. Poverty imposes constraints on healthcare access, including transportation costs, limited health literacy, and the prioritization of immediate survival needs over health-seeking behavior [32]. Consistent with these findings, studies from low-resource settings have demonstrated that TB disproportionately affects socioeconomically disadvantaged populations, further entrenching health inequities [33, 34]. To address these barriers, health systems in resource-limited settings could adopt pro-poor models of care tailored to the needs of vulnerable populations [34]. Based on our findings, there is a need to scale up community-based screening initiatives targeting impoverished households, to improve access to essential TB prevention and treatment services. Implementing such approaches could reduce disparities in TB care and improve health outcomes in underserved populations, particularly in rural settings.

The association between lack of formal education in index patients and higher likelihood for missed

opportunities for TB prevention in our study aligns with findings from Ethiopia, where individuals unable to read or write were more likely to miss TB contact investigation opportunities [35]. Studies from Pakistan and Indonesia have demonstrated that individuals with higher levels of education have a better understanding of TB's clinical features and risk factors, which is crucial for timely detection and prevention [36, 37]. These findings highlight the need for targeted educational and counseling interventions within TB care programs, especially for populations with low education levels, so as to reduce missed opportunities for TB prevention [38].

Overall, our study reveals a high prevalence of missed opportunities for TB screening and prevention, which has significant public health implications, particularly concerning the implementation of TPT. Various studies have identified barriers to increased TPT coverage, including stockouts, lack of healthcare provider buy-in, and limited access to treatment [39, 40]. The recent WHO recommendation to screen all household contacts, including adults, for TB and initiate TPT for eligible individuals represents a critical strategy to reduce the global TB burden [41]. However, the feasibility of implementing

Table 3 Factors associated with missed opportunity for TB screening and prevention among exposed children aged 0–14 years, Kanungu district, Uganda, November 2023 to February 2024

Characteristic	Unadjusted analysis		Adjusted analysis	
	cPR (95%CI)	p value	aPR (95%CI)	p value
Age of contact (Years)				
< 5	1.39 (1.06–1.82)	0.017	1.45 (1.12–1.88)	0.005
5–10	1.11 (0.82–1.49)	0.502	1.15 (0.89–1.49)	0.283
11–14	Ref		Ref	
Household condition of contact				
Well ventilated	Ref		Ref	
Poorly ventilated	1.88 (1.51–2.33)	< 0.001	1.36 (0.99–2.38)	0.056
Age of index patient (years)				
< 25	Ref		1.10 (0.51–2.37)	0.809
25–50	1.52 (0.90–2.57)	0.121	Ref	
> 50	1.34 (0.78–2.31)	0.293	0.89 (0.65–1.20)	0.440
Sex of index patient				
Female	Ref		Ref	
Male	1.02 (0.85–1.82)	0.815	1.04 (0.81–1.36)	0.741
Weekly household income				
≤ 25k	1.94 (1.40–2.45)	< 0.001	1.62 (1.19–2.21)	0.002
> 25k	Ref		Ref	
Cadre that initiated TB treatment				
Nurse	Ref		Ref	
Medical officer or clinical officer	1.61 (1.38–1.88)	< 0.001	1.27 (0.99–1.49)	0.053
Education level of index patient				
None	1.41 (1.18–1.69)	< 0.001	1.41 (1.09–1.83)	0.008
Primary	Ref		Ref	
Secondary/Tertiary	1.05 (0.82–1.34)	0.726	1.06 (0.81–1.38)	0.677
Distance to nearest health facility				
< 5km	Ref		Ref	
≥ 5km	1.44 (1.14–1.81)	0.002	1.35 (0.99–1.84)	0.057
Health facility level of index patient				
HC III	Ref		Ref	
Hospital or HC IV	0.81 (0.68–0.96)	0.016	1.01 (0.81–1.27)	0.912

cPR Crude Prevalence Ratio, aPR Adjusted Prevalence Ratio, 1k 1,000 Ugandan shillings, 1USD 3,600 shillings, Ref Reference Category, HC Health Center

this recommendation in resource-limited settings like Uganda is challenged by existing barriers, such as limited healthcare access, insufficient community awareness, and gaps in healthcare worker training. Additionally, health facilities in Uganda often face capacity constraints that could hinder comprehensive screening and TPT provision [42]. While the WHO recommendation is vital for advancing TB control, a phased implementation strategy tailored to low-resource settings may be more feasible. This strategy could prioritize high-risk areas such as TB hotspots, informed by pilot programs and community engagement. Furthermore, addressing logistical and financial constraints will require substantial programmatic adjustments, including healthcare worker training, improving drug supply chains, and strengthening health system infrastructure to ensure effective implementation.

Our study has several limitations. First, the reliance on self-reported data introduces the potential for inaccuracies. Caregivers may have provided responses influenced by social desirability or misremembered events, leading to misclassification and potential overestimation or underestimation of the actual prevalence of missed opportunities. In addition, the reliance on caregiver-reported data on a binary “ever had TB symptoms” measure, may have misclassified children at the very first screening step since paediatric TB often presents subtly and caregivers can under- or over-report respiratory or constitutional symptoms [43]. Second, the lack of qualitative data limits the study’s ability to explore the underlying reasons for these missed opportunities, such as healthcare system challenges, caregiver perceptions, stigma, or healthcare worker practices. These limitations may reduce the depth of the findings and hinder the identification of specific, actionable barriers. Incorporating qualitative approaches in future research could provide richer insights and a more holistic understanding to guide targeted interventions. Third, we were not able to estimate the duration between diagnosis of index case and screening of contacts. Finally, although our study identified associations between some socio-economic factors and missed opportunities, it may be limited by residual confounding due to unmeasured variables, such as family access to food, which were not included in the analysis. Future studies in this setting should consider incorporating additional socio-economic factors to provide a more comprehensive understanding of their influence on TB preventive care.

Conclusion

Nearly two-thirds of children aged 0–14 years who were contacts of bacteriologically confirmed TB cases missed opportunities for TB screening and prevention. Socio-demographic and household factors, such as poverty, lack of formal education, and having a younger household

TB contact (<5 years of age), were significantly associated with a missed opportunity. Interventions should target socio-economically disadvantaged households to improve access to TB screening and preventive care and accelerate progress toward TB elimination, particularly in such high-burden rural settings.

Abbreviations

aPR	Adjusted Prevalence Ratio
CI	Confidence Interval
HC	Health Centre
HIV	Human Immunodeficiency Virus
IPT	Isoniazid Preventive Therapy
LTBI	Latent Tuberculosis Infection
MUAC	Mid-Upper Arm Circumference
TB	Tuberculosis
TPT	Tuberculosis Preventive Therapy
UNICEF	United Nations International Children's Emergency Fund
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

MMM, GT, RM, and FB conceptualized the study, and designed the methodology. MMM supervised data collection. RM and FB analyzed the data. MMM and RM drafted the initial manuscript. FB critically revised the manuscript for intellectual content. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Faculty Research and Ethics Committee (FREC) and the Research Ethics Committee of Mbarara University of Science and Technology (MUST-REC 2023 – 949). Permission to conduct the study was obtained from the Kanungu District leadership. Written informed consent was obtained from the legal guardians of all study participants, and assent was obtained from children aged 7 years and older. All study procedures were conducted in accordance with relevant ethical guidelines and regulations, including the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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