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Closing the Missing Children Gap: Paediatric Tuberculosis Case-Finding Through School-Based, Child-Led Screening in Kakamega, Kenya

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ABSTRACT : Kenya's NTLD-P targets children as 10–15% of all notified tuberculosis (TB) cases, a target the country has struggled to meet. This study examines the paediatric TB care cascade generated by the Kenya Innovation Challenge Tuberculosis (KIC-TB) project's school-based, child-led screening model in Kakamega, asking whether it displays the sex-based inequity previously documented among adults reached by the same programme, and whether its paediatric contribution meets national case-finding benchmarks. This is a retrospective, descriptive and analytical study of programmatic screening data from the NFM3 funding phase (July 2021–June 2024), the period for which complete, sex-disaggregated paediatric records are available. The care cascade: screened, presumptive, investigated, diagnosed, and linked to treatment was analysed by sex using chi-square and Fisher's exact tests, with odds ratios and 95% confidence intervals, and benchmarked against national and global literature. Of 266,943 children screened, 214 were diagnosed with TB (117 bacteriologically confirmed) and all were linked to treatment (100%). No significant sex difference was found at any cascade stage (all $p > 0.17$). Children accounted for 23.2% of all TB cases diagnosed, exceeding national targets, with bacteriological confirmation (54.7%) above typical global figures (20–30%), though the number needed to screen (1,247) exceeded the pooled global school-setting estimate (464). School-based, child-led screening can close a meaningful share of Kenya's paediatric case-finding gap without introducing sex-based inequity, and current evidence supports expanding this channel rather than treating it as an unproven pilot.

KEYWORDS: paediatric tuberculosis, case detection gap, school-based screening, child-led screening, Kenya, care cascade, gender equity, active case-finding

1. INTRODUCTION

Childhood tuberculosis (TB) remains substantially under-detected worldwide. Of the estimated 10.8 million people who fell ill with TB globally in 2023, roughly 12% were children and young adolescents aged 0–14 years; among children under five specifically, fewer than half of estimated cases were notified (World Health Organization, 2024). Children with TB are frequently paucibacillary, cannot easily produce sputum, and present with non-specific symptoms that overlap with common childhood illnesses, all of which depress both clinical recognition and bacteriological confirmation relative to adults (Seddon et al., 2015).

Kenya's NTLD-P has set a paediatric notification target of 10–15% of all notified TB cases; in 2022, children accounted for 11.4% of national notifications (NLTD-P, 2023). Kakamega County's own paediatric notification performance has historically lagged behind this already-modest national target, despite the county carrying a substantial share of Kenya's overall TB burden. Passive, facility-based case-finding in the county's rural and peri-urban sub-counties faces the same structural barriers documented nationally: caregivers must first recognise a child's symptoms as TB-related, then be willing and able to bring the child to a facility, a sequence that can break down at multiple points before a child is ever tested. The Kenya Innovation Challenge Tuberculosis (KIC-TB) project piloted a school-based model designed specifically to bypass this sequence: children were screened themselves, within their schools, and equipped to prompt screening of household members, on the premise that schools offer an efficient, already-trusted channel for reaching a population conventional case-finding structurally under-serves.

This program's two previously published analyses examined gender-disaggregated diagnostic pathways among adults reached through this model (Barasa, 2025) and the comparative yield of children versus adults as a case for schools as adult TB surveillance hubs (Barasa & Kibebe, 2025). In both, children functioned as a comparison group rather than the primary subject. This leaves an open question directly relevant to programme

and policy design: does the paediatric cascade specifically show the same sex-based inequity documented among adults, and does this model's paediatric contribution meaningfully help close Kenya's national case-finding gap. This study addresses both questions directly, using the complete cascade data available for the programme's most recent funding phase.

2. LITERATURE REVIEW

The evidence base on active case-finding (ACF) for childhood TB has grown substantially in the past decade, but remains fragmented across settings and modalities. A 2023 systematic review conducted for the WHO Guidelines Development Group on systematic TB screening estimated the number needed to screen (NNS) to detect one active case across screening settings: 107 in healthcare settings (inpatient and outpatient combined), 1,117 in community settings, and 464 in school settings (Robsky et al., 2023). The same review concluded that heterogeneity across screening modalities and populations makes firm comparative conclusions difficult, and called for pediatric case-finding interventions to incorporate local contextual information rather than assume a single optimal channel.

Large-scale, longitudinal school-based programmes remain comparatively rare in the published literature. A prospective eight-year study of combined TB screening and preventive treatment across schools and residential institutions in Ladakh, India, found that repeated screening rounds combined with preventive therapy reduced TB incidence by 83% and TB infection prevalence by 32% between 2017 and 2024, with a herd-protection effect extending even to participants who did not themselves receive preventive treatment (Dorjee et al., 2026). Notably, that study found TB infection risk was significantly higher among male participants (adjusted prevalence ratio 1.23, 95% CI 1.16–1.30) — a sex disparity that stands in contrast to the null sex-difference finding this study reports for KIC-TB, and which is addressed directly in the Discussion below.

On diagnosis, the persistent difficulty of bacteriologically confirming TB in young children is well documented (Seddon et al., 2015), and clinical scoring systems have been developed specifically to compensate for this limitation, though systematic evaluation suggests their diagnostic accuracy still varies considerably by setting and population (Kakinda et al., 2024).

This literature establishes three things relevant to the present study. First, school-based screening is a recognised but comparatively under-evidenced ACF channel, with a documented NNS benchmark (464) against which new programmes can be assessed. Second, sex-based disparities in paediatric TB risk or detection are neither universal nor absent in the literature, they appear to be context-dependent, which makes an empirical test within any given programme necessary rather than assumable. Third, bacteriological confirmation difficulty in children is a persistent, well-established constraint that any programme's diagnostic performance should be read against. None of the existing literature, including this programme's own two prior publications, has examined these three dimensions together for a single school-based, child-led screening cohort. This is the gap the present study addresses.

2.1 Theoretical framework

This study draws on Levesque, Harris, and Russell's (2013) conceptual framework of patient-centred access to health care, which distinguishes five interacting dimensions: approachability, acceptability, availability and accommodation, affordability, and appropriateness. Facility-based passive case-finding for children depends on a caregiver first recognising symptoms as warranting care, then being able and willing to bring the child to a health facility; a sequence that can fail at multiple points along Levesque et al.'s framework, particularly approachability (whether the service is visible and known to the population) and availability (whether it can be physically reached without undue cost in time or money). School-based screening restructures this sequence by bringing approachability and availability to the child directly, within an institution already embedded in daily routine and already trusted by caregivers, rather than requiring a caregiver-initiated care-seeking journey. This framework offers a way to interpret, rather than merely describe, the equity finding this study reports: if the mechanism by which school-based screening improves access operates at the level of approachability and availability (dimensions that do not intrinsically vary by a child's sex) then the absence of a sex-based disparity in this study's cascade is theoretically consistent with, not merely incidental to, the design of the intervention itself.

3. MATERIALS AND METHODS

3.1 Study design and setting

This is a retrospective, descriptive and analytical study of programmatic screening data from the KIC-TB project, implemented by the Community Support Platform (CSP) as a Global Fund sub-recipient under Amref Health Africa in Kenya, across eight sub-counties of Kakamega County (Lurambi, Shinyalu, Mumias West, Butere, Ikolomani, Mumias East, Malava, and Lugari) and 205 primary and secondary schools. Kakamega County is a predominantly agricultural, densely populated county in western Kenya, and the eight sub-counties covered by this analysis vary considerably in population density, distance to the nearest diagnostic-capable health facility, and baseline TB notification performance, factors that this programme's companion geographic analysis addresses separately. The analysis presented here is scoped to the NFM3 funding phase (July 2021–June 2024), for which complete, sex-disaggregated cascade data for children are available in the programme's closure reporting; sex-disaggregated paediatric data for the earlier NFM2 phase (October 2019–May 2021) were not available at the level of detail required for this cascade analysis and are referenced only in aggregate, whole-programme context.

3.2 Study population and sampling

The study population comprises all school-going children (primary and secondary) across the 205 participating schools who underwent TB symptom screening as part of routine school-based health talks and individualised assessment conducted by trained community health volunteers and healthcare workers. Screening was universal within participating schools rather than sampled, meaning the cascade reported here reflects a full programmatic census for the phase studied, not a drawn sample.

3.3 Care cascade definition and data sources

The cascade comprises five stages: (i) screened for TB symptoms; (ii) identified as presumptive (symptomatic, referred for further assessment); (iii) investigated (sputum collected and tested via GeneXpert, TrueNat, or microscopy); (iv) diagnosed with TB, either bacteriologically confirmed

or clinically diagnosed in the absence of a positive bacteriological result; and (v) linked to treatment. All figures are drawn from the KIC-TB NFM3 closure report and underlying programmatic laboratory and referral records maintained by CSP and Amref Health Africa in Kenya.

3.4 Analytical procedures

Cascade outcomes were disaggregated by sex and compared using Pearson's chi-square test (with Yates' continuity correction for 2×2 tables), calculated in Python (SciPy, version consistent with the analysis environment used). Odds ratios with 95% confidence intervals (Wald method) were calculated for each comparison. Because four cascade-stage comparisons were tested, a Bonferroni-adjusted significance threshold of $p < 0.0125$ was applied as a sensitivity check. For the comparison with the smallest cell count (diagnostic modality by sex), Fisher's exact test was additionally run as a cross-check on the chi-square result. Statistical significance for the primary analysis was set at $p < 0.05$. In plain terms, these tests assess whether an observed difference between boys and girls at a given cascade stage is larger than would be expected by chance alone, while the odds ratio and its confidence interval indicate both the direction and the precision of that difference; a confidence interval spanning 1.0 indicates the data are consistent with no real difference between sexes. Children's contribution to overall programme case detection was calculated as their share of all TB cases diagnosed in the same phase, and the number needed to screen was calculated as total children screened divided by total children diagnosed, for direct comparison with the Robsky et al. (2023) pooled school-setting benchmark.

3.5 Ethical approval and consent

This analysis uses secondary, aggregated, de-identified programmatic data; no new human-subjects data were collected for this study. The underlying KIC-TB screening activities from which the aggregated data derive were conducted with authorisation from Kenya's Ministry of Health, Ministry of Education, and Teachers Service Commission, and with parental consent obtained for children's screening and children's own assent sought, as documented in this programme's companion publications and closure reporting.

4. RESULTS

4.1 The paediatric care cascade

Table 1 presents the full cascade. Of 266,943 children screened (93.6% of the target of 285,120), 7,717 (2.9%) were identified as presumptive TB cases. Of these, 7,265 (94.1%) were investigated, yielding 214 diagnosed cases: 117 (54.7%) bacteriologically confirmed and 97 (45.3%) clinically diagnosed. All 214 diagnosed children (100%) were linked to treatment. The number needed to screen to detect one case was 1,247.

Table 1. Paediatric TB care cascade by sex, KIC-TB NFM3 (July 2021–June 2024)

Cascade stage	Male	Female	Total	% of previous stage
Screened for TB	137,666	129,277	266,943	93.6% of target
Presumptive TB identified	3,921 (2.85%)	3,796 (2.94%)	7,717 (2.89%)	2.9% of screened
Investigated (sputum/GeneXpert)	3,684	3,581	7,265	94.1% of presumptive
Bacteriologically confirmed	56	61	117	54.7% of TB cases
Clinically diagnosed	53	44	97	45.3% of TB cases
Total TB cases	109	105	214	2.9% of investigated
Linked to treatment	109	105	214	100% of diagnosed

4.2 Sex-based comparison across the cascade

Table 2 presents the sex comparison at each cascade stage. No comparison reached statistical significance at $p < 0.05$, and all four comparisons remained non-significant under the Bonferroni-adjusted threshold of $p < 0.0125$. The Fisher's exact cross-check on the diagnostic-modality comparison (the smallest-cell comparison) returned $p = 0.339$, consistent with the chi-square result.

Table 2. Sex-based comparison across the paediatric care cascade

Cascade comparison (male vs. female)	χ^2	p-value	Odds ratio (95% CI)
Presumptive rate among screened	1.813	0.178	0.97 (0.93–1.01)
Investigation completion among presumptive	0.440	0.507	0.93 (0.77–1.13)
Diagnostic yield among screened	0.014	0.906	0.98 (0.75–1.28)
Diagnostic modality (bacteriological vs. clinical)*	0.722	0.396	0.76 (0.44–1.31)

**Fisher's exact test cross-check: p = 0.339.*

4.3 Benchmarking against national and global figures

Children accounted for 214 of the 922 total TB cases (23.2%) diagnosed through KIC-TB during the NFM3 phase, across all target populations combined. Table 3 situates this and the bacteriological confirmation rate against national and global benchmarks, including the school-setting NNS reported by Robsky et al. (2023).

Table 3. Children's contribution to case detection against national and global benchmarks

Benchmark	Value	KIC-TB (children, NFM3)
Kenya national paediatric notification target	10–15% of all notified TB cases	—
Kenya national paediatric notifications, 2022	11.4% of all notified cases	—
Children's share of all TB cases found by KIC-TB, NFM3	—	23.2% (214 / 922)
Global paediatric bacteriological confirmation (typical range)	20–30%	54.7%
Pooled number needed to screen, school settings (Robsky et al., 2023)	464	1,247

5. DISCUSSION

Four findings from this analysis warrant discussion in relation to the existing literature and this programme's own prior publications.

First, this school-based model identified and successfully linked to treatment a share of TB cases among children (23.2% of all cases found) that exceeds Kenya's national paediatric case-finding target and its most recently reported actual performance. Given that childhood TB is estimated to be substantially under-notified nationally and globally (World Health Organization, 2024), this is a meaningful contribution to closing Kenya's missing-children gap within the geography this programme reached.

Second, the complete absence of a statistically significant sex disparity anywhere in the paediatric cascade contrasts with two other findings in the literature this study draws on: the gender disparities documented among adults reached through the same programme (Barasa, 2025), and the significantly higher TB infection risk found among boys in the Ladakh school-screening cohort (adjusted prevalence ratio 1.23; Dorjee et al., 2026). This contrast is informative rather than contradictory. Read through Levesque et al.'s (2013) access framework, the mechanism plausibly at work here operates on the approachability and availability dimensions of access where school-based screening brings the service to the child within an institution already trusted and already part of daily routine, rather than requiring a caregiver-initiated journey through the health system. Neither approachability nor availability, as constructed by universal in-school screening, intrinsically varies by a child's sex, which is theoretically consistent with the null finding reported here. The adult gender disparities documented elsewhere in this programme, by contrast, arise further along the same framework's dimensions; acceptability and appropriateness of care-seeking, which are more directly shaped by household gender norms that a school-based channel does not, by design, remove for adults. The Ladakh finding, for its part, concerned TB infection prevalence detected through tuberculin/interferon-gamma testing across repeated screening rounds in a different population and setting, and is not a directly comparable outcome measure to the active-disease diagnosis cascade reported here. The broader conclusion is that sex-based patterns in paediatric TB risk and detection are setting- and mechanism-dependent rather than universal, which is itself a reason to test for them empirically within any given programme rather than assume either their presence or their absence.

Third, the bacteriological confirmation rate among KIC-TB's paediatric cases (54.7%) is markedly higher than the 20–30% typically reported in the global paediatric TB literature (Seddon et al., 2015). A plausible, though untested, explanation is population composition: KIC-TB's screened children were overwhelmingly school-going pupils aged approximately five years and above, a group that may find it easier to produce a usable sputum sample than the under-five children who dominate the hardest-to-confirm end of the global paediatric TB literature. Age at diagnosis was not captured at the resolution needed to test this directly in the present dataset (see Limitations below), so this explanation should be treated as a hypothesis for future analysis rather than an established finding.

Fourth, and less favourably, KIC-TB's number needed to screen among children (1,247) exceeded the pooled global estimate for school-based settings (464) reported by Robsky et al. (2023). This is worth stating plainly rather than omitting: by this specific efficiency metric, KIC-TB screened more children per case detected than the pooled literature benchmark for school-based programmes. Read alongside the target-exceeding case-share finding above, the honest interpretation is that this model trades some screening efficiency, relative to the global school-setting pooled estimate, for a paediatric case-finding contribution that nonetheless exceeds Kenya's national target; a trade-off that is reasonable in a high-burden, target-shortfall context, but should not be obscured by leading only with the more favourable comparison.

This comparison of children's 23.2% programme-level case share against Kenya's 10-15% national notification target also warrants a methodological caution: the two are not the same metric. The 23.2% figure describes children's share of TB cases within KIC-TB's own programme, whereas the national figures describe children's share of all TB cases notified across Kenya's entire health system. A screening programme that specifically targets schools would be expected, almost by design, to find a higher proportion of children than a passive, facility-based national notification system. The comparison is offered as context for interpreting the scale of this contribution, not as a claim that KIC-TB has directly moved the national notification percentage.

The 100% linkage-to-treatment rate among diagnosed children, for both sexes, is itself worth brief comment. A plausible contributing factor is that diagnosis and follow-up occurred within the same school-community structure that had already engaged the child's household through the screening process itself, potentially shortening the distance (logistical and relational) between diagnosis and treatment initiation relative to a

facility-initiated diagnosis with no prior household contact. This is offered as a plausible mechanism rather than a tested one, since the data reviewed here do not include time-to-treatment-initiation or follow-up process measures.

5.1 Limitations

This analysis is scoped to the NFM3 phase because sex-disaggregated paediatric cascade data for the earlier NFM2 phase were not available at the required level of detail; the true full-programme (2019–2024) paediatric contribution to case detection may therefore differ from the NFM3-specific figure reported here. Age at screening was not captured at the resolution needed to test the under-five versus school-age hypothesis raised above, or to disaggregate the number-needed-to-screen finding by age band. The analysis relies on programmatic screening and laboratory records rather than independent case verification. This is a deterministic, point-estimate analysis in most respects, without probabilistic sensitivity analysis. Finally, these findings derive from a single county-level implementation of one funding model and should not be generalised to other TB active case-finding contexts without local validation.

6. CONCLUSION

School-based, child-led TB screening in Kakamega identified and linked to treatment a share of childhood TB cases that exceeds Kenya's national paediatric case-finding target, with no evidence of sex-based inequity in the process and a bacteriological confirmation rate well above typical global figures, even though its screening efficiency (number needed to screen) trailed the pooled global benchmark for school-based settings. On balance, the evidence supports treating this model as a demonstrated contributor to national paediatric case-finding rather than an unproven pilot. This conclusion also speaks to a broader policy objective beyond TB control specifically: Kenya's commitment to Universal Health Coverage, and the Sustainable Development Goals' emphasis on leaving no one behind, both depend on closing exactly the kind of access gap this study examines; one where a caregiver-initiated, facility-based pathway systematically under-serves a population that an institution-based, child-initiated pathway can reach directly. A programme that demonstrably narrows this gap for one disease, without introducing a new equity problem along the way, is a relevant reference case for other conditions where school-age children are similarly under-diagnosed through passive, facility-based systems. From an education-sector and child-rights perspective, the finding also underscores that schools are not merely convenient screening venues but functioning access institutions in their own right: a child's routine presence in school, rather than a caregiver's initiative, was sufficient to trigger equitable access to diagnosis and treatment, which is itself an argument for embedding health screening more deliberately within the education system's existing infrastructure rather than treating it as an external health-sector intervention hosted temporarily on school grounds.

For policy and practice: the National TB, Leprosy and Lung Disease Program should consider adopting school-based, child-led screening as a funded, core paediatric case-finding strategy rather than a time-limited pilot, given that it already exceeds the national target within a single county. Donors and county governments should prioritise expanding the reach of this model- more schools, more sub-counties, over further pilot-stage evidence generation; the case for expansion rests on what NFM3 already demonstrates, not on an untested hypothesis. Resources for expansion need not be differentially targeted by sex, given the absence of sex-based inequity found here, but could instead be prioritised by school or sub-county coverage gaps identified in this programme's companion geographic analysis.

For future research directions: any future funding phase should be designed prospectively including age capture at the point of screening from the outset so that continued scale-up itself generates progressively stronger evidence on the under-five versus school-age question raised in this study, rather than positioning further study as a precondition for expansion. Future analyses would also benefit from a societal-perspective costing companion (already under development within this research programme) and from age-stratified replication once prospective data collection permits it.

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Conflict of Interest: The authors declare that they have no conflict of interest.

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