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Tuberculosis diagnostic utilization in Oromia Region, Ethiopia: a cross-sectional study on extent and associated factors

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Abstract

Background

Tuberculosis (TB) remains a leading cause of morbidity and mortality in Ethiopia, yet the utilization of confirmatory and supportive diagnostic tests is not adequately characterized. This study assessed the extent of TB diagnostic utilization and identified associated factors in health facilities of Oromia Region, Ethiopia.

Methods

A quantitative cross-sectional study was conducted from December 2023 to August 2024. Using stratified random sampling, 112 health facilities (31 hospitals, 42 health centers, 38 public-private facilities, and 3 referral laboratories) were included, along with 222 health professionals. Sample size was determined using the WHO Service Availability and Readiness Assessment (SARA) methodology. Data were collected using adapted WHO SARA tools via electronic Kobo Collect. Descriptive statistics, logistic regression (with Hosmer-Lemeshow goodness-of-fit and variance inflation factor diagnostics), Pearson correlation, and multiple linear regression were used for analysis. Sensitivity analyses were conducted using 2.7%, 5%, 7.5%, 10%, and 15% presumptive TB prevalence assumptions.

Results

Over six years (2018–2023), confirmatory TB tests increased modestly from 35,038 to 48,935 despite a rise in outpatient attendees from 2.3 to 6.6 million. Community-level test utilization averaged < 8%, and facility-based utilization remained below 11% across all sensitivity assumptions. The overall test positivity rate was 8.7%, with Xpert positivity stable at 10% and LF-LAM positivity fluctuating between 16.8% and 33.3%. Bacteriologically confirmed TB cases accounted for only 40.6% of notified cases. Rifampicin DST coverage increased from 30% to 80.7%, but second-line DST remained below 36%. Among health professionals, 75.2% (95% CI: 69.5%–80.9%) perceived diagnostic utilization as inadequate. In multivariate analysis of facility-level data, lack of a certified microscopist (aOR = 0.249, 95% CI: 0.073–0.845, p = 0.026), larger catchment population (aOR = 1.516 per doubling, 95% CI: 1.112–2.065, p = 0.008), and absence of a formal sample transport system (aOR = 13.893, 95% CI: 4.597–41.982, p < 0.001) were significantly associated with low diagnostic utilization. Private-for-profit management showed borderline significance (aOR = 4.480, 95% CI: 0.943–21.277, p = 0.059). The perception-based model identified low patient flow (OR = 0.018, 95% CI: 0.001–0.218), inadequate supply (OR = 0.023, 95% CI: 0.002–0.299), and no information about sample referral systems (OR = 0.006, 95% CI: 0.000–0.112) as significant predictors. Multiple linear regression revealed that X-ray tests (β = 0.940, p = 0.002) and OPD visits (β = 0.557, p = 0.044) were positively associated with TB case detection.

Conclusion

TB diagnostic utilization in Oromia Region was substantially lower than expected demand based on presumptive TB prevalence, with major gaps in confirmatory testing, DST coverage, and chest X-ray use. Systemic barriers including supply shortages, equipment failure, and weak referral systems were associated with low utilization and represent priority areas for intervention. Strengthening sample transport systems, ensuring certified microscopist availability, and integrating TB screening into routine OPD services are critical interventions.

Background

Tuberculosis (TB) remains a leading cause of morbidity and mortality globally, with an estimated 10.8 million new cases and 1.25 million deaths annually [1]. The disease disproportionately affects low and middle-income countries, where health systems face persistent challenges in early detection and effective management [1, 2]. Prompt and accurate diagnosis is the foundation of TB control, enabling timely treatment initiation, reducing transmission, and improving patient outcomes [3]. The World Health Organization's End TB Strategy underscores this by advocating for universal access to rapid molecular diagnostics [4].

Ethiopia, a high TB burden country, has committed to this global strategy. National policies and guidelines have been developed to integrate WHO-recommended rapid diagnostics (mWRDs) such as Xpert MTB/RIF and urine lipoarabinomannan (LF-LAM) assays into the healthcare system [5, 6]. Despite these commitments, significant implementation gaps persist. The national TB strategic plan acknowledges that most TB diagnoses still rely on conventional sputum microscopy (low sensitivity) and that coverage and full utilization of mWRDs remain inadequate [6]. A critical, under-evaluated aspect is the suboptimal utilization of both confirmatory and supportive TB diagnostic tools, a factor directly contributing to diagnostic delays and ongoing community transmission [7, 8].

Although the sensitivity and specificity of individual TB diagnostic technologies are well documented [9, 10], there is a remarkable lack of evidence regarding the system-level factors that influence their use in high-burden settings like Ethiopia. Moreover, no established benchmarks exist to guide countries on how many TB tests should be performed annually. Benchmarks for coverage, physical accessibility, and actual use of the full range of TB diagnostics from smear microscopy and Xpert to chest X-ray (CXR) and LF-LAM remain poorly defined [6, 11]. In the Oromia Region, Ethiopia's most populous region, the absence of empirical data on diagnostic utilization patterns represents a critical evidence gap [12].

Current monitoring and planning efforts by National TB Programs (NTPs) in many settings tend to focus on mWRD coverage among individuals already diagnosed with TB, rather than on the broader group of presumptive TB cases. In this study, the tuberculosis (TB) diagnostic workload at the health facility level was evaluated using all available testing methods such as WHO-recommended rapid molecular diagnostics (mWRD), smear microscopy, and other laboratory tests depending on each facility's capacity.

While the analysis covered all diagnostic modalities, particular emphasis was placed on mWRD utilization.

To overcome this gap, we estimated the expected diagnostic demand based on each facility's catchment population and WHO TB incidence estimates. We then compared this expected demand with the actual number of TB tests performed. This method allows for an assessment of diagnostic utilization relative to the expected burden of presumptive TB, instead of limiting the evaluation only to confirmed TB cases. Sensitivity analyses were conducted using 2.7%, 5%, 7.5%, 10%, and 15% presumptive TB prevalence assumptions to test the robustness of our conclusions. Given this context, the present study aimed to determine the level of TB diagnostic utilization and the factors associated with it within health facilities in Oromia Region, Ethiopia.

Methods

Study design and setting

A quantitative, descriptive cross-sectional study was conducted from December 15, 2023 to August 6, 2024 in Oromia Regional State, Ethiopia. Oromia is the largest region, comprising 21 administrative zones with a population of over 40 million [13]. The cross-sectional design allowed assessment of diagnostic utilization at a single point in time [14, 15].

Sampling and sample size

A stratified random sampling approach was used [16, 17]. Six geographical strata (Western, South-west, Central, Eastern, South-east, and Southern Oromia) were defined. Zonal health departments and hospitals were randomly selected from each stratum; districts were randomly selected within chosen zones; and public and private health facilities were randomly selected within selected districts [18].

Sample size for health facilities was estimated using the WHO Service Availability and Readiness Assessment (SARA) methodology [19, 20]. The SARA formula for facility-based surveys with a 15% margin of error and 95% confidence level is: $n = (Z^2 \times P \times (1-P)) / ME^2$, where $Z = 1.96$, $P = 0.5$ (maximum variability), and $ME = 0.15$ [19]. The target sample was 176 health facilities. We achieved 171 organizations (112 service delivery health facilities: 31 hospitals, 42 health centers, 39 public-private mix facilities; and 59 managing health offices). Additionally, 222 health professionals were purposively selected (one head of each health facility, two diagnostic specialists per facility, and one TB expert at each managing health office) [21]. Post-hoc, with 222 respondents in the perception-based logistic model (10 predictor variables), events per variable exceeded 10, indicating adequate power. For the facility-level analysis with 112 facilities and 6 predictors, the events per variable ratio was adequate (58 low-utilization events, EPV ≈ 9.7).

Data collection

Data were collected using structured questionnaires and checklists adapted from the WHO SARA facility readiness assessment tool, adapted to Kobo Collect data collection tool [19, 20]. Instruments captured: availability and utilization of confirmatory TB tests (smear microscopy, Xpert MTB/RIF, culture, LF-LAM) [22]; drug susceptibility testing (DST) coverage [23]; supportive diagnostics (CXR, ultrasound, CT, MRI) [24]; and health system factors (supply chain, equipment, manpower, sample referral systems) [25]. The tools were reviewed by TB program specialists and statisticians, and a pilot test was conducted in four health facilities (two hospitals, two health centres) [26, 27], establishing content and construct validity [28].

Ethical considerations

Ethical approval

was obtained from the College of Human Sciences Research Ethics Committee, University of South Africa (reference: 17677041_CREC_ChS_2023, 13 October 2023) and from the Oromia Health Bureau Ethical Review Committee (reference: OHRC/021/2023). Written informed consent was obtained from all participants. All methods were performed in accordance with relevant guidelines and regulations.

Data analysis

Data were entered into IBM SPSS version 29. Descriptive statistics (frequencies, means, proportions) were used [29]. To estimate expected diagnostic demand, we used WHO-reported TB prevalence (146/100,000) and varied presumptive TB prevalence among healthcare seekers from 2.7%, 5%, 7.5%, 10%, and 15% based on prior Ethiopian studies [30-32]. The 10% assumption was used as the primary estimate, with 2.7% representing the lower bound based on LF-LAM utilization among HIV-positive patients. Test utilization rates were calculated as the proportion of expected presumptive cases that received testing.

Outcome definitions

Two complementary approaches were used to assess factors associated with low diagnostic utilization:

1. Perception-based outcome (health professional survey, N = 222): "Low diagnostic utilization" was defined based on the question "Do you perceive TB diagnostic utilization as adequate?" (yes/no). This captures health workers' perceptions of systemic gaps in access, supply chain reliability, and service delivery efficiency which will be decided by Health facilities and Managing organizations.

2. Facility-based outcome (checklist data, N = 112 facilities): "Low diagnostic utilization" was defined as a health facility performing less than the median of the expected test volume based on catchment population and presumptive TB prevalence (10% primary assumption). Facilities were categorized as low

utilization (1) if their actual test volume was below the median expected volume, and high utilization (0) if above.

Statistical modeling

Perception-based logistic regression (N = 222): Binary logistic regression was performed to identify factors associated with perceived low diagnostic utilization [33]. Predictor variables (all binary, self-reported) were: low health seeking/patient flow, low TB screening practice, inadequate supply, equipment failure, inadequate manpower, lack of trained manpower, no information about sample referral system, postal office availability, alternative MOH transport system, and absence of laboratory professionals. Odds ratios (OR) with 95% confidence intervals (CI) were reported. Model diagnostics: Hosmer-Lemeshow test ($\chi^2 = 6.23$, $p = 0.621$, good fit); variance inflation factor (VIF) values ranged from 1.12 to 2.34, indicating no problematic multicollinearity.

Facility-based logistic regression (N = 112): Variables with bivariate $p < 0.05$ were entered into a multivariable logistic regression model. Covariates included: certified microscopist availability, catchment population (log2-transformed due to right skew), number of health officers, X-ray availability, private-for-profit vs government, and formal sample transport system availability. Adjusted odds ratios (aOR), 95% CI, and p-values were reported. Model diagnostics: Hosmer-Lemeshow $\chi^2 = 5.279$, df = 8, $p = 0.727$ (good fit); McFadden pseudo $R^2 = 0.391$; classification accuracy = 83.0%; AUC = 0.88 (excellent discrimination); VIF < 2 for all predictors, indicating no multicollinearity.

Linear regression: Multiple linear regression (stepwise) identified predictors of TB case detection. R^2, adjusted R^2, regression coefficients, and 95% CIs were reported.

Sensitivity analyses: Expected diagnostic utilization was recalculated using 2.7%, 5%, 7.5%, 10%, and 15% presumptive TB prevalence to assess whether the conclusion of "low utilization" remained robust.

Handling of missing data: For CXR data, only 11 of 31 hospitals maintained usable records; these were analysed as available, and the limitation is noted. For other variables, missing data were minimal (< 5%) and handled by listwise deletion.

Results

Sociodemographic characteristics

A total of 171 health organizations participated (112 service delivery health facilities and 59 managing health offices). Among 222 health professionals, 173 (78%) were male, 49 (22%) female. Facilities: 79 (70%) urban, 33 (30%) rural; 88% serving agrarian, 12% pastoralist communities. Educational qualifications: diploma 59 (26.5%), bachelor's 142 (63.9%), master's 17 (7.6%), specialized certificate 1 (0.4%). Professional roles: outpatient specialists 65 (29.2%), diagnostics professionals 99 (44.6%), woreda TB focal persons 38 (17.2%), regional TB focal persons 20 (9.0%).

Confirmatory diagnostic utilization

Between 2018 and 2023, catchment population served increased from 21.4 million to 26.3 million, and outpatient department (OPD) attendees rose from 2.3 million to 6.6 million. Total confirmatory TB tests increased from 35,038 to 48,935 (Table 1). Average community-level test utilization was < 8%, and facility-based utilization remained below 11% under the primary 10% presumptive TB prevalence assumption.

Table 1 TB diagnostic test utilization among eligible communities and expected OPD attendees, 112 health facilities

Year	Total population	OPD attendants	Expected presumptive cases (community)*	Expected presumptive cases (OPD)**	Confirmatory tests done	Utilization rate (community)	Utilization rate (OPD)
2018	21,405,073	2,329,131	577,937	232,913	35,038	6.1%	15.0%
2019	23,065,197	2,133,608	622,760	213,361	34,850	5.6%	16.3%
2020	22,248,189	2,475,825	600,701	247,583	28,353	4.7%	11.5%
2021	23,690,907	3,544,919	639,654	354,492	38,644	6.0%	10.9%
2022	23,288,029	3,774,231	628,777	377,423	47,894	7.6%	12.7%
2023	26,286,985	6,568,308	709,749	656,831	48,935	6.9%	7.5%

Sensitivity analysis of expected diagnostic demand

Because the 10% presumptive-TB-prevalence assumption is central to the utilization estimates above, we recalculated expected demand and utilization using a broad prevalence range (5%, 7.5%, 10%, 15%) and a range anchored to the only Ethiopia-specific pooled estimate available in the literature, 2.7% (95% CI 1.3–5.3%) [30], at both the community and facility (OPD) levels.

At the community level, under the 5%–15% prevalence range, utilization ranged from 1.09% (15% assumption, 2018) to 4.11% (5% assumption, 2022) (Table 2). Under the Ethiopia-specific range (1.3%–5.3%), the primary point estimate of 2.7% yielded utilization rates between 4.7% and 7.6% over the study period, while the lowest bound (1.3%) produced rates up to 15.8% (Table 3).

Table 2

Community-level TB diagnostic utilization under varying presumptive TB prevalence assumptions (5%–15%), region-wide

Year	Population	Tests	5%	7.5%	10%	15%
2018	21,405,073	35,038	3.27%	2.18%	1.64%	1.09%
2019	23,065,197	34,850	3.02%	2.01%	1.51%	1.01%
2020	22,248,189	28,353	2.55%	1.70%	1.27%	0.85%
2021	23,690,907	38,644	3.26%	2.17%	1.63%	1.09%
2022	23,288,029	47,894	4.11%	2.74%	2.06%	1.37%
2023	26,286,985	48,935	3.72%	2.48%	1.86%	1.24%

Table 3

Community-level TB diagnostic utilization under Ethiopia-specific literature-anchored presumptive TB prevalence assumptions (1.3%–5.3%), region-wide

Year	Population	Tests	1.3%	2.0%	2.7%	5.3%
2018	21,405,073	35,038	12.60%	8.20%	6.10%	3.10%
2019	23,065,197	34,850	11.60%	7.60%	5.60%	2.90%
2020	22,248,189	28,353	9.80%	6.40%	4.70%	2.40%
2021	23,690,907	38,644	12.50%	8.20%	6.00%	3.10%
2022	23,288,029	47,894	15.80%	10.30%	7.60%	3.90%
2023	26,286,985	48,935	14.30%	9.30%	6.90%	3.50%

at the facility (OPD) level, utilization based on the 10% primary assumption ranged from 7.5% to 16.3% (Table 4). Under the Ethiopia-specific range, the 2.7% assumption produced utilization rates of 27.6% to 60.5%, with the 1.3% assumption resulting in rates approaching or exceeding 100% (e.g., 115.7% in 2018) (Table 5). This latter finding suggests that the 1.3% prevalence anchor underestimates the true proportion of presumptive TB among OPD attendees in this high-burden setting, or reflects that recorded testing was not strictly limited to narrowly symptom-screened patients.

Table 4

Facility (OPD)-level TB diagnostic utilization under varying presumptive TB prevalence assumptions (5%–15%), region-wide

Year	OPD attendees	Tests	5%	7.5%	10%	15%
2018	2,329,131	35,038	30.10%	20.10%	15.00%	10.00%
2019	2,133,608	34,850	32.70%	21.80%	16.30%	10.90%
2020	2,475,825	28,353	22.90%	15.30%	11.50%	7.60%
2021	3,544,919	38,644	21.80%	14.50%	10.90%	7.30%
2022	3,774,231	47,894	25.40%	16.90%	12.70%	8.50%
2023	6,568,308	48,935	14.90%	9.90%	7.50%	5.00%

Table 5
Facility (OPD)-level TB diagnostic utilization under Ethiopia-specific literature-anchored presumptive TB prevalence assumptions (1.3%–5.3%), region-wide

Year	OPD attendees	Tests	1.3%	2.0%	2.7%	5.3%
2018	2,329,131	35,038	115.70%	75.20%	55.70%	28.40%
2019	2,133,608	34,850	125.60%	81.70%	60.50%	30.80%
2020	2,475,825	28,353	88.10%	57.30%	42.40%	21.60%
2021	3,544,919	38,644	83.90%	54.50%	40.40%	20.60%
2022	3,774,231	47,894	97.60%	63.40%	47.00%	23.90%
2023	6,568,308	48,935	57.30%	37.30%	27.60%	14.10%

Subgroup analysis of diagnostic performance

To further characterize diagnostic performance, we examined test positivity and utilization across livelihood, residence, and facility type subgroups (Table 6).

Table 6
Subgroup analysis of TB diagnostic test performance by facility and population characteristics (N = 112 facilities)

Subgroup	Facilities (n)	Overall Positivity	95% Confidence Interval
Livelihood			
Agrarian	98	9.40%	(8.9–9.9%)
Pastoralist	10*	9.10%	(7.8–10.4%)
Residence			
Urban	79	9.80%	(9.3–10.3%)
Rural	31*	8.80%	(7.5–10.1%)
Facility Type			
Hospital	30*	9.90%	(9.1–10.7%)
Health Center	42	5.20%	(4.3–6.1%)
PPM / Private Provider	38*	7.00%	(6.1–7.9%)

Hospitals demonstrated the highest positivity rate (9.9%), consistent with their role as referral centers managing more severe cases. Health centers had the lowest positivity (5.2%), likely reflecting reliance on less sensitive diagnostics (e.g., AFB microscopy) and broader screening criteria. Agrarian (9.4%) and pastoralist (9.1%) communities showed comparable positivity rates, suggesting similar TB burden. Urban facilities (9.8%) had slightly higher positivity than rural facilities (8.8%), possibly reflecting better diagnostic access. PPM/private facilities had an intermediate positivity rate (7.0%). Because the pastoralist and rural subgroups were small (Table 7), comparisons between subgroups should be interpreted with caution.

Table 7
Annual Facility (OPD)-level TB Diagnostic Utilization Rates (%) Stratified by Subgroup, Using 10% Presumptive TB Prevalence (Primary Estimate), 112 Health Facilities, Oromia Region, Ethiopia (2018–2023)

Year	Agrarian (%)	Pastoralist (%)	Urban (%)	Rural (%)	Hospital (%)	Health Center (%)	PPM / Private (%)
2018	11.8	9.2	10.8	17.7	14	8.8	7.7
2019	12.7	10.3	11.4	18.8	13.4	12.8	6.9
2020	8.6	7.6	8	10	9.5	8	5
2021	8.5	6.6	8	9.8	12.5	5.1	5.5
2022	10.7	12	10.8	10.5	14.5	6.3	5.8
2023	6	10	6	6.9	6.9	5.2	3.8

GeneXpert tests increased from 22,223 to 32,460; AFB microscopy (Ziehl-Neelsen) from 12,815 to 15,908. Urine LF-LAM was introduced in 2021 (171 tests), reaching 567 tests in 2023. Among HIV-positive patients with CD4 < 200, LF-LAM utilization increased from 0% in 2020 to 21.5% in 2023, but overall utilization among all ART patients remained ≤ 2.7% (Table 8).

Table 8
Trends of Urine LF-LAM utilization among HIV-positive patients, 112 health facilities

year	LF-LAM Tests Performed	HIV-positive patients with CD4 < 200	LF-LAM Utilization (%)	Total ART patients	Overall Utilization (%)
2020	0	14,261	0%	37,952	0%
2021	171	14,416	1.20%	42,231	0.40%
2022	342	14,825	2.30%	48,607	0.70%
2023	567	15,021	3.80%	53,586	1.10%

Test positivity rate

Overall positivity rate across all modalities was 8.7%. Xpert MTB/RIF positivity was consistently ~ 10%. Urine LF-LAM positivity varied annually (2.1% to 25.7%). AFB microscopy positivity averaged 5.8% (Table 9).

Table 9
Trends of Confirmatory test positivity rates by year (2018–2023), 112 health facilities

Year	Xpert MTB/RIF	AFB microscopy (ZN)	Urine LF-LAM
2018	10.20%	6.20%	Test not available
2019	10.50%	6.60%	Test not available
2020	9.50%	5.90%	Test not available
2021	10.10%	5.50%	25.70%
2022	9.80%	4.80%	2.10%
2023	9.90%	3.90%	16.60%

Mean annual pulmonary TB case detection efficacy was 64%. Bacteriologically confirmed TB among notified cases was 40.6%; 59.4% were clinically diagnosed (Table 10). Rifampicin DST coverage increased from 30% (2018) to 80.7% (2023). Second-line (fluoroquinolone) DST reached 36% by 2023; DST for bedaquiline/linezolid remained < 5%.

Table 10
Trends in pulmonary TB case detection and DST coverage among confirmed pulmonary cases, 112 health facilities

Year	Pulmonary cases (% of all forms)	Bacteriologically confirmed (% of all TB)	Rifampicin DST coverage (%)	Fluoroquinolone DST coverage (%)	Bedaquiline/linezolid DST coverage (%)
2018	62%	35%	30%	0%	0%
2019	63%	38%	37%	0%	0%
2020	64%	39%	45%	0%	0%
2021	65%	42%	59%	22%	5%
2022	64%	43%	71%	30%	4%
2023	66%	45%	81%	36%	0%

Supportive diagnostic utilization

Among 31 hospitals with CXR, only 11 had usable records. CXRs performed increased from 2,755 (2018) to 5,251 (2023). The proportion of OPD attendees receiving CXR varied from 6.1% to 12.8%. Abnormal CXR findings ranged from 5.0% to 15.6% of examinations (Table 11). It is important to note that CXR data were incomplete and should not be generalized to the entire region.

Table 11
Trends of Chest X-ray utilization among 11 hospitals with available records

Year	CXRs Performed	OPD attendees at the Hospital	CXR/OPD%	Abnormal CXR
2018	2,755	44,930	6.1	5
2019	3,124	41,560	7.5	15.6
2020	3,251	38,124	8.5	15
2021	3,789	44,557	8.5	12.3
2022	4,501	51,156	8.8	8.9
2023	5,251	55,800	9.4	10.2

Perception-based factors associated with low diagnostic utilization (N = 222 health professionals)

Among all respondents, 75.2% (95% CI: 69.5%–80.9%) perceived TB diagnostic utilization as inadequate. Table 12 shows the proportion of respondents citing various reasons for low diagnostic utilization.

Table 12
Proportion of TB experts responding on reasons for low diagnostic utilisation (N = 222, multiple responses allowed)

Perceived reason	% agreeing (yes)
Low health seeking / low patient flow	59.30%
Low TB screening practice	67.00%
Inadequate supply / reagent shortage	71.00%
Diagnostic equipment failure	67.90%
Inadequate manpower (general)	39.40%
Lack of trained manpower	56.60%
No information about sample referral system	51.60%
Absence of laboratory professionals	45.70%
Postal system for sample referral	50.20%
Alternative sample referral by health professional	22.70%

Multivariate logistic regression (Table 13) showed that low health seeking/patient flow (OR = 0.018, 95% CI: 0.001–0.218, p = 0.002), inadequate supply/reagent shortage (OR = 0.023, 95% CI: 0.002–0.299, p = 0.004), and no information about the sample referral system (OR = 0.006, 95% CI: 0.000–0.112, p < 0.001) were significantly associated with perceived low diagnostic utilization. Equipment failure showed

a borderline association (OR = 0.114, p = 0.083). The Hosmer-Lemeshow test indicated good fit (p = 0.621); VIF < 2.34.

Table 13
Factors associated with perceived low TB diagnostic test utilisation (binary logistic regression) among N = 222 health care workers

Variable	Odds Ratio (Exp(B))	95% C.I. for Exp(B)	Significance (Sig.)
Low health seeking/low patient flow	0.018	0.001–0.218	0.002
Low TB screening	0.358	0.070–1.821	0.216
Inadequate supply	0.023	0.002–0.299	0.004
Equipment failure	0.114	0.010–1.328	0.083
Inadequate manpower	0.59	0.101–3.443	0.558
Trained manpower	1.731	0.247–12.110	0.58
No information about sample referral system	0.006	0.000–0.112	< .001
Postal office	0.296	0.041–2.139	0.228
Alternative Ministry of Health	4.33	0.482–38.918	0.191
Laboratory professionals	1.507	0.179–12.685	0.706
Constant	153.06		0.004

Facility-level factors associated with diagnostic utilization (N = 112 facilities)

Bivariate analysis

Table 14 presents bivariate associations between facility characteristics and low diagnostic utilization. Significant predictors (p < 0.05) included: certified microscopist (OR = 0.251, p = 0.004), stethoscope availability (OR = 9.913, p = 0.034), X-ray availability (OR = 2.569, p = 0.029), number of health officers (OR = 0.657 per doubling, p = 0.028), catchment population (OR = 1.384 per doubling, p = 0.001), OPD attendants (OR = 0.843 per doubling, p = 0.010), private-for-profit management (OR = 3.730, p = 0.011), and formal sample transport system (OR = 17.082 for postal, p < 0.001; OR = 4.141 for Alternative MOH, p = 0.026).

Table 14
Bivariate analysis of facility characteristics associated with low TB diagnostic utilization (N = 112 facilities)

Variable / Category	Crude OR	95% CI Low	95% CI High	Wald p-value
Certified_ microscopist	0.251	0.1	0.634	0.0035
stethoscope	9.913	1.196	82.165	0.0335
x-ray_ available	2.569	1.103	5.985	0.0288
health _officers (per doubling)	0.657	0.452	0.956	0.028
catchment_ population (per doubling)	1.384	1.134	1.689	0.0014
OPD_ attendants (per doubling)	0.843	0.741	0.96	0.01
Managing _authority: private–for-profit	3.73	1.345	10.346	0.0114
Sample _transport _method: Postal	17.082	5.717	51.039	< 0.001
Sample _transport_ method: Alternative _MOH	4.141	1.187	14.45	0.0258

Variables with bivariate $p < 0.05$ were entered into a multivariable logistic regression model. The final model (Table 15) included: certified microscopist availability, catchment population (log2-transformed), number of health officers, X-ray availability, private-for-profit management, and formal sample transport system. The model showed excellent fit and discrimination (Hosmer-Lemeshow $p = 0.727$; McFadden pseudo $R^2 = 0.391$; AUC = 0.88; classification accuracy = 83.0%).

Table 15
Multivariable logistic regression: factors associated with low TB diagnostic utilization (N = 112 facilities)

Predictor	Adjusted OR (aOR)	95% CI Low	95% CI High	p-value	Significant?
Has accredited/certified microscopist (Yes vs No)	0.249	0.073	0.845	0.0258	Yes
Catchment population served (per DOUBLING)	1.516	1.112	2.065	0.0084	Yes
Number of health officers (per + 1)	0.902	0.7	1.162	0.4239	No
X-ray available & functioning (Yes vs No)	1.573	0.35	7.068	0.5546	No
Managing authority: Private-for-profit (vs Government/NGO)	4.48	0.943	21.277	0.0592	Marginal
Has a formal sample transport system (Postal/Alternative vs None)	13.893	4.597	41.982	< 0.001	Yes

Interpretation: Facilities with a certified microscopist had approximately 75% lower odds of low utilization (aOR = 0.249) (Table 16). Facilities serving larger catchment populations had higher odds of low utilization (aOR = 1.516 per doubling of population), reflecting a capacity-vs-demand mismatch (Table 16). The strongest predictor was absence of a formal sample transport system (aOR = 13.893), indicating that facilities without a way to move samples to testing sites had nearly 14-fold higher odds of low utilization (Table 16). Private-for-profit management showed borderline significance (aOR = 4.480, p = 0.059). Health officer numbers and X-ray availability were attenuated in the adjusted model, suggesting their bivariate associations were confounded by other factors (Table 16).

Pearson correlation and multiple linear regression

Table 16
Pearson correlations between facility characteristics and TB test utilisation (N = 112 facilities)

Variable pair	Pearson r	p-value	Interpretation
Catchment population ↔ Total test utilisation	0.822	< 0.001	Strong, positive
Total health professionals ↔ Total test utilisation	0.451	< 0.001	Moderate, positive
BSc lab technicians ↔ Total test utilisation	0.166	0.04	Weak, positive
Total health professionals ↔ Generalist doctors	0.822	< 0.001	Strong, positive (expected collinearity)
Catchment population ↔ BSc lab technicians	-0.021	0.412	Weak, negative, not significant

Interpretation: Facilities serving larger populations performed more TB tests (r = 0.822), which is expected (Table 17). However, the very weak and non-significant correlation between catchment population and number of BSc lab technicians (r = -0.021, p = 0.412) indicates that staffing of qualified laboratory personnel is not aligned with population need (Table 17).

Table 17
Multiple linear regression results for TB case detection (N = 112 facilities)

Predictor	Coefficient (β)	t-value	p-value	95% CI
Number of X-ray tests	0.94	4.254	0.002	[0.36, 1.52]
OPD visits	0.557	2.31	0.044	[0.02, 1.09]

Interpretation: Each additional X-ray examination was associated with a near-equivalent increase in TB cases detected (β = 0.940, p = 0.002), reflecting the critical role of chest X-ray in clinically diagnosing pulmonary TB, especially where bacteriological confirmation is limited. Facilities with higher patient volumes detected more TB cases (β = 0.557, p = 0.044), but this also highlights missed opportunities —

as shown earlier, only 12.3% of OPD attendees with presumptive TB were actually tested. Catchment population, total health professionals, and number of BSc lab technicians were not statistically significant in the multivariate model ($p > 0.05$), likely due to collinearity with OPD visits and X-ray availability.

Discussion

To our knowledge, this study provides one of the most comprehensive assessments of TB diagnostic utilization in Oromia Region, Ethiopia, using both perception-based (N = 222 health professionals) and facility-based (N = 112 facilities) analyses. The findings reveal alarmingly low utilization rates for both confirmatory and supportive diagnostics, with systemic barriers severely limiting access to quality TB diagnosis. The convergence of findings from both analytical approaches strengthens the evidence base for targeted interventions.

Diagnostic utilization

Despite substantial growth in OPD attendance, confirmatory TB testing increased only marginally. Community-level test utilization remained below 8%, facility-based utilization below 11% under the primary 10% presumptive TB prevalence assumption. Sensitivity analyses using 2.7%, 5%, 7.5%, and 15% assumptions confirmed that utilization remained substantially below expected demand across all scenarios. At the most conservative 2.7% assumption (representing LF-LAM utilization among HIV-positive patients), facility utilization rates ranged from 13.2% to 20.7% still far below the 100% benchmark. These findings align with previous Ethiopian studies reporting low case detection and diagnostic delays [7, 8]. The underutilization is particularly concerning given Ethiopia's national strategic plan target of 90% case detection [6]. A systematic review of barriers to TB diagnosis in low- and middle-income countries identified geographical inaccessibility, financial constraints, and inadequate diagnostic facilities as key obstacles [35].

Test positivity rate

The overall 8.7% positivity rate reflects diagnostic yield in this setting. Consistent Xpert positivity (~ 10%) aligns with expected yield among presumptive TB cases [9]. The fluctuating LF-LAM positivity (2.1–25.7%) suggests initial targeting of high-risk subgroups. A systematic review reported smear microscopy positivity of 15% and CXR positivity of 53% in TB screening populations [36], indicating opportunities for improved case detection through sensitive tests. The high proportion of clinically diagnosed TB (59.4%) is concerning, as clinical diagnosis lacks specificity and may lead to misdiagnosis or delayed treatment [37].

Drug susceptibility testing

While rifampicin DST coverage improved from 30% to 80.7%, second-line DST remained critically low (≤ 36%). This gap is alarming given the emergence of pre-XDR-TB in Ethiopia. A study from Amhara reported 6.3% of MDR-TB isolates resistant to at least one second-line drug, with pre-XDR-TB accounting

for 5.7% [38]. Without comprehensive second-line DST, patients may receive inappropriate regimens, leading to treatment failure and ongoing transmission [39, 40].

Systemic barriers to diagnostic utilization

The perception-based model identified low patient flow, inadequate supplies, and lack of referral system information as the strongest predictors of perceived low utilization — all modifiable health system challenges [7, 41, 42]. The facility-based model corroborated these findings, with absence of a formal sample transport system emerging as the strongest predictor (aOR = 13.893, $p < 0.001$), followed by lack of a certified microscopist (aOR = 0.249, $p = 0.026$) and larger catchment population (aOR = 1.516 per doubling, $p = 0.008$).

The strong association between lack of sample transport and low utilization is particularly important. Many peripheral facilities cannot run confirmatory tests (e.g., Xpert, culture) on-site and depend entirely on being able to physically get samples to a facility that can — if that logistics chain doesn't exist, presumptive cases simply don't get tested, regardless of demand. Reagent supply interruptions and equipment breakdowns are documented constraints in Ethiopia and Uganda [7, 43, 44]. A study in Jimma Zone, Oromia, identified distance to facility and educational status as determinants of patient delay [45].

The correlation between test utilization and health professional availability underscores the importance of human resources, but the non-significant association of trained manpower in the adjusted model suggests that supply and referral systems must be addressed simultaneously [46]. The weak and non-significant correlation between catchment population and BSc lab technicians ($r = -0.021$, $p = 0.412$) indicates that staffing of qualified laboratory personnel is not aligned with population need — a critical system bottleneck.

Interpretation of catchment population findings

The finding that larger catchment population was associated with higher odds of low utilization requires careful interpretation. Because expected presumptive cases = Population × a fixed constant, population is mathematically built into the denominator of the outcome. A facility's testing volume (numerator) would have to scale up proportionally just to keep the rate constant as its population grows. In this dataset, testing capacity clearly does not scale linearly with catchment size: the two largest-population facilities (a national reference institute with population ~ 24 million, and a large hospital with ~ 3 million) show far lower testing volume relative to their nominal population than smaller facilities do.

This finding is best read as "facilities that serve very large nominal catchments/referral populations are not testing proportionally more people" — a capacity-versus-demand mismatch, rather than "a bigger population directly discourages utilization." Large referral hospitals and national institutions are typically assigned an administrative catchment (sometimes the whole region or country) that does not reflect how many of those people realistically walk in daily for TB testing at that specific site most will be tested

at smaller peripheral facilities first. This inflates the denominator far more than any real under-performance at the facility.

Notably, OPD attendants tell a different and more actionable story. In bivariate analysis, more OPD attendants was protective (OR = 0.843 per doubling, p = 0.010) — i.e., busier general outpatient departments had higher TB diagnostic utilization, the opposite direction from population. Importantly, OPD attendants is essentially uncorrelated with catchment population (r = 0.06) and only weakly correlated with total test volume (r = 0.18) — so it is capturing something different from facility size. It likely reflects genuine day-to-day facility functionality and patient flow: a facility that is actively seeing and moving patients through general outpatient care has more opportunities to screen for TB symptoms, refer patients to the lab, and follow through on testing.

Implications for policy and practice

Based on these findings, we recommend:

Integrate TB screening into routine OPD services [47]. OPD attendants emerged as a protective factor in bivariate analysis, suggesting that strengthening symptom-screening and referral pathways from general outpatient care into TB diagnostics is a lever health manager can act on. Currently, only 12.3% of OPD attendees with presumptive TB were actually tested.

Expand access to rapid molecular tests (Xpert, LF-LAM) and CXR, especially in rural areas [4, 48]. The multiple linear regression showed that each additional X-ray examination was associated with a near-equivalent increase in TB cases detected (β = 0.940, p = 0.002).

Strengthen sample referral networks. The absence of a formal sample transport system was the strongest predictor of low utilization (aOR = 13.893). Functional sample referral networks (postal, courier, or MOH alternative systems) are essential for peripheral facilities that cannot run confirmatory tests on-site [50, 51].

Ensure every facility running TB diagnostics has a certified microscopist on staff. Facilities with a certified microscopist had approximately 75% lower odds of low utilization (aOR = 0.249, p = 0.026). This is a direct, actionable staffing/training gap.

Strengthen supply chain management to prevent stock-outs [49]. Inadequate supply/reagent shortage was a significant predictor in the perception-based model (OR = 0.023, p = 0.004).

Establish routine M&E of diagnostic utilization with corrective action plans [53]. The perception-based model revealed that lack of information about sample referral systems virtually eliminated the chance of adequate diagnostic utilization (OR = 0.006, p < 0.001).

Address private-for-profit sector integration. Private-for-profit facilities showed borderline higher odds of low utilization (aOR = 4.480, p = 0.059). Government and NGO facilities are typically integrated into the

national TB programme's free-testing and sample-referral network, while private-for-profit facilities may sit partly outside that network.

Strengths and limitations

This is one of the largest studies to date assessing TB diagnostic utilization in Oromia, using robust sampling and standardized WHO SARA tools [19, 20]. The use of both perception-based (N = 222) and facility-based (N = 112) analyses allowed triangulation of findings, and the sensitivity analyses confirmed the robustness of our conclusions.

Limitations:

CXR data were incomplete (only 11 of 31 hospitals had usable records due to absence of monitoring and evaluation system for supportive diagnostics). CXR findings should not be generalized to the entire region.

Utilization rates relied on assumptions about presumptive TB prevalence; actual prevalence may vary [30, 31]. However, sensitivity analyses using 2.7%, 5%, 7.5%, 10%, and 15% assumptions confirmed that utilization remained low across all scenarios.

The study did not capture patient-level barriers (e.g., cost, distance, stigma) that may influence diagnostic utilization.

The catchment population denominator issue for large referral facilities means the population association should be interpreted as a capacity-vs-demand mismatch rather than a causal effect.

Conclusions

TB diagnostic utilization in Oromia Region was substantially lower than expected demand based on presumptive TB prevalence, with major gaps in confirmatory testing, DST coverage, and chest X-ray use. Systemic barriers including supply shortages, equipment failure, and weak referral systems were associated with low utilization and represent priority areas for intervention. Urgent interventions are needed to strengthen the diagnostic network, expand access to rapid and sensitive tests, and address health system bottlenecks to achieve End TB Strategy targets [1, 4].

The convergence of findings from perception-based and facility-based analyses strengthens the evidence base. Specifically:

Facilities with certified microscopists had 75% lower odds of low utilization.

Facilities without formal sample transport had nearly 14-fold higher odds of low utilization.

Private-for-profit management showed borderline higher odds of low utilization.

OPD attendants (a marker of facility functionality) was protective, while catchment population (a denominator artifact) was associated with low utilization.

These findings point to two clearly actionable levers: (1) ensure every facility running TB diagnostics has a certified microscopist on staff, hence in Ethiopia situation still AFB microscopy is dominantly available at health facilities for diagnostics and (2) guarantee every facility has a working sample-transport pathway to a site that can run confirmatory testing. Strengthening symptom-screening and referral within routine outpatient care would likely improve TB test utilization more than anything related to catchment size.

Abbreviations

AFB
Acid-fast bacilli
ART
Antiretroviral therapy
CI
Confidence interval
CXR
Chest X-ray
DST
Drug susceptibility testing
LF-LAM
Lipoarabinomannan
MOH
Ministry of Health
OPD
Outpatient department
OR
Odds ratio
SARA
Service Availability and Readiness Assessment
TB
Tuberculosis
WHO
World Health Organization
XDR
Extensively drug-resistant.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the College of Human Sciences Research Ethics Committee, University of South Africa (reference: 17677041_CREC_ChS_2023, 13 October 2023) and from the Oromia Health Bureau Ethical Review Committee (reference: OHRC/021/2023). Written informed consent was obtained from all participants. All methods were performed in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable — no individual person's data are presented.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

Bizuneh Alemu Fetenesa conceptualized the study, designed the methodology, supervised data collection, performed formal analysis, and wrote the original draft. Professor Patrone Rebecca Risenga supervised the research, reviewed the manuscript, and provided critical revisions. Both authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request, subject to the ethical approvals and institutional data sharing policies of the Oromia Health Bureau and UNISA.

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