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The epidemiological burden and trends of pulmonary tuberculosis and rifampicin resistance at the Atua Government Hospital, Ghana: a 12-year retrospective analysis

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Introduction: Tuberculosis, a disease caused by *Mycobacterium tuberculosis* is a global public health threat. The problem is compounded by the development of resistance to antimicrobial agents, especially, rifampicin resistance. This 12-year retrospective study was conducted to determine the trends of tuberculosis and rifampicin resistance at Atua Government Hospital in the Lower Manya Krobo Municipality.

Methods: A retrospective study was conducted at Atua Government Hospital in the Eastern Region of Ghana. The study population included archived records of suspected patients whose sputum samples were tested between 2013 and 2024 using the Gene Xpert Mycobacterium tuberculosis/Rifampicin (MTB/RIF) version 5.0 assay on the Gene Xpert platform (Cepheid, USA). Data were entered into Microsoft Excel 365, cleaned, and analysed using R version 4.5.0.

Result: The study included 3,976 participants, of which 610 (15.3%) tested positive for tuberculosis. Positivity was highest in the 41–60 years (17.1%). MTB was significantly higher in males (18.6%) compared to females (12.6%) ($p<0.001$). The highest prevalence of the infection was observed in 2021 (24.4%) and 2024 (21.7%), while the lowest occurred in 2023 (5.3%) ($p<0.001$). The prevalence of rifampicin resistance was 21.5% (131/610), with higher prevalence in females (26.3%) compared to males (17.6%).

Conclusion: The study reported *Mycobacterium tuberculosis* and rifampicin resistance prevalence of 15.3% and 21.5% respectively. This high prevalence underscores the need for sustained efforts to combat the growing public health concern. There is therefore the need for enhancing surveillance systems and prioritising early detection strategies.

KEYWORDS
antibiotic resistance, Atua Government Hospital, *Mycobacterium tuberculosis*, rifampicin, tuberculosis

Introduction

Tuberculosis (TB) is a contagious and infectious disease caused by an acid-fast bacillus known as *Mycobacterium tuberculosis* (MTB). The primary site of infection of this infectious agent is the lung, but can also affect other organs and systems such as genitourinary tract, lymph nodes, central nervous system, bones and joints, among others. TB is both preventable and curable disease. Even though it is both preventable and curable disease, it was the world's second-biggest cause of death from a single infectious agent in 2022, trailing only coronavirus disease (COVID-19), and accounted for nearly twice as many deaths as HIV/AIDS (Sharew et al., 2024).

Globally, TB is the leading cause of mortality from infectious diseases, and African is the most affected region (Liyew et al., 2025). In 2023, more than 10.8 million individuals worldwide were diagnosed with active TB, of which 8.2 million were newly diagnosed, unacceptably higher than the 7.5 million in 2022 (World Health Organization, 2024). In Ghana, Deku et al. (2024) reported pulmonary TB and rifampicin resistance prevalence of 10.76% and 3.45% respectively in their study to determine the trends of *M. tuberculosis* and rifampicin resistance at the Ho Teaching Hospital. In another recent study by Bedzina et al. (2025) the overall prevalence of *M. tuberculosis* was 9.1%.

Even though TB can be treated with antibiotics, the emergence of drug resistance in MTB, particularly rifampicin resistance has thwarted its control efforts (Sharew et al., 2024). Deaths from drug resistance TB accounted for about one third of all anti-microbial deaths worldwide (Wingfield et al., 2021). Identifying the pattern of rifampicin resistance will ensure that the most effective therapy can be selected (Amin et al., 2024). Despite the ongoing efforts to curb pulmonary tuberculosis and rifampicin resistance, there is limited facility-level data and paucity of longitudinal, facility-based data in Ghana that comprehensively document the burden and temporal trends of pulmonary tuberculosis and rifampicin resistance limiting effective monitoring of programmatic investments and resistance dynamics. This study therefore aimed to describe the 12-year prevalence and temporal trends of rifampicin resistance among pulmonary TB cases at Atua Government Hospital in the Eastern Region of Ghana.

Methodology

Study design

The study employed a retrospective study design that analysed secondary data on TB obtained from the Atua Government Hospital. The dataset comprised archived TB testing records spanning a 12-year period: from 2013 to 2024.

Study site and study

The study was conducted at Atua Government Hospital. Atua Government Hospital, located in the Lower Manya Krobo Municipality in the Eastern Region of Ghana, is a major healthcare facility providing comprehensive medical and diagnostic services to the surrounding communities. The hospital plays a vital role in public health, particularly in managing infectious diseases such as tuberculosis and HIV. It is actively engaged in research and community health initiatives aimed at improving patient care, promoting treatment adherence, and enhancing preventive health awareness. Through collaboration with local and international partners, the hospital continues to strengthen its capacity to deliver quality, accessible, and patient-centred healthcare. According to the 2021 population and housing census, the Municipality has a total population of 121,478 with male gender accounting for 46.6% (56,662) of the total population (Ghana Statistical Service, 2021). It lies between latitudes 6° 05'N and 6° 30'N and longitudes 0° 08'E and 0° W, with Odumase as its Municipal capital (https://mofa.gov.gh/site/sports/district-directorates/eastern-region/207-lower-manya-krobo).

Study participants

The study population comprised archived records of patients whose sputum samples were tested for tuberculosis at Atua Government Hospital between 2013 and 2024.

Inclusion and exclusion criteria

All archived records of TB tests performed between 2013 and 2024 were included in the study. However, test records with incomplete data such as missing age (402), sex (417), year (1), MTB infection status (100) or rifampicin susceptibility status (80) were excluded from the analysis.

Tuberculosis diagnostic protocol in Ghana

The TB diagnostic protocol is overseen by the National TB Control Programme (NTP), which emphasises rapid molecular testing using Gene Xpert MTB/RIF as the first-line diagnostic tool. In lower-level laboratories where the Gene Xpert is unavailable, sputum smear microscopy is performed, followed by referral for GeneXpert if smear-negative but clinical suspicion remains high.

For this study, sputum samples of sufficient volume were analysed using the Xpert *Mycobacterium tuberculosis*/Rifampicin (MTB/RIF) version 5.0 assay on the GeneXpert platform (Cepheid, USA). The assay was performed following the manufacturer's standard protocol to detect the presence of *Mycobacterium tuberculosis* and determine rifampicin resistance. The laboratory participates in regular External Quality Assessment (EQA) schemes and performs internal quality control using in-house–generated control materials to ensure the accuracy, consistency, and reliability of test results. All the cases reported in this study are newly diagnosed patients.

Data collection

Archived data were obtained from the microbiology unit of Atua Government Hospital, organised, and entered into Microsoft Excel 365 for cleaning and preparation before analysis. The

retrieved variables included age, sex, date, year of testing, and tuberculosis test results.

Outcome variables

The main outcome variables were the prevalence of MTB among individuals tested at Atua Government Hospital and the prevalence of rifampicin resistance among confirmed MTB cases over the 12-year period.

Independent variables

The independent variables included the year of testing, patient age, and sex.

TABLE 1 Prevalence of MTB stratified by sociodemographic characteristics of study participants.

Variables	Overall n (%)	Mycobacterium tuberculosis (MTB)		P-value
		MTB not detected n (%) [95% CI]	MTB detected n (%) [95% CI]	
Total	3976 (100.0)	3366 (84.7) [83.5–85.8]	610 (15.3) [14.2–16.5]	
Age categories				0.161
≤20	334 (8.4)	292 (87.4) [83.4–90.8]	42 (12.6) [9.2–16.6]	
21-40	1398 (35.2)	1196 (85.6) [83.6–87.4]	202 (14.4) [12.6–16.4]	
41-60	1493 (37.6)	1238 (82.9) [80.9–84.8]	255 (17.1) [15.2–19.1]	
61-80	574 (14.4)	488 (85.0) [81.8–87.8]	86 (15.0) [12.2–18.2]	
>80	177 (4.5)	152 (85.9) [79.9–90.6]	25 (14.1) [9.4–20.1]	
Sex				0.000
Female	2146 (54.0)	1876 (87.4) [85.9–88.8]	270 (12.6) [11.2–14.1]	
Male	1830 (46.0)	1490 (81.4) [79.6–83.2]	340 (18.6) [16.8–20.4]	
Years				0.000
2013	438 (11.0)	362 (82.6) [78.8–86.1]	76 (17.4) [13.9–21.2]	
2014	45 (1.1)	36 (80.0) [65.4–90.4]	9 (20.0) [9.6–34.6]	
2015	137 (3.4)	114 (83.2) [75.9–89.0]	23 (16.8) [11.0–24.1]	
2016	114 (2.9)	99 (86.8) [79.2–92.4]	15 (13.2) [7.6–20.8]	
2017	705 (17.7)	629 (89.2) [86.7–91.4]	76 (10.8) [8.6–13.3]	
2018	809 (20.3)	717 (88.6) [86.2–90.7]	92 (11.4) [9.3–13.8]	
2019	149 (3.7)	130 (87.2) [80.8–92.1]	19 (12.8) [7.9–19.2]	
2020	329 (8.3)	270 (82.1) [77.5–86.1]	59 (17.9) [13.9–22.5]	
2021	676 (17.0)	511 (75.6) [72.2–78.8]	165 (24.4) [21.2–27.8]	
2022	104 (2.6)	93 (89.4) [81.9–94.6]	11 (10.6) [5.4–18.1]	
2023	226 (5.7)	214 (94.7) [90.9–97.2]	12 (5.3) [2.8–9.1]	
2024	244 (6.1)	191 (78.3) [72.6–83.3]	53 (21.7) [16.7–27.4]	
Months				0.000
January	426 (10.7)	374 (87.8) [84.3–90.7]	52 (12.2) [9.3–15.7]	
February	330 (8.3)	289 (87.6) [83.5–90.9]	41 (12.4) [9.1–16.5]	
March	370 (9.3)	305 (82.4) [78.2–86.2]	65 (17.6) [13.8–21.8]	
April	432 (10.9)	320 (74.1) [69.7–78.1]	112 (25.9) [21.9–30.3]	
May	239 (6.0)	214 (89.5) [84.9–93.1]	25 (10.5) [6.9–15.1]	
June	445 (11.2)	376 (84.5) [80.8–87.7]	69 (15.5) [12.3–19.2]	
July	239 (6.0)	221 (92.5) [88.4–95.5]	18 (7.5) [4.5–11.6]	
August	184 (4.6)	163 (88.6) [83.1–92.8]	21 (11.4) [7.2–16.9]	
September	228 (5.7)	200 (87.7) [82.7–91.7]	28 (12.3) [8.3–17.3]	
October	399 (10.0)	330 (82.7) [78.6–86.3]	69 (17.3) [13.7–21.4]	
November	415 (10.4)	351 (84.6) [80.7–87.9]	64 (15.4) [12.1–19.3]	
December	269 (6.8)	223 (82.9) [77.9–87.2]	46 (17.1) [12.8–22.1]	

P-value is significant at $p<0.050$.

Data analysis

Data were entered into Microsoft Excel 365, cleaned, and analysed using R version 4.5.0. Descriptive statistics were used to summarise sociodemographic characteristics and prevalence estimates, with categorical variables presented as frequencies and percentages. Differences in *Mycobacterium tuberculosis* (MTB) detection and rifampicin resistance were assessed using chi-square tests. Prevalence estimates were reported with 95% confidence intervals (CIs) calculated using the Wilson method. Temporal trends in MTB detection and rifampicin resistance were assessed using regression models with year included as a continuous variable. Statistical significance of temporal change was determined based on the p-value for the year term. Multivariable regression analyses were conducted to assess associations between explanatory variables and outcomes. Log-binomial regression models were fitted to estimate

TABLE 2 Prevalence of rifampicin resistance stratified by sociodemographic characteristics of study participants.

		Rifampicin resistance		
Variables	Overall n (%)	Susceptible n (%) [95% CI]	Resistant n (%) [95% CI]	P-value
Total	610 (100.0)	479 (78.5) [75.0–81.7]	131 (21.5) [18.3–25.0]	
Age categories				0.951
≤20	42 (6.9)	33 (78.6) [63.2–89.7]	9 (21.4) [10.3–36.8]	
21-40	202 (33.1)	159 (78.7) [72.4–84.1]	43 (21.3) [15.9–27.6]	
41-60	255 (41.8)	197 (77.3) [71.6–82.3]	58 (22.7) [17.7–28.4]	
61-80	86 (14.1)	70 (81.4) [71.6–89.0]	16 (18.6) [11.0–28.4]	
>80	25 (4.1)	20 (80.0) [59.3–93.2]	5 (20.0) [6.8–40.7]	
Sex				0.013
Female	270 (44.3)	199 (73.7) [68.0–78.9]	71 (26.3) [21.1–32.0]	
Male	340 (55.7)	280 (82.4) [77.9–86.3]	60 (17.6) [13.7–22.1]	
Years				0.178
2013	76 (12.5)	65 (85.5) [75.6–92.5]	11 (14.5) [7.5–24.4]	
2014	9 (1.5)	6 (66.7 [29.9–92.5]	3 (33.3) [7.5–70.1]	
2015	23 (3.8)	19 (82.6) [61.2–95.0]	4 (17.4) [5.0–38.8]	
2016	15 (2.5)	13 (86.7) [59.5–98.3]	2 (13.3) [1.7–40.5]	
2017	76 (12.5)	66 (86.8) [77.1–93.5]	10 (13.2) [6.5–22.9]	
2018	92 (15.1)	70 (76.1) [66.1–84.4]	22 (23.9) [15.6–33.9]	
2019	19 (3.1)	17 (89.5) [66.9–98.7]	2 (10.5) [1.3–33.1]	
2020	59 (9.7)	39 (66.1) [52.6–77.9]	20 (33.9) [22.1–47.4]	
2021	165 (27.0)	126 (76.4) [69.1–82.6]	39 (23.6) [17.4–30.9]	
2022	11 (1.8)	8 (72.7) [39.0–94.0]	3 (27.3) [6.0–61.0]	
2023	12 (2.0)	10 (83.3) [51.6–97.9]	2 (16.7) [2.1–48.4]	
2024	53 (8.7)	40 (75.5) [61.7–86.2]	13 (24.5) [13.8–38.3]	
Months				0.367
January	52 (8.5)	43 (82.7) [69.7–91.8]	9 (17.3) [8.2–30.3]	
February	41 (6.7)	30 (73.2) [57.1–85.8]	11 (26.8) [14.2–42.9]	
March	65 (10.7)	57 (87.7) [77.2–94.5]	8 (12.3) [5.5–22.8]	
April	112 (18.4)	85 (75.9) [66.9–83.5]	27 (24.1) [16.5–33.1]	
May	25 (4.1)	21 (84.0) [63.9–95.5]	4 (16.0) [4.5–36.1]	
June	69 (11.3)	54 (78.3) [66.7–87.3]	15 (21.7) [12.7–33.3]	
July	18 (3.0)	14 (77.8) [52.4–93.6]	4 (22.2) [6.4–47.6]	
August	21 (3.4)	13 (61.9) [38.4–81.9]	8 (38.1) [18.1–61.6]	
September	28 (4.6)	21 (75.0) [55.1–89.3]	7 (25.0) [10.7–44.9]	
October	69 (11.3)	54 (78.3) [66.7–87.3]	15 (21.7) [12.7–33.3]	
November	64 (10.5)	47 (73.4) [60.9–83.7]	17 (26.6) [16.3–39.1]	
December	46 (7.5)	40 (87.0) [73.7–95.1]	6 (13.0) [4.9–26.3]	

P-value is significant at $p<0.050$.

adjusted prevalence ratios (aPRs), while multivariable logistic regression models were used to estimate adjusted odds ratios (aORs), with both measures reported alongside 95% CIs and adjusted for age, sex, year, and month. Both aPRs and aORs were presented to improve interpretability and comparability: aPRs provide a more accurate measure of association for common outcomes in cross-sectional studies, whereas aORs facilitate comparison with existing literature and allow assessment of the robustness of findings across different modelling approaches. Model adequacy for logistic regression analyses was assessed using goodness-of-fit tests. The rifampicin resistance model demonstrated adequate fit based on the Pearson chi-square goodness-of-fit test ($p = 0.28$). In contrast, the TB model showed a statistically significant Pearson goodness-of-fit test ($p < 0.001$), which was interpreted in the context of the large sample size and high number of covariate patterns, conditions under which global goodness-of-fit tests are known to be highly sensitive to minor departures from model assumptions. Receiver operating characteristic (ROC) curve analysis was used to further evaluate model performance, with the area under the curve (AUC), Youden's index, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) reported. Potential multicollinearity among covariates was assessed using variance inflation factors (VIFs). Mean VIF values were low for both the rifampicin (mean VIF = 1.92) and TB (mean VIF = 1.83) models, indicating no evidence of problematic multicollinearity. Missing data were handled using listwise deletion, and statistical significance was set at $p < 0.05$.

Ethical consideration

Ethical approval with reference number UHAS-REC A.8 [46] 24–25 was obtained from the Research Ethics Committee of the University of Health and Allied Sciences. Informed consent was not obtained from the participants since the study was a retrospective one. Data were fully anonymised before access, and no information that could be linked to the participants was retrieved. All archived data for the study were kept undisclosed and used for the study only by keeping them on a password-protected computer accessible to only the principal investigator.

Results

Prevalence of MTB stratified by sociodemographic characteristics of study participants

Among 3,976 participants tested for tuberculosis, the prevalence of MTB detection was 15.3% (95% CI: 14.2–16.5). Prevalence varied across sociodemographic groups. By age, positivity was highest in the 41–60 years (17.1%) and 61–80 years (15.0%) groups, while the ≤20 years group had the lowest (12.6%) (p=0.161). By sex, MTB detection was significantly higher among males (18.6%) compared to females (12.6%) (p<0.001). Temporal trends showed marked variation across years (p<0.001), with the highest prevalence observed in 2021 (24.4%) and 2024 (21.7%), while the lowest occurred in 2023 (5.3%). Monthly distribution also showed significant differences (p<0.001), with peaks in April (25.9%) and troughs in July (7.5%) Table 1.

Prevalence of rifampicin resistance stratified by sociodemographic characteristics of study participants

Among 610 participants with MTB detected, the prevalence of rifampicin resistance was 21.5% (95% CI: 18.3–25.0). Resistance did not differ significantly by age group (p=0.951), ranging from 18.6% in the 61–80 years group to 22.7% among 41–60 years. However, sex differences were observed (p=0.013), with rifampicin resistance higher among females (26.3%) compared to males (17.6%). Resistance varied across years (p=0.178), peaking in 2020 (33.9%) and 2014 (33.3%), and lowest in 2019 (10.5%). Monthly distribution showed fluctuations, with the highest resistance in August (38.1%) and lowest in March (12.3%), though differences were not statistically significant (p=0.367) Table 2.

Monthly distribution of MTB and rifampicin resistance stratified by sex

Figure 1 below show the monthly distribution of MTB detection and rifampicin resistance stratified by sex. MTB and rifampicin resistance percentages show fluctuating trends across months for both males and females, with no consistent gender-based pattern.

Year-on-year distribution of MTB and rifampicin resistance stratified by sex.

The year-on-year distribution of MTB detection and rifampicin resistance, stratified by sex from 2013 to 2024, revealed fluctuations in both parameters. MTB detection showed higher variability with peaks in 2016 and 2021, while rifampicin resistance displayed extreme spikes, reaching 100% in 2023 among females Figure 2.

Rif, rifampicin resistance; MTB, *Mycobacterium tuberculosis*.

Adjusted prevalence ratio and adjusted odds ratio of factors associated with MTB and rifampicin resistance

In multivariable models, For MTB, males had significantly higher risk compared to females (aPR: 1.55, 95% CI: 1.32–1.82; aOR: 1.72, 95% CI: 1.44–2.06; both p<0.001). Age was not significantly associated with MTB or rifampicin resistance after adjustment. Compared with 2013, MTB prevalence was significantly lower in 2017 (aPR: 0.68, 95% CI: 0.49–0.94; p=0.021) and 2023 (aPR: 0.36, 95% CI: 0.18–0.65; p=0.001), but higher in 2021 (aPR: 1.51, 95% CI: 1.15–1.99; p=0.003). At the monthly level, increased MTB risk was observed in March (aPR: 1.52, 95% CI: 1.05–2.22; p=0.028) and April (aPR: 1.76, 95% CI: 1.25–2.52; p=0.001). For rifampicin resistance, males had a significantly lower risk than females (aPR: 0.64, 95% CI: 0.44–0.91; aOR: 0.54, 95% CI: 0.36–0.82). Resistance was higher in 2020 (aOR: 2.82, 95% CI: 1.16–7.11; p=0.024), while no other year showed significant associations. Across months, no statistically significant variation in rifampicin resistance was observed Table 3.

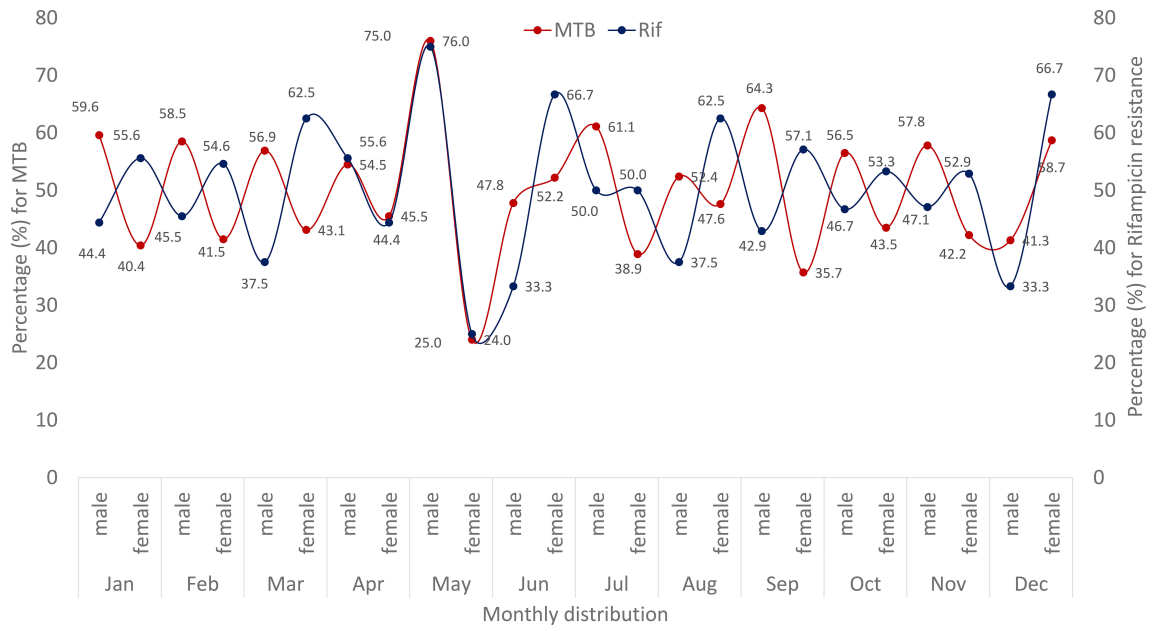

FIGURE 1
Monthly distribution of MTB and rifampicin resistance stratified by sex.

Model performance of binary logistic regression models of factors associated with MTB and rifampicin resistance

The logistic regression model for MTB detection demonstrated moderate discriminative ability, with an AUC of 65.9%. At the optimal cut-off (0.16), the model achieved a sensitivity of 59.0%, specificity of 65.0%, PPV of 23.4%, and NPV of 89.7%. For rifampicin resistance, the logistic regression model yielded an AUC of 66.7%, with an optimal cut-off of 0.21. At this threshold, sensitivity was 64.9%, specificity 64.1%, PPV 33.1%, and NPV 87.0%. Both models thus demonstrated fair performance, with high NPVs indicating utility for ruling out disease, but modest PPVs limiting their predictive accuracy for positive cases Figure 3.

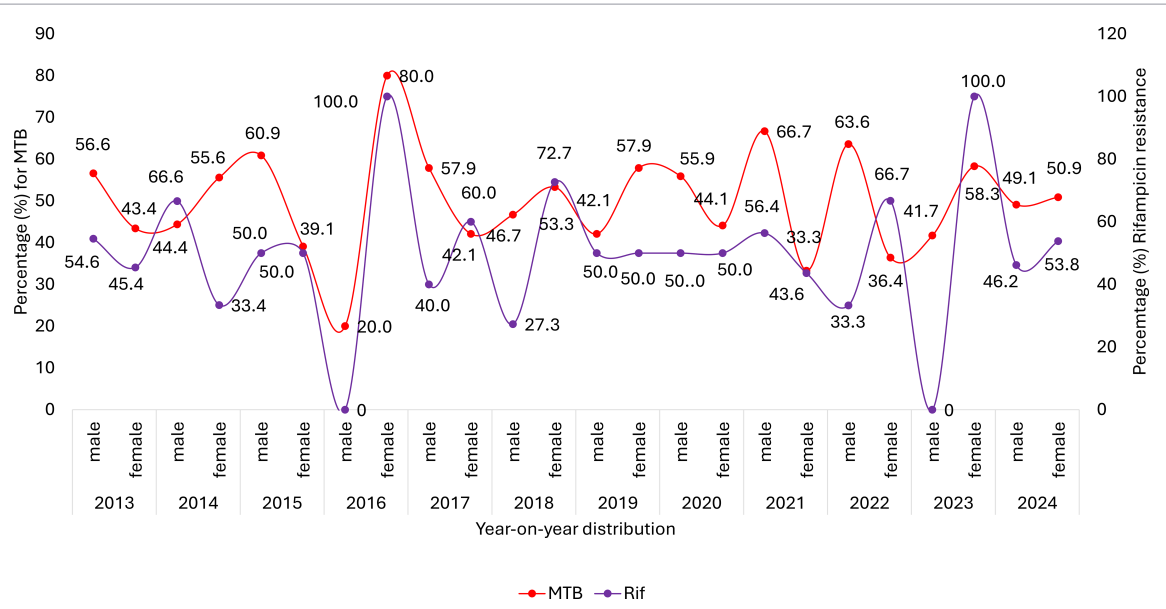

FIGURE 2
Year-on-year distribution of MTB and rifampicin resistance stratified by sex.

Rif; rifampicin resistance, MTB; *Mycobacterium tuberculosis*.

Discussion

The findings of this study have important implications for TB control and management at Atua Government Hospital and in similar healthcare settings. The overall prevalence of MTB among presumptive TB cases was 15.3%, indicating that TB remains a major public health concern in the area. This suggests that a significant proportion of individuals presenting with TB-like symptoms are truly infected, emphasising the need for robust screening and diagnostic systems to ensure early detection and timely treatment. Comparatively, the 15.3% prevalence observed in this study falls within the intermediate range globally but still reflects a substantial disease burden. According to Jiang et al. (2025), the global prevalence of TB was estimated at 236.1 cases

TABLE 3 Adjusted prevalence ratio and adjusted odds ratio of factors associated with MTB and rifampicin resistance.

Variables	MTB				Rifampicin resistance			
	aPR [95% CI]	P-value	aOR [95% CI]	P-value	aPR [95% CI]	P-value	aOR [95% CI]	P-value
Sex								
Female	1		1		1		1	
Male	1.55 [1.32–1.82]	**0.000**	1.72 [1.44–2.06]	**0.000**	0.64 [0.44–0.91]	**0.012**	0.54 [0.36–0.82]	**0.004**
Age categories								
≤20	1	1			1		1	
21-40	1.20 [0.86–1.70]	0.296	1.24 [0.87–1.81]	0.245	1.05 [0.53–2.33]	0.891	1.08 [0.48–2.63]	0.865
41-60	1.30 [0.95–1.83]	0.118	1.38 [0.97–2.00]	0.077	1.08 [0.55–2.37]	0.830	1.12 [0.50–2.70]	0.792
61-80	1.12 [0.78–1.64]	0.551	1.14 [0.76–1.72]	0.528	0.93 [0.41–2.22]	0.858	0.91 [0.36–2.44]	0.846
>80	1.18 [0.71–1.93]	0.504	1.23 [0.71–2.11]	0.453	1.00 [0.30–2.95]	0.994	0.99 [0.26–3.51]	0.988
Year								
2013	1		1		1		1	
2014	1.10 [0.51–2.08]	0.795	1.11 [0.48–2.35]	0.789	2.68 [0.59–8.93]	0.141	3.73 [0.67–17.91]	0.106
2015	1.17 [0.71–1.87]	0.519	1.23 [0.71–2.07]	0.453	1.27 [0.34–3.83]	0.695	1.33 [0.33–4.68]	0.665
2016	0.94 [0.51–1.62]	0.837	0.94 [0.49–1.71]	0.850	0.85 [0.13–3.39]	0.837	0.81 [0.11–3.86]	0.812
2017	0.68 [0.49–0.94]	**0.021**	0.64 [0.44–0.92]	**0.015**	1.05 [0.42–2.61]	0.909	1.08 [0.40–2.91]	0.878
2018	0.78 [0.57–1.08]	0.129	0.75 [0.53–1.07]	0.112	1.70 [0.80–3.82]	0.176	1.96 [0.84–4.80]	0.128
2019	0.79 [0.46–1.29]	0.361	0.76 [0.42–1.30]	0.328	0.77 [0.12–3.03]	0.743	0.74 [0.10–3.36]	0.724
2020	1.26 [0.88–1.80]	0.206	1.34 [0.89–2.01]	0.154	2.17 [1.00–4.89]	0.053	2.82 [1.16–7.11]	**0.024**
2021	1.51 [1.15–1.99]	**0.003**	1.71 [1.25–2.34]	**0.001**	1.74 [0.90–3.63]	0.116	2.01 [0.96–4.51]	0.073
2022	0.65 [0.32–1.19]	0.192	0.60 [0.29–1.17]	0.155	2.91 [0.60–10.95]	0.138	4.18 [0.69–22.53]	0.099
2023	0.36 [0.18–0.65]	**0.001**	0.32 [0.16–0.60]	**0.001**	1.00 [0.15–4.09]	0.999	0.96 [0.12–4.98]	0.964
2024	1.42 [0.97–2.07]	0.069	1.56 [1.02–2.39]	**0.040**	1.58 [0.67–3.81]	0.297	1.78 [0.67–4.79]	0.250
Months								
January	1		1		1		1	
February	1.01 [0.67–1.53]	0.948	1.01 [0.65–1.58]	0.951	1.53 [0.62–3.88]	0.353	1.76 [0.62–5.06]	0.287
March	1.52 [1.05–2.22]	**0.028**	1.67 [1.11–2.52]	**0.015**	0.79 [0.29–2.12]	0.636	0.76 [0.25–2.24]	0.617
April	1.76 [1.25–2.52]	**0.001**	2.07 [1.41–3.07]	**0.000**	1.22 [0.57–2.88]	0.623	1.29 [0.53–3.36]	0.579
May	0.86 [0.52–1.38]	0.541	0.84 [0.49–1.40]	0.513	1.11 [0.29–3.53]	0.868	1.14 [0.27–4.20]	0.845
June	1.21 [0.84–1.77]	0.307	1.26 [0.84–1.90]	0.266	1.15 [0.50–2.80]	0.745	1.19 [0.46–3.21]	0.724
July	0.63 [0.36–1.06]	0.091	0.59 [0.33–1.03]	0.071	1.28 [0.34–4.01]	0.681	1.37 [0.32–5.17]	0.649
August	0.78 [0.45–1.31]	0.368	0.74 [0.41–1.30]	0.307	1.77 [0.60–5.18]	0.291	2.27 [0.62–8.35]	0.211
September	0.89 [0.55–1.43]	0.641	0.86 [0.51–1.43]	0.571	1.57 [0.53–4.44]	0.397	1.80 [0.53–6.03]	0.337
October	1.31 [0.91–1.90]	0.152	1.38 [0.92–2.08]	0.117	1.26 [0.55–3.04]	0.589	1.35 [0.53–3.61]	0.534
November	1.07 [0.73–1.59]	0.724	1.08 [0.71–1.66]	0.713	1.48 [0.63–3.70]	0.381	1.69 [0.63–4.72]	0.304
December	1.37 [0.91–2.08]	0.133	1.47 [0.93–2.32]	0.099	0.60 [0.18–1.82]	0.377	0.52 [0.14–1.78]	0.308

CI, Confidence Interval; aOR, Adjusted odds ratio; aPR, Adjusted prevalence ratio. P-value is significant at p<0.050.

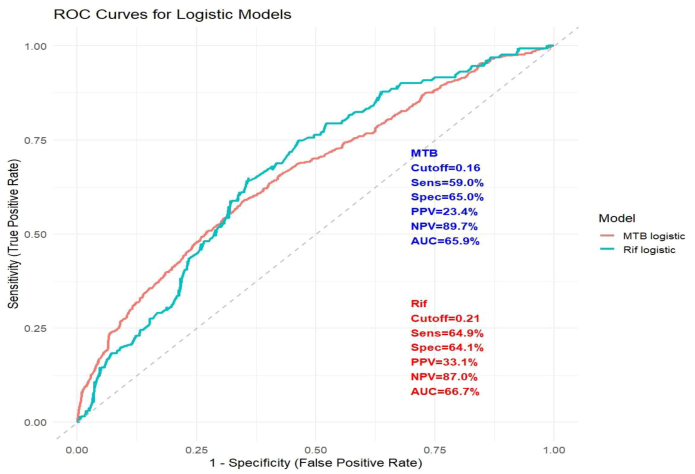

FIGURE 3
Model performance of binary logistic regression models of factors associated with MTB and rifampicin resistance. Rif, rifampicin resistance; MTB, Mycobacterium tuberculosis.

per 100,000 population, with the highest rates recorded in low- and middle-income countries where healthcare systems are often under-resourced. The relatively higher prevalence found in this study compared to global averages underscores the persistent challenges of TB control in local settings like Atua Government Hospital, where socioeconomic and infrastructural limitations may affect case detection and treatment outcomes. Regionally, the 15.3% prevalence is lower than that reported in Nigeria (28.7%) by Dankuma and Samuel (2025) and in Bangladesh (28%) by Karim et al. (2025) among suspected TB patients, yet higher than the 10.7% found in the Gofa Zone of Southern Ethiopia (Liyew et al., 2025). In sub-Saharan Africa, national TB prevalence rates range between 0.25 and 7.32 per 1,000 population, with Ghana among the countries showing comparatively higher rates (Liyew et al., 2025). Additionally, a pool prevalence study in India by Chauhan et al. (2023) reported a 41% tuberculosis infection. Such variations may be attributed to differences in diagnostic techniques, population characteristics, HIV co-infection rates, and the overall efficiency of healthcare systems.

The present study found that males (18.6%) had a higher prevalence of MTB than females (12.6%), which aligns with global trends showing men account for about 64% of TB cases compared to 36% in women (Ahmad et al., 2025). The regression analysis further showed that male gender was positively associated with MTB infection but negatively associated with rifampicin resistance. Similar patterns were observed by Neudecker et al. (2025) in Switzerland who reported that men have a 53% higher risk of TB. These differences are often linked to men's greater exposure through smoking, alcohol use, and occupational risks, as well as delays in seeking care. In contrast, lower TB detection in women may reflect underdiagnosis caused by social stigma, limited health access, and financial dependence (Ahmad et al., 2025). Miller et al. (2021) also noted that men have more adult contacts, increasing their risk of infection. Interestingly, while men in this study were more likely to have MTB, rifampicin resistance was higher among females (26.3%), unlike global patterns where resistance is usually higher in men. This may point to treatment adherence or access issues among women.

The results showed changes in MTB prevalence over time, with certain years (such as 2021 and 2024) and months (like April) recording higher rates. These fluctuations may be linked to seasonal variations, public health campaigns, or changes in diagnostic practices. For example, during certain months or years, there might have been increased community transmission, higher hospital attendance, or better access to diagnostic tools such as the Gene Xpert test. This highlights the importance of maintaining consistent TB control measures throughout the year to prevent peaks in infection.

The study also reported a rifampicin resistance rate of 21.5% among those who tested positive for MTB, which is quite high. Drug-resistant TB poses serious challenges to treatment success and can lead to longer illness, higher treatment costs, and an increased risk of death. The higher resistance rate among females (26.3%) compared to males (17.6%) suggests that women may face challenges such as poor adherence to medication, delayed diagnosis, or limited follow-up care. This finding calls for special attention to treatment support and follow-up among female TB patients to ensure treatment completion and reduce resistance development.

In comparison, the rifampicin resistance rate of 21.5% observed in this study is considerably higher than most published estimates. A global meta-analysis by Rostamian et al. (2023) reported an average rifampicin resistance prevalence of 7.3%, identifying the *rpoB S531L* mutation as the most common cause of resistance. This global estimate is about three times lower than the rate found in the current study, suggesting that Atua Government Hospital may be facing a higher-than-expected burden of drug-resistant TB. Similarly, studies from different regions show varying but generally lower prevalence rates. In Ethiopia, Sharew et al. (2024) reported 10.7% rifampicin resistance among pulmonary TB patients, with prior TB treatment identified as a major risk factor.

In China's Guizhou Province, Zhou et al. (2024) found resistance rates of 8.9% among new cases and 28% among previously treated patients, indicating that retreatment and incomplete adherence are major contributors. The rate in the current study (21.5%) falls close to the retreatment group level in China, suggesting that either treatment default or reinfection could be contributing factors in this setting. Also, Bainara et al. (2016) reported a prevalence of 19.4%, which is similar to the findings of the present study, while Ibrahim et al. (2022) recorded a much lower figure of 4.5%, and Deku et al. (2024) found 3.45% at a teaching hospital in Ghana, with slightly higher resistance among women. Likewise, in Egypt, Amin et al. (2024) reported 5.01% rifampicin resistance, showing that resistance levels in many regions remain relatively low compared to what was observed in Atua. Furthermore, Sijabat and Novettiandari (2024) found that global MDR/RR-TB prevalence typically ranges from 5% to 15%, depending on diagnostic methods and healthcare quality. The 21.5% resistance found in this study therefore exceeds the global upper limit, suggesting potential issues such as delayed diagnosis, poor treatment adherence, or the spread of resistant strains in the community. The higher resistance among females (26.3%) compared to males (17.6%) further aligns with findings by Deku et al. (2024), who also noted slightly higher rates among women. This pattern could point to gender-related barriers to accessing or completing treatment, including social stigma or limited follow-up support. Emerging evidence of rifampicin monoresistance, as reported by Malenfant and Brewer (2021), also adds concern, highlighting the importance of molecular surveillance to detect early resistance patterns. The high prevalence found in this study underscores the urgent need for continuous molecular monitoring, adherence counselling, and strengthened treatment supervision to prevent further escalation of drug-resistant TB in the Atua Government Hospital and similar settings.

Collectively, these findings stress the importance of continuous surveillance, effective case detection, and proper treatment monitoring to prevent further spread and drug resistance. The study also highlights the need for gender-sensitive TB control strategies, health education, and community involvement to ensure both men and women are equally supported in TB prevention, diagnosis, and treatment. Strengthening diagnostic capacity, ensuring regular drug supply, and promoting adherence to treatment are key steps towards achieving better TB control outcomes in the Atua Government Hospital and the surrounding communities.

Limitation of the study

The study did not account for important potential confounding factors such as HIV co-infection status, prior tuberculosis treatment history, and socioeconomic variables. The absence of these data limits the ability to adjust for factors known to influence tuberculosis susceptibility, disease progression, and treatment outcomes, thereby restricting causal inference and the generalisability of the findings.

Conclusion

This study found a 15.3% prevalence of MTB and a high rifampicin resistance rate of 21.5% among presumptive TB cases at Atua Government Hospital over 12 years. Males were more likely to have MTB, while resistance was higher among females. The results highlight ongoing TB transmission and emerging drug resistance, emphasising the need for stronger diagnostic systems, continuous surveillance, and gender-sensitive TB control strategies.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by University of Health and Allied Sciences Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

LD: Conceptualization, Resources, Writing – original draft, Methodology, Investigation, Data curation. JD: Conceptualization, Writing – original draft, Resources, Writing – review & editing, Methodology, Project administration, Supervision. IB: Data curation, Writing – original draft. EA: Investigation, Writing – review & editing, Methodology. KA: Formal analysis, Writing – original draft, Data curation. OM: Writing – review & editing, Methodology, Data curation, Conceptualization. IA: Supervision, Writing – review & editing. KD: Project administration, Writing – review & editing.

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Conflict of interest

Author IB was employed by company Fly Zipline Ghana Limited.

The remaining author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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