



Research Article

Copyright© Md Samiul Bashir

Detection and determination of drug resistance pattern of MTB among non-suspected TB patients admitted in a tertiary care level hospital in Bangladesh using FAST Strategy

Md. Shamim Hossain¹, SM Mostafa Kamal², Asif Mahmud³, Mousumi Chowdhury⁴, Md Samiul Bashir^{5*}, Md. Khaja Mohi Uddin⁶, Md. Abu Sayem⁷, Moazzam Hossain⁸, Afrin Sultana⁹ and Shib Shankar Das¹⁰

¹Department of Clinical Laboratory, Institute of Public Health and Nutrition, Dhaka, Bangladesh

²Department of Microbiology, Anwar Khan Modern Medical College Hospital, Dhaka, Bangladesh

³Department of Microbiology, Auburn University, Alabama, United States of America

⁴Department of Pathology and Microbiology, National Institute of Diseases of the Chest and Hospital, Dhaka, Bangladesh

⁵Department of Laboratory Medicine, Institute of Health Technology, Kurigram, Bangladesh

⁶Department of Laboratory Medicine, Dhaka Medical College Hospital, Dhaka, Bangladesh

⁷Department of Haematology, Chittagong Medical College Hospital, Chittagong, Bangladesh

⁸Department of Laboratory Medicine, Upazila Health Complex, Feni, Bangladesh

⁹Department of Laboratory Medicine, National Institute of Laboratory Medicine and Referral Centre, Dhaka, Bangladesh

¹⁰Department of Laboratory Medicine, Upazila Health Complex, Serajdikhan, Munshiganj, Bangladesh

***Corresponding author:** Md Samiul Bashir, Department of Laboratory Medicine Institute of Health Technology, Kurigram, Bangladesh, mtsamiulbashir@gmail.com.

To Cite This Article: Md. Shamim Hossain, SM Mostafa Kamal, Asif Mahmud, Mousumi Chowdhury, Md Samiul Bashir*, et al. Detection and determination of drug resistance pattern of MTB among non-suspected TB patients admitted in a tertiary care level hospital in Bangladesh using FAST Strategy. Am J Biomed Sci & Res. 2025 27(1) AJBSR.MS.ID.003527, DOI: [10.34297/AJBSR.2025.27.003527](https://doi.org/10.34297/AJBSR.2025.27.003527)

Received: 📅 May 19, 2025; **Published:** 📅 May 22, 2025

Abstract

Background: Tuberculosis (TB) and drug-resistant tuberculosis (DR-TB) often present with overlapping symptoms, leading to misclassification as other lung diseases. This misclassification acts as a significant barrier to effective TB control. The FAST strategy has proven to be effective in overcoming this barrier by facilitating early detection.

Aim: This study aimed to detect TB and DR-TB among patients provisionally diagnosed with other lung diseases, with or without a previous history of TB, by using rapid diagnostic techniques such as GeneXpert MTB/RIF, LED fluorescence microscopy, and solid culture with drug susceptibility testing (DST).

Methods: The study was conducted from April to September 2015, involving 476 consecutively admitted patients diagnosed with various lung diseases at a tertiary-level hospital. Sputum specimens were collected from all patients, including early morning spu-

tum samples from both TB-suspected and non-suspected cases. These specimens were tested using LED fluorescence microscopy, GeneXpert MTB/RIF, and culture-based DST (NALC-NaOH method) to identify *Mycobacterium tuberculosis* (MTB) and detect drug resistance.

Results: Among the 476 patients, 114 (24%) had a history of TB, and 362 (76%) had no previous TB history. TB was detected in 26 (22.8%) patients with a previous TB history and 33 (9.1%) patients without prior TB history. A total of 59 MTB cases (12.39%) were detected by GeneXpert MTB/RIF, including 4 (6.78%) rifampicin-resistant cases. The microscopy test identified 16 MTB-positive cases in the group with previous TB history and 20 in the group without previous TB history. Among the 59 GeneXpert-positive cases, 56 were confirmed by culture, and 4 of them were found to be multidrug-resistant TB (MDR-TB) by DST.

Conclusion: The study reveals that TB and DR-TB cases are frequently misclassified as other lung diseases due to overlapping symptoms, even in tertiary-level hospitals. Rapid diagnostic techniques, such as GeneXpert MTB/RIF, play a crucial role in detecting hidden TB and DR-TB cases, ultimately improving early detection and TB control efforts.

Keywords: Tuberculosis (TB), Drug-Resistant Tuberculosis (DR-TB), GeneXpert MTB/RIF, Rapid Screening, Drug Susceptibility Testing (DST)

Introduction

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains one of the most pressing public health challenges worldwide, particularly in developing nations. While TB primarily affects the lungs (pulmonary TB), it can also manifest as extra-pulmonary TB (EPTB), involving organs such as the lymph nodes, spine, kidneys, and central nervous system. Despite the availability of effective diagnostic tools, antibiotics, and the *Bacillus Calmette-Guérin* (BCG) vaccine, TB continues to be one of the top ten causes of death globally, and the leading cause of death from a single infectious agent, surpassing HIV/AIDS [1,2].

In Bangladesh, TB poses a significant public health threat. The country ranks among the 30 high TB burden nations designated by the World Health Organization (WHO). According to the National Tuberculosis Control Programme (NTP), an estimated 300,000 new TB cases are reported annually, with approximately 70,000 deaths attributed to the disease [3]. TB incidence in Bangladesh is fueled by multiple socio-economic factors such as poverty, undernutrition, overcrowding, inadequate housing, and limited healthcare access-conditions prevalent in both urban slums and rural communities [4]. A particularly alarming concern is the rise of drug-resistant TB (DR-TB). Multidrug-resistant TB (MDR-TB), defined as resistance to at least isoniazid and rifampicin-the two most powerful anti-TB drugs-accounts for approximately 1.6% of new cases and up to 38% of retreatment cases in Bangladesh [5]. DR-TB requires longer, more complex, and costlier treatments with more toxic second-line drugs, often resulting in poor outcomes. Compounding the issue is the detection of non-tuberculous mycobacteria (NTM), environmental organisms now recognized as opportunistic pathogens, which further complicate TB diagnosis and management [6-8].

Although Bangladesh has implemented the DOTS (Directly Observed Treatment, Short-course) strategy nationwide and has made progress in TB control, gaps remain in early case detection,

especially among asymptomatic or non-suspected individuals. This contributes to ongoing community transmission. Traditional diagnostic approaches often fail to identify TB in patients who do not present with classic symptoms like chronic cough, night sweats, and weight loss-thus creating a silent reservoir of undiagnosed and untreated TB cases [9]. The detection of TB from non-suspected or subclinical cases is now considered critical for achieving WHO's End TB Strategy, which aims to reduce TB incidence by 90% and TB deaths by 95% by 2035 [10]. Innovative and rapid diagnostic approaches that can identify TB early-even among individuals without apparent symptoms-are essential to break the chain of transmission, especially in high-burden settings like Bangladesh [11].

Historically, TB has been a major affliction of mankind, dating back thousands of years. Archeological studies have revealed evidence of TB lesions in Egyptian and Andean mummies, and molecular techniques such as PCR and HPLC have confirmed the presence of *M. tuberculosis* DNA in ancient human and animal remains, illustrating the disease's longstanding presence and adaptability. The pathogen was first discovered by Robert Koch in 1882. *M. tuberculosis* belongs to the *Mycobacterium tuberculosis* complex (MTC), which also includes *M. bovis*, *M. africanum*, *M. microti*, and others, each with varying pathogenicity and host specificity [12,13]. Among them, *M. tuberculosis* is the dominant human pathogen. The BCG vaccine, derived from an attenuated strain of *M. bovis*, has been part of Bangladesh's Expanded Programme on Immunization (EPI) since the 1980s and plays a key role in preventing severe TB forms in children [14-16].

Genomically, members of the MTC are over 99.9% identical, yet they exhibit variations in virulence and host adaptation [17]. *M. tuberculosis* is a slow-growing, obligate aerobe with a complex, lipid-rich cell wall that enables it to survive harsh environments, resist disinfectants, and persist in host tissues [18]. The reference strain *M. tuberculosis* H37Rv, with a genome size of 4.4 Mb, has

been instrumental in advancing molecular TB research. However, genotypic studies in Bangladesh are limited, and there is an urgent need to understand local strain diversity to improve diagnostics and treatment outcomes [19-20].

The aim of this study to detect TB and DR-TB among non-suspected individuals using the F-A-S-T strategy with GeneXpert MTB/RIF, and to determine drug sensitivity patterns through LPA and LJ culture with DST.

Methods and Materials

Study Population

The study included patients of all ages and both sexes, admitted with complaints related to various lung diseases. Patients currently undergoing anti-TB treatment were excluded from the study. The study was conducted over a period of six months, from April 2015 to September 2015. A total of 476 patients were included in the study, based on purposive sampling.

Collection of Specimens

Sputum specimens were collected from non-suspected TB/DR-TB patients admitted to the indoor wards of the National Institute of Diseases of the Chest and Hospital (NIDCH), Mohakhali, Dhaka. These patients, suffering from other lung diseases, were from various regions of Bangladesh. The study was conducted at the National Tuberculosis Reference Laboratory (NTRL).

Sampling Technique

Purposive and probability sampling techniques were employed for patient selection. Participants were chosen without random allocation, and their socio-demographic data, clinical history, and drug history were collected using a pre-designed data collection sheet.

Ethical Considerations

The study protocol was reviewed and approved by the National Tuberculosis Reference Laboratory (NTRL) at NIDCH. Informed oral consent was obtained from each patient or their legal guardian before specimen collection.

Procedure of Specimen Collection

Sputum specimens were collected aseptically from admitted presumptive TB/DR-TB patients. The initial specimen was tested using GeneXpert MTB/RIF. A second sample was collected in the morning from Xpert-positive cases before initiating anti-TB therapy.

Solid Culture on Lowenstein-Jensen (L-J) Media

Lowenstein-Jensen (L-J) media was prepared by mixing mineral salt solution, glycerol, malachite green solution, and eggs. The media was sterilized, and 8 mL was distributed into sterile McCartney bottles. After coagulation, sputum sediment was inoculated onto the slants using Pasteur pipettes. The inoculated media was incubated at 37°C. Growth was observed weekly for up to 8 weeks,

with visible growth of *Mycobacterium tuberculosis* typically occurring within 3-4 weeks. Colonies were confirmed through morphology, Ziehl-Neelsen staining, and biochemical tests.

Drug Susceptibility Testing (DST) on L-J Media

DST was performed using the proportion method to test Isoniazid (INH) and Rifampicin (RIF) resistance. The preparation involved adding working solutions of INH, RIF, and Para-nitro benzoic acid (PNB) to separate L-J media bottles. Bacterial suspension was standardized to McFarland standard No. 1 (1 mg/mL, equivalent to 10^7 to 10^8 CFU/mL). Serial dilutions (10^{-3} to 10^{-5}) were prepared, and 0.5 mL of each dilution was inoculated onto the respective L-J slants. Bottles were incubated at 37°C and examined weekly. A strain was considered resistant if the number of colonies growing on drug-containing media was 1% or more compared to the drug-free media. The results were interpreted as susceptible or resistant.

GeneXpert MTB/RIF Testing

GeneXpert MTB/RIF is a real-time PCR-based diagnostic tool that automates the detection of *M. tuberculosis* and RIF resistance. The system uses disposable cartridges containing all reagents necessary for nucleic acid extraction, amplification, and detection. The procedure involves adding a sample reagent to sputum in a 3:1 ratio, followed by a 15-minute incubation at room temperature. After transferring the inactivated specimen to the GeneXpert cartridge, the cartridge is placed into the GeneXpert device for PCR amplification. Results are automatically generated in 90 minutes, indicating the presence of MTB and resistance to rifampicin.

Line Probe Assay (LPA)

The Line Probe Assay (LPA) was used for the rapid detection of drug resistance in *Mycobacterium tuberculosis*. Two assays were employed: the INNO-LiPA Rif TB Assay, which detects rifampicin resistance by identifying mutations in the *rpoB* gene, and the GenoType MTBDRplus, which detects resistance to both rifampicin (RIF) and isoniazid (INH) by identifying mutations in the *rpoB*, *katG*, and *inhA* genes. Both assays use reverse hybridization, where the DNA of *M. tuberculosis* is amplified through PCR and hybridized to specific probes fixed on a membrane, with the presence or absence of mutations visualized by color changes, enabling the detection of drug-resistant strains.

Result Interpretation

The results from GeneXpert MTB/RIF testing were categorized into three groups: positive, negative, and invalid. A positive result indicated that *Mycobacterium tuberculosis* (MTB) was detected, with or without resistance to Rifampicin. A negative result meant MTB was not detected in the sample. An invalid result was considered inconclusive due to potential technical errors or sample-related issues. Line Probe Assay (LPA) results were interpreted by analyzing the presence or absence of specific mutations in the *rpoB*, *katG*, and *inhA* genes. Resistance to Rifampicin (RIF) and Isoniazid (INH) was determined based on mutations in these gene regions.

The detection of these mutations allowed for the rapid identification of drug-resistant TB strains.

Statistical Analysis

The collected data was subjected to statistical analysis to assess the diagnostic performance of GeneXpert MTB/RIF, LPA, and culture with Drug Susceptibility Testing (DST). Calculations of sensitivity, specificity, and accuracy were performed to evaluate the reliability of each method. Statistical software, such as SPSS, was used to analyze the data and establish relationships between diagnostic test outcomes and clinical variables. This analysis helped in determining the effectiveness of each diagnostic tool in detecting TB and drug-resistant TB among non-suspected patients.

Results

The study involved a total of 476 non-suspected TB/DR-TB patients, with a significant male predominance-361 males (75.8%) and 115 females (24.2%). The age distribution of the study population showed that the majority of patients (60.7%) fell within the 25-54 years age group, making it the most common age range for non-suspected TB/DR-TB cases. The next largest group was patients aged 55 years and above, comprising 20% of the total population, while 19% were in the 15-24 years age range. The mean age of the participants was 30.5 ± 13.9 years, indicating a relatively young population. This suggests that TB/DR-TB could impact adults across a wide range of ages, but particularly middle-aged individuals (Figure 1).

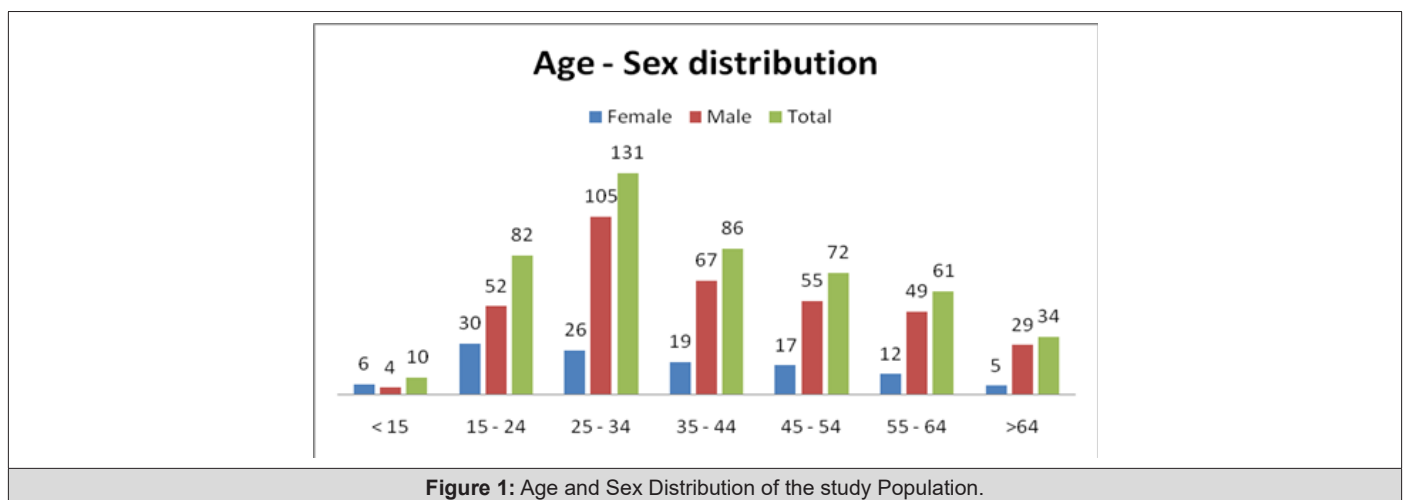


Table 1 presents the GeneXpert results for non-TB suspects, categorized by their previous TB history. Out of the 476 non-TB suspects, 114 had a history of TB, while 362 did not. Among the 362 patients without a previous TB history, 329 were negative for MTB, 31 were MTB-positive with rifampicin sensitivity, and 2 were

MTB-positive with rifampicin resistance. In the group with a previous TB history, 88 patients were included, with 24 showing rifampicin sensitivity and 2 showing rifampicin resistance. In total, of the 59 MTB-positive cases, only 4 exhibited rifampicin resistance (Figures 2-4).

Table 1: GeneXpert Results for Non-TB Suspects with and without Previous TB History: Detection of MTB and Rifampicin Resistance.

	Non - TB Suspects with previous TB history	Non - TB Suspects without previous TB history	Total
MTB not detected	88	329	417
Rif S	24	31	55
Rif R	2	2	4
Total	114	362	476

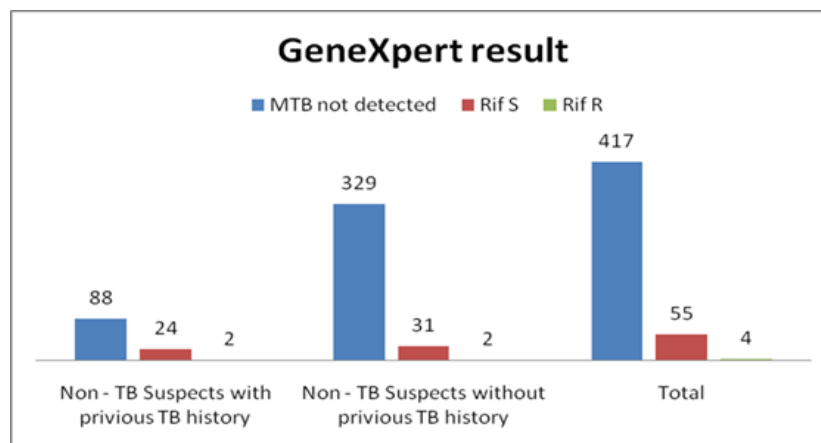


Figure 2: Comparative Analysis of Non-TB Suspects with and without Previous TB History.

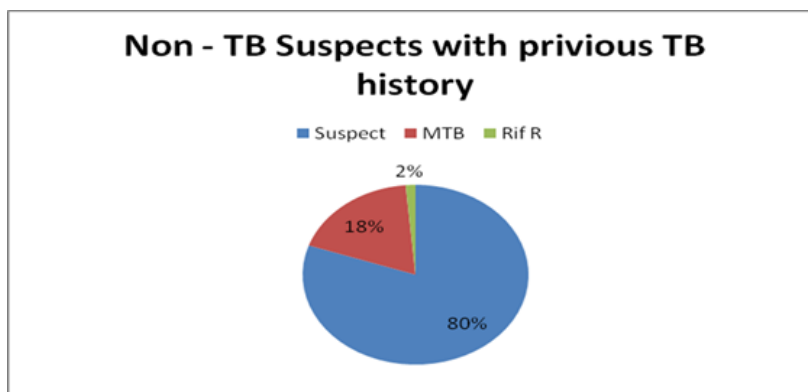


Figure 3: Prevalence of MTB and Rifampicin Resistance Among Non-TB Suspects with Prior TB History.

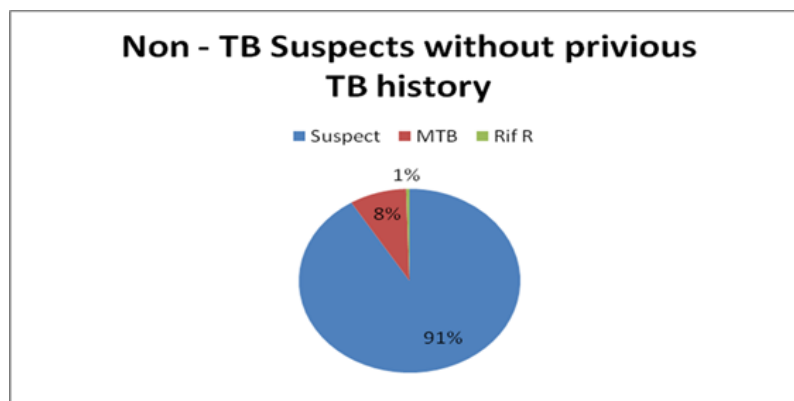


Figure 4: GeneXpert Results for Non-TB Suspects without Previous TB Exposure.

Table 2 compares the results of GeneXpert-positive cases with microscopy (sediment) results. Out of the 59 GeneXpert-positive cases, 19 were negative on LED fluorescence microscopy, all of which were from the rifampicin-sensitive group. Among the re-

maining 40 microscopy-positive cases, 4 showed rifampicin resistance and 36 were rifampicin-sensitive. Of the 40 microscopy-positive cases, 6 were classified as scanty, 7 as 1+, 16 as 2+, and 11 as 3+ based on the microscopy results.

Table 2: Comparison of GeneXpert and Microscopy Results in Rifampicin-Sensitive and Rifampicin-Resistant TB Cases (n=59).

		GeneXpert Positive (+ve) cases vs Microscopy (sediment)					
		Microscopy Result					
		Negative	Scanty	1+	2+	3+	Total
GeneXpert Result	Rif S	19	6	7	13	10	55
	Rif R	0	0	0	3	1	4
	Total	19	6	7	16	11	59

Table 3 shows that among the 59 GeneXpert-positive cases, 6 were classified as MTB not detected in LPA, all of which were rifampicin-sensitive according to GeneXpert results. All 4 cases with rifampicin resistance in GeneXpert were identified as multidrug-resistant

(MDR) by LPA. Among the 49 rifampicin-sensitive cases identified by GeneXpert, 2 were found to be rifampicin-resistant, and 4 showed resistances to isoniazid (INH) in LPA, with 1 case exhibiting both rifampicin and isoniazid resistance, indicating MDR.

Table 3: Comparison of GeneXpert and LPA Results in Rifampicin-Sensitive and Rifampicin-Resistant TB Cases (n=59).

		GeneXpert positive vs LPA result					
		MTB not detected/In-valid	Rif S	Rif R	INH S	INH R	MDR
GeneXpert Result	Rif S	6	47	2	45	4	1
	Rif R	0	0	4	0	4	4

Table 4 shows that among the 59 GeneXpert-positive cases tested by the solid LJ culture method, 45 were culture-positive. Out of the 45 positive cultures, 5 were identified as multidrug-resistant

(MDR), of which 1 was sensitive in both GeneXpert and LPA results. Among the 40 non-MDR cases, 7 showed mono-resistance to isoniazid (INH).

Table 4: GeneXpert Positive vs Culture Growth and Drug Susceptibility Testing (DST).

		GeneXpert positive vs Culture Growth & DST				
		Negative	Positive			
			MDR	Mono R	Mono H	Others
GeneXpert Result	Rif S	14	1	0	7	33
	Rif R	0	4	0	0	0

Discussion

This study aimed to evaluate the prevalence of Mycobacterium tuberculosis (MTB) and drug-resistant tuberculosis (DR-TB) in a cohort of non-suspected TB/DR-TB patients using the GeneXpert MTB/RIF, Line Probe Assay (LPA), and solid LJ culture with drug susceptibility testing (DST). The findings suggest that, while the majority of cases were rifampicin-sensitive, a notable proportion exhibited resistance, particularly in patients with a history of pre-

vious TB treatment.

The study population consisted of 476 individuals, with a significant male predominance (75.8%), which is consistent with findings from other studies that show a higher prevalence of TB among males due to factors such as occupational exposure and delayed healthcare seeking in men [21]. The mean age of the patients was 30.5 ± 13.9 years, suggesting that TB/DR-TB predominantly affects younger adults, particularly those in the 25-54 years age group

(60.7%). This is consistent with global TB trends, where TB incidence peaks in economically active age groups, potentially impacting the workforce and exacerbating economic burdens [22].

Table 2 showed the GeneXpert results for non-TB suspects with and without previous TB history. A significant number of individuals without a previous TB history (329 out of 362) were negative for MTB, which is expected since they did not have prior exposure. However, 33 individuals from this group showed MTB positivity, and 4 of them exhibited rifampicin resistance. This highlights the possibility of undiagnosed TB or DR-TB in non-suspect populations, underscoring the importance of active screening and testing in high-risk groups. In contrast, among individuals with previous TB history, 24 of 88 showed rifampicin sensitivity, while only 2 had rifampicin resistance. Previous studies have also reported higher rates of rifampicin resistance among individuals with a history of prior TB treatment due to incomplete or improper treatment regimens [23].

In the comparison of GeneXpert and microscopy results (Table 2), it was found that out of 59 GeneXpert-positive cases, 19 were negative on LED fluorescence microscopy. This discrepancy could be attributed to the higher sensitivity of GeneXpert in detecting MTB, including cases with low bacterial loads that might not be detectable by traditional microscopy, which is limited in sensitivity. Other studies have reported similar findings where GeneXpert outperforms microscopy, especially in detecting drug resistance [24]. Among the 40 microscopy-positive cases, 4 were rifampicin-resistant, and 36 were rifampicin-sensitive. This further highlights the role of GeneXpert in detecting resistance that may not be easily detected by microscopy, particularly in resource-limited settings where microscopy remains a primary diagnostic tool.

The comparison between GeneXpert and LPA results (Table 3) showed that among 59 GeneXpert-positive cases, 6 were classified as MTB not detected in LPA, but all 6 were rifampicin-sensitive according to GeneXpert. This discrepancy could be due to the differences in the mechanisms by which the two tests detect resistance. While GeneXpert directly detects rifampicin resistance mutations in the *rpoB* gene, LPA identifies a broader spectrum of mutations that can influence resistance patterns. Interestingly, all 4 cases with rifampicin resistance in GeneXpert were found to be multidrug-resistant (MDR) in LPA, which is consistent with the global trend where rifampicin resistance often correlates with resistance to other first-line drugs, such as isoniazid (INH) [25]. Among the rifampicin-sensitive cases, 2 were found to be rifampicin-resistant by LPA, and 4 showed isoniazid resistance, with 1 case demonstrating both rifampicin and isoniazid resistance, indicating MDR. These findings align with other studies that highlight the challenges of dual resistance in TB cases and the importance of using multiple diagnostic methods to fully characterize the drug resistance profile [26].

Table 4 presented the comparison of GeneXpert-positive cases with culture growth and DST. Among the 59 GeneXpert-positive cases, 45 were culture-positive, and 5 of these were identified as

MDR. Interestingly, 1 MDR case was sensitive to both GeneXpert and LPA, suggesting a potential discrepancy between molecular and culture-based results. This finding may reflect the limitations of molecular tests in detecting all forms of resistance, particularly in cases with complex resistance patterns. Among the non-MDR cases, 7 showed mono-resistance to isoniazid, highlighting the continued burden of drug resistance in the study population. These results are consistent with other studies showing that while GeneXpert and LPA are highly accurate in detecting rifampicin resistance, they may not always detect all forms of drug resistance, particularly in cases of mono-resistance [27].

This study emphasizes the utility of GeneXpert MTB/RIF, LPA, and LJ culture in diagnosing TB/DR-TB, but also highlights the challenges in detecting all forms of drug resistance. The findings suggest that while rifampicin resistance is a critical marker of drug-resistant TB, multidrug resistance and mono-resistance to isoniazid are also significant concerns. The study underscores the importance of using a combination of diagnostic tools to ensure comprehensive detection of drug resistance patterns and improve TB management. Future research should focus on improving diagnostic methods to detect more complex resistance patterns, particularly in high-risk populations with previous TB history.

Conclusion

This study shows that using GeneXpert MTB/RIF, Line Probe Assay (LPA), and LJ culture with drug susceptibility testing (DST) improves the diagnosis of TB and drug-resistant TB (DR-TB), especially in patients not initially suspected of TB. GeneXpert was more sensitive than microscopy, though some results varied between methods. TB was most common in middle-aged men, with prior TB history linked to drug resistance. Combining molecular and culture-based tests is key to accurate diagnosis and better treatment, helping to control DR-TB. More research is needed to improve detection of complex resistance patterns.

Author Contributions

All authors contributed equally to all aspects of the study, including study design, data collection, data analysis, manuscript writing, and final approval of the version to be published.

References

1. World Health Organization (2013) Global tuberculosis report 2013. World health organization.
2. Nazneen A, Tarannum S, Chowdhury KI, Islam MT, Islam SH, et al. (2021) Implementation status of national tuberculosis infection control guidelines in Bangladeshi hospitals. *PloS one* 16(2): e0246923.
3. Hossain A, Saimum SH, Banu S (2022) Towards ending tuberculosis in Bangladesh. *Journal BMANA* 22: 75-80.
4. Hasan MZ, Ahmed S, Islam Z, Dorin F, Rabbani MG, et al. (2023) Costs of services and funding gap of the Bangladesh National Tuberculosis Control Programme 2016–2022: An ingredient based approach. *PLoS One* 18(6): e0286560.

5. Zaman S, Rifat M (2024) Tuberculosis, community engagement, and person-centred care in Bangladesh. *A Brief Social History of Tuberculosis* pp. 60-75.
6. Islam MS, Tarannum S, Banu S, Chowdhury KI, Nazneen A, et al. (2022) Preparedness of tertiary care hospitals to implement the national TB infection prevention and control guidelines in Bangladesh: A qualitative exploration. *Plos one* 17(2): e0263115.
7. Zaman S, Rifat M (2024) Tuberculosis, community engagement, and person-centred care in Bangladesh: Successes and challenges. In *A Brief Social History of Tuberculosis* pp. 60-75.
8. Sultana S, Salwa M, Towhid MI, Islam SS, Haque MA (2022) Challenges for tuberculosis control at selected primary healthcare centers in Bangladesh: A mixed-method study. *Indian J Tuberc* 69(2): 134-140.
9. Kamal SM, Hossain A, Sultana S, Begum V, Haque N, et al. (2015) Anti-tuberculosis drug resistance in Bangladesh: reflections from the first nationwide survey. *Int J Tuberc and Lung Dis* 19(2): 151-156.
10. Ahmed FW (2018) A critical analysis of Bangladesh national tuberculosis control program. *J Pulmonol Clin Res* 2:16-9.
11. Aribi M (2011) Autoimmunity and immunotherapy of type 1 Diabetes. *Type 1 Diabetes-Pathogenesis, Genetics and Immunotherapy*.
12. Mahbub A, Mamun AA, Zaman T, Islam S, Jannat T, et al. (2025) Comparison of Culture, Multiplex PCR and Histopathology for the Detection of Etiological Agents of Cervicitis. *Molecular Mechanism Research* 3(1): 8744.
13. Chakaya J, Khan M, Ntoumi F, Aklillu E, Fatima R, et al. (2021) Global Tuberculosis Report 2020–Reflections on the Global TB burden, treatment and prevention efforts. *Int j infect dis* 113: S7-12.
14. Mutingwende I, Development and validation of a molecular diagnostic for tuberculosis (Doctoral dissertation, North-West University (South Africa), Potchefstroom Campus).
15. Cheon SA, Cho HH, Kim J, Lee J, Kim HJ, et al. (2016) Recent tuberculosis diagnosis toward the end TB strategy. *J microbiol methods* 123: 51-61.
16. Oga Omenka C, Tseja Akinrin A, Sen P, Mac Seing M, Agbaje A, et al. (2020) Factors influencing diagnosis and treatment initiation for multidrug-resistant/rifampicin-resistant tuberculosis in six sub-Saharan African countries: a mixed-methods systematic review. *BMJ glob health* 5(7): e002280.
17. Hossain MB, Ahmed A, Tukade A, Mahbub C, Haque A, et al. (2025) Frequency of Tuberculous Lymphadenitis (TBLA) in Somalia: A Retrospective Study with GeneXpert PCR-Based Diagnosis 4(1): 18-23.
18. Sharma SK, Kohli M, Yadav RN, Chaubey J, Bhasin D, et al. (2015) Evaluating the diagnostic accuracy of Xpert MTB/RIF assay in pulmonary tuberculosis. *PloS one* 10(10): e0141011.
19. Detjen AK, DiNardo AR, Leyden J, Steingart KR, Menzies D, et al. (2015) Xpert MTB/RIF assay for the diagnosis of pulmonary tuberculosis in children: a systematic review and meta-analysis. *lancet respir med* 3(6): 451-461.
20. Whitfield MG, Warren RM, Streicher EM, Sampson SL, Sirgel FA, et al. (2015) Mycobacterium tuberculosis pncA polymorphisms that do not confer pyrazinamide resistance at a breakpoint concentration of 100 micrograms per milliliter in MGIT. *J clin microbiol* 53(11): 3633-3635.
21. Allana S, Shashkina E, Mathema B, Bablishvili N, Tukvadze N, et al. (2017) pncA gene mutations associated with pyrazinamide resistance in drug-resistant tuberculosis, South Africa and Georgia. *Emerg infect dis* 23(3): 491-495.
22. Zahran M, El-Shabasy RM, Elrashedy A, Mousa W, Nayel M, et al. (2023) Recent progress in the genotyping of bovine tuberculosis and its rapid diagnosis via nanoparticle-based electrochemical biosensors. *RSC advances* 13(45):31795-31810.
23. Adam T, Baddeley A, Bastard M, den Boon S, Dean A (2023) WHO's global tuberculosis report 2023. World Health Organization.
24. Cheng J, Wang L, Zhang H, Xia Y (2015) Diagnostic value of symptom screening for pulmonary tuberculosis in China. *PloS one* 10(5): e0127725.
25. Ou X, Li Q, Xia H, Pang Y, Wang S, et al. (2014) Diagnostic accuracy of the PURE-LAMP test for pulmonary tuberculosis at the county-level laboratory in China. *PLoS One* 9(5): e94544.
26. Gong W, Wu X (2021) Differential diagnosis of latent tuberculosis infection and active tuberculosis: a key to a successful tuberculosis control strategy. *Frontiers in microbiology* 12: 745592.
27. Gong W, Wu X (2021) Differential diagnosis of latent tuberculosis infection and active tuberculosis: a key to a successful tuberculosis control strategy. *Frontiers in microbiology* 12: 745592.