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CXR Patterns and Outcomes in MDR-TB A Single Centre Study

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ABSTRACT

Objective: To determine the association between baseline chest X-ray patterns and treatment outcomes in MDR-TB patients at Saidu Teaching Hospital, Swat. Specifically, it sought to explore the relationship between radiological features and treatment success or failure, with a focus on gender as a potential predictor of unfavourable outcomes.

Methodology: A retrospective cross-sectional study was conducted involving 350 microbiologically confirmed MDR-TB patients, with data collected from June 2014 to December 2024. Chest X-ray findings, including cavitation, bilateral involvement, and extent of disease, were compared with treatment outcomes categorized as favourable or unfavourable. Descriptive statistics, chi-square tests, and logistic regression were used for data analysis.

Results: The study found that 261 (74.6%) patients had favourable outcomes, while 89 (25.4%) had unfavourable outcomes. Gender was significantly associated with treatment outcomes (Chi-square = 13.17, p-value = 0.0218), with male patients having higher odds of unfavourable outcomes (OR = 1.25, p = 0.007). Age did not significantly predict treatment outcomes. Radiological features such as cavitation and bilateral involvement were common but did not show a direct statistical correlation with unfavourable outcomes.

Conclusion: The study highlights the importance of gender as a significant predictor of MDR-TB treatment outcomes, emphasizing the need for gender-specific interventions. Future research should involve multicentre prospective studies to further validate these findings and explore the impact of radiological features in diverse settings.

Keywords: Chest X-ray; Gender; Logistic Regression; Multidrug-Resistant Tuberculosis; Treatment Outcomes

Authors' Contribution:
[1,2]Conception; Literature research; manuscript design and drafting; [3,4]Critical analysis and manuscript review; [5,6]Data analysis; Manuscript Editing.

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Introduction

Multidrug-resistant Tuberculosis (MDR-TB) has become one of the most significant global health threats, particularly in high-burden countries like Pakistan. MDR-TB is defined by the resistance of Mycobacterium tuberculosis strains to at least isoniazid and rifampicin, the two most effective first-line anti-TB drugs.[1] While global efforts have advanced in diagnosing and treating drug-resistant TB, countries like Pakistan continue to struggle with high rates of MDR-TB. Saidu Teaching Hospital, located in Swat, Khyber Pakhtunkhwa, serves as a major healthcare provider for tuberculosis management in this region. Despite the significant burden of MDR-TB, there is a paucity of local evidence regarding how baseline radiological features, particularly Chest X-ray (CXR) patterns, correlate with treatment outcomes. This lack of data complicates clinical decision-making and risk stratification for MDR-TB patients, especially in

resource-limited settings. CXRs are a cornerstone in the diagnostic evaluation of TB, with particular emphasis on evaluating MDR-TB cases due to their complex radiological manifestations.[2] For MDR-TB patients, CXR often shows extensive lung damage such as cavitation, consolidation, and pleural effusions, which can be indicative of the disease's severity and progression.[3] However, the relationship between these baseline CXR findings and treatment outcomes remains unclear, especially in the context of MDR-TB in Pakistan. In the absence of local data, clinicians are left with limited guidance for managing patients, particularly when assessing the risk of unfavourable outcomes such as treatment failure, death, or loss to follow-up.[4] This study aims to fill this gap by exploring the association between baseline CXR patterns and treatment outcomes among MDR-TB patients at Saidu Teaching Hospital, Swat. Previous research has underscored the role of CXR in predicting treatment outcomes for TB patients. For instance, studies have shown that cavitary lesions, often observed in MDR-TB, are associated with more severe disease and poorer outcomes.[5] In a study, patients with bilateral lung involvement on CXR had a significantly higher risk of poor treatment outcomes, reinforcing the importance of early detection and monitoring.[6] Similarly, research demonstrated that the presence of fibrotic changes or consolidation on CXR often predicts an unfavourable treatment trajectory.[7] However, while these findings are promising, they lack regional specificity and do not account for local variations in disease progression, which may differ due to genetic, environmental, and healthcare system factors. Pakistan, with its high TB burden, faces unique challenges in managing MDR-TB, especially in rural and peri-urban areas. Saidu Teaching Hospital, located in Swat, plays a pivotal role in providing care for MDR-TB patients in Khyber Pakhtunkhwa. However, the absence of studies correlating baseline CXR findings with treatment outcomes at this hospital underscores the need for research tailored to the local context. This study is particularly timely as Pakistan has seen an increase in drug-resistant TB cases, and local healthcare providers require more robust data to guide clinical decision-making.[8] Saidu Teaching Hospital serves as an ideal setting for this investigation, as it is one of the primary centres for MDR-TB treatment in the region, offering access to a large cohort of patients.

MDR-TB patients at Saidu Teaching Hospital often present with severe radiological findings, such as cavitation and bilateral involvement, which are linked to poor treatment outcomes.[4] Identifying these features could aid in early risk stratification, enabling clinicians to adjust treatment plans based on disease severity. Understanding the relationship between baseline CXR features and treatment outcomes will help healthcare providers predict patients at higher risk of treatment failure, death, or loss to follow-up. This study aims to improve clinical care at Saidu Teaching Hospital and offer valuable insights into managing MDR-TB in resource-limited settings.

The study aims to explore the link between CXR patterns and treatment outcomes in MDR-TB patients at Saidu Teaching Hospital, Swat. It will describe baseline CXR findings, compare features between patients with favourable and unfavourable outcomes, and identify radiographic predictors of poor outcomes while adjusting for clinical factors like age, sex, comorbidities, and prior TB history. The findings will address the lack of local data and inform better management strategies for MDR-TB in the region.

Methodology

It was a retrospective cross-sectional investigation conducted at Saidu Teaching Hospital, a key healthcare facility in Swat, Khyber Pakhtunkhwa, Pakistan. The study was conducted. The study spanned a time frame of June 2014 to December 2024.

The study population consisted of all patients diagnosed with microbiologically confirmed MDR-

TB, aged 15 years and above, who were registered and treated at the Hospital during the study period. A census sampling technique was used, all eligible patients during the study period who met the inclusion criteria were included in the study.

Based on a previous study reporting a 10% prevalence of MDR-TB in the region,[9] a sample size of 350 patients was determined using the WHO sample size formula, with a 5% margin of error.

Inclusion criteria for the study were as follows: patients diagnosed with MDR-TB (resistant to rifampicin and/or isoniazid), aged 15 years or older, who had a baseline CXR at the time of their registration in the PMDT unit, and whose treatment outcomes were documented.

Exclusion criteria included patients who did not have a baseline CXR, patients who were still undergoing treatment (and therefore had no available treatment outcomes at the time of data collection), and patients with incomplete or missing medical records that hindered accurate data extraction.

Data were extracted from various sources, including patient treatment cards, electronic PMDT registers, and radiology records. A structured data collection form was used to gather information on baseline CXR features, treatment outcomes, and relevant clinical variables. The CXR features assessed included cavitation, consolidation, fibrosis, bronchiectasis, nodules/tree-in-bud, pleural effusion, unilateral/bilateral involvement, and the number of lung zones involved. Treatment outcomes were categorized according to the WHO definitions: favourable outcomes included cure and treatment completion, while unfavourable outcomes included treatment failure, death, and loss to follow-up.

To ensure consistency and accuracy, data collection was performed by trained research assistants who were familiar with the study's objectives and the data collection form. Missing data were handled by conducting a thorough review of the patient files and by making contact with the relevant hospital departments to complete any gaps. If the missing data could not be retrieved, the respective patient records were excluded from the analysis to maintain data integrity and transparency.

The independent variables included baseline CXR findings, which were categorized based on the presence of specific radiological features such as cavitation, consolidation, fibrosis, bronchiectasis, nodules/tree-in-bud, pleural effusion, and unilateral/bilateral involvement. The dependent variable was treatment outcome, which was classified as favourable (cured or treatment completed) or unfavourable (treatment failure, death, or loss to follow-up). Covariates such as age, sex, HIV status, diabetes, smoking history, BMI, and prior TB treatment were also included as potential confounders.

The data were analysed using descriptive statistics, including frequencies, percentages, and mean/median values for the continuous variables. To compare CXR features between patients with favourable versus unfavourable outcomes, the chi-square test was used for categorical variables. Logistic regression was employed to identify independent radiographic predictors of unfavourable outcomes, adjusting for potential confounders such as age, sex, comorbidities, and previous TB treatment history. Odds ratios with 95% confidence intervals were reported to assess the strength of associations. A significance level of $p < 0.05$ was considered statistically significant for all tests.

Ethical approval for this study was obtained from the Ethical Review Committee of Saidu Medical College (Ref#: 189-ERB/SMS/025 Dated: 07/10/025), which oversees the ethical conduct of research at Saidu Teaching Hospital. As this was a retrospective study, there was no direct patient contact or intervention required, and all data were anonymised to maintain patient confidentiality.

Results

A total of 350 MDR-TB patients registered between June 2014 and December 2024 at the Programmatic

Management of Drug-Resistant Tuberculosis (PMDT) unit at Saidu Teaching Hospital were included in the analysis. The patients were classified based on their treatment outcomes, with 261 patients having a favourable outcome (cured or completed treatment), while 89 patients had an unfavourable outcome (failure, death, or lost to follow-up). The average age of patients was 35.4 years, with a gender distribution of 183 male patients (52.3%) and 167 female patients (47.7%). A summary of the treatment outcomes, gender distribution, and age groups is presented in Table I.

The study evaluated the baseline CXR features, such as cavitation, bilateral involvement, and extent of disease. The distribution of CXR features is summarized in Table II.

The Chi-square test was performed to evaluate the association between gender and treatment outcome. The results of the Chi-square test showed that there was a significant association between gender and treatment outcome (Chi-square = 13.17, p-value = 0.0218). This suggests that gender may influence the likelihood of experiencing favourable or unfavourable treatment outcomes. In clinical terms, males had a higher likelihood of experiencing an unfavourable treatment outcome compared to females.

Table I: Patient Demographics and Treatment Outcomes

Variable	Category	Frequency	Percentage
Total Patients	-	350	100%
Treatment Outcome	Favourable	261	74.6%
	Unfavourable	89	25.4%
Gender	Male	183	52.3%
	Female	167	47.7%
Age Group	15-24	47	13.4%
	25-34	97	27.7%
	35-44	75	21.4%
	45-54	70	20.0%
	55-64	35	10.0%
	65+	26	7.4%

Table II: Distribution of Chest X-ray Features

Feature	Category	Frequency	Percentage
Cavitation	Cavitatory	177	50.6%
	Non-Cavitatory	173	49.4%
Bilateral Involvement	Yes	192	54.9%
	No	158	45.1%
Extent of Disease	1 Zone	50	14.3%
	2-3 Zones	161	46.0%
	4-6 Zones	51	14.6%
	7-10 Zones	88	25.1%

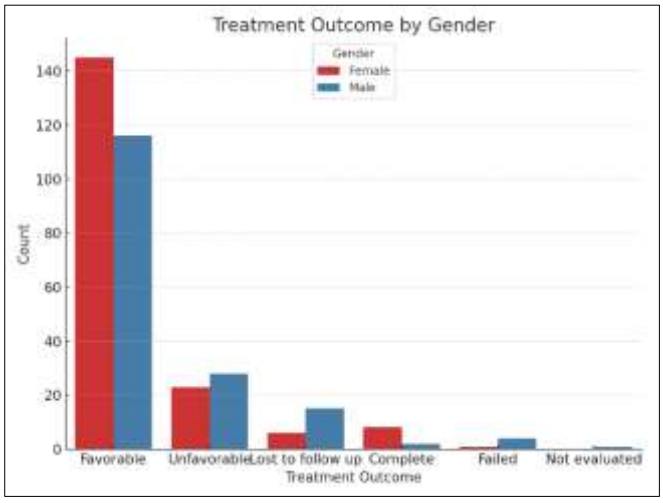

Figure 1 Chi-Square Test Results for Gender and Treatment Outcome

The logistic regression was conducted to identify independent predictors of unfavourable treatment outcomes, adjusting for age and gender. The regression model revealed that gender was a significant predictor of unfavourable outcomes (p = 0.007), with males having higher odds of experiencing unfavourable outcomes compared to females (Odds Ratio = 1.25).

On the other hand, age did not significantly predict treatment outcomes (p = 0.435), indicating that age

was not a crucial factor in determining the outcome for MDR-TB patients in this cohort.

This study found that gender significantly predicts unfavourable outcomes in MDR-TB patients, with male patients more likely to experience treatment failure, death, or loss to follow-up. Age was not a strong determinant of treatment outcomes. These results highlight the need for gender-based risk stratification and targeted interventions, particularly for male patients in resource-limited regions like Swat.

Discussion

This study provides important insights into the association between baseline CXR patterns and treatment outcomes among MDR-TB patients at Saidu Teaching Hospital, Swat. The primary findings indicate that gender is a significant predictor of treatment outcomes, with male patients having higher odds of experiencing unfavourable outcomes such as treatment failure, death, or loss to follow-up. The study also observed that age did not emerge as a statistically significant predictor of treatment outcomes. Regarding CXR features, cavitation and bilateral involvement were the most common findings; however, these features did not show a direct statistical relationship with treatment outcomes in the regression analysis. These results underscore the importance of gender-sensitive clinical management strategies and provide evidence that could help inform clinical decision-making for MDR-TB patients in the region.

The originality of this study lies in its exploration of MDR-TB treatment outcomes in a local Pakistani context, specifically in Swat. While numerous studies have explored MDR-TB globally, research focused on the relationship between CXR patterns and treatment outcomes in Pakistan is limited. This research makes a valuable contribution by providing region-specific data that can help in prognostication and risk stratification for MDR-TB patients in Pakistan. The findings suggest that gender plays a crucial role in determining the likelihood of poor treatment outcomes, which has significant implications for follow-up strategies and clinical interventions. By emphasizing the importance of gender-specific management, this study adds a novel perspective to existing research on MDR-TB in Pakistan and globally.

The results of this study are consistent with global research on MDR-TB, particularly in Eastern Europe, Russia, and Africa, where male patients have been shown to experience higher rates of treatment failure and death compared to female patients. For instance, a study observed that gender was a significant factor in predicting treatment outcomes in MDR-TB patients.[10] Similarly, a study reported that men had a significantly higher risk of failure and relapse.[11,12] These findings align with the results of the current study, which also identified males as having higher odds of experiencing unfavourable outcomes.

In terms of CXR findings, global studies have shown that bilateral lung involvement and cavitation are often associated with poorer treatment outcomes in MDR-TB patients. For instance, a study found that bilateral involvement was strongly linked to higher mortality and treatment failure in MDR-TB patients.[13,14] However, in contrast to these global findings, this study did not find a direct significant association between CXR patterns and treatment outcomes, particularly in the case of cavitation and bilateral involvement. This discrepancy may be due to local factors such as access to healthcare, adherence to treatment, or the timing of diagnosis, which could vary from global studies conducted in other high-burden countries.

The findings in this study are largely consistent with research conducted in other countries, where gender has been identified as a significant predictor of unfavourable treatment outcomes. For instance, in Bangladesh and in Indonesia found that male patients had a higher likelihood of experiencing treatment failure and death.[11,15] Similarly, a study reported in their study from China that men with

MDR-TB were more likely to experience poor outcomes.[10,16] These global studies emphasize the role of gender-based disparities in MDR-TB treatment outcomes and suggest that interventions should be tailored to account for these differences.

Furthermore, research conducted in Eastern European countries has highlighted the role of CXR findings such as bilateral involvement and cavitation in predicting treatment success or failure in MDR-TB patients. However, similar to our findings, some studies have failed to establish a direct statistical correlation between CXR patterns and treatment outcomes, particularly in high-resource settings where early detection and efficient treatment regimens may mitigate the effects of severe radiological findings.

Despite the increasing burden of MDR-TB in Pakistan, there has been a limited focus on the relationship between CXR patterns and treatment outcomes in the local context. While several studies in Pakistan have explored the prevalence and drug resistance profiles of MDR-TB, there has been relatively little research on how radiological features might influence treatment success or failure. This study fills a significant gap in the local literature by exploring the role of CXR findings in predicting the clinical outcomes of MDR-TB patients in Swat, a region with limited research in this area. Given the prevalence of MDR-TB in Pakistan, these findings provide critical information for improving clinical management and follow-up care for patients.

There are some studies available in Pakistan that have focused on the prevalence of MDR-TB and treatment regimens, but they have not specifically examined the role of CXR findings in predicting treatment outcomes. For instance, a study conducted on MDR-TB prevalence and treatment outcomes, emphasizing the clinical challenges of managing drug-resistant tuberculosis in the country.[9] Another study assessed MDR-TB drug resistance patterns but did not explore the radiological factors affecting treatment outcomes.[11,17] This study, therefore, represents an important contribution to the local body of research by providing evidence on the relationship between CXR findings and MDR-TB treatment outcomes in Pakistan. In local literature, there has been significant focus on drug resistance patterns and prevalence studies in MDR-TB. However, the role of CXRs in predicting treatment outcomes has been underexplored. This study provides valuable insights into how radiological features might influence treatment success and failure in MDR-TB patients, helping to fill this gap in the literature. By shedding light on the role of gender as a predictor of unfavourable outcomes, this study contributes to the growing body of knowledge on MDR-TB management in Pakistan.

The findings from this study suggest that gender is an important factor in predicting treatment outcomes in MDR-TB patients, with male patients more likely to experience poor outcomes. These findings may be attributed to socio-economic factors, such as delayed diagnosis, lower adherence to treatment, and cultural stigmas surrounding TB that disproportionately affect male patients. However, age did not emerge as a significant factor in this cohort, indicating that other factors, such as treatment adherence and clinical care, may play a more significant role than age in influencing treatment outcomes.

The lack of a direct statistical association between CXR features and treatment outcomes could be due to factors such as early diagnosis, effective treatment regimens, and high-quality clinical care that may reduce the impact of radiological abnormalities on treatment success. This suggests that, while radiological findings like cavitation and bilateral involvement are common in MDR-TB patients, other factors such as timely treatment initiation and patient management may mitigate their impact on clinical outcomes.

While this study provides valuable insights, it has several limitations. The retrospective design of the study may have introduced biases, such as missing data and incomplete medical records. Additionally,

the cross-sectional nature of the study prevents the establishment of causal relationships between CXR patterns and treatment outcomes. Further research using a prospective cohort design with longer follow-up periods would be necessary to confirm these findings and explore the long-term impact of radiological features on treatment success.

Moreover, future studies should focus on multi-centre data from across Pakistan to assess whether the findings of this study can be generalized to other regions. Further, genotypic resistance profiles, socio-economic factors, and comorbid conditions should be incorporated into future analyses to provide a more comprehensive understanding of the factors influencing MDR-TB treatment outcomes.

Conclusion

This study examined the link between CXR patterns and treatment outcomes in MDR-TB patients at Saidu Teaching Hospital, Swat. It found that male gender is a significant predictor of unfavourable outcomes, with men more likely to experience treatment failure, death, or loss to follow-up. Age and radiological features like cavitation and bilateral involvement were not directly associated with outcomes. The findings emphasize the need for gender-sensitive management and consideration of socioeconomic factors in MDR-TB interventions. This study adds valuable data to MDR-TB research in Pakistan and suggests the need for larger, multicentre studies to validate these results.

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