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Original Article

Exploring Obstructive and Restrictive Patterns of Pulmonary Function in Post-Tuberculosis Patients at Secondary Care Hospital in Kohat

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ABSTRACT

Objective: To determine the patterns of pulmonary function impairment among patients with previously treated pulmonary tuberculosis (TB) at a secondary care hospital in Kohat, Pakistan.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Medicine, Divisional Headquarters Teaching Hospital, Kohat, Khyber Pakhtunkhwa, Pakistan, from Aug 2024 to Jan 2025.

Methodology: A total of 139 post-tuberculosis patients who had completed the full course of anti-TB therapy with microbiological cure were included. Pulmonary function was assessed using a portable MiniSpir S spirometer, and results were categorized as normal, obstructive, restrictive, or mixed ventilatory patterns according to American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines. Data were analyzed using IBM SPSS Statistics version 27.

Results: The mean age of participants was 52.9±13.5 years, with females comprising 54% of the sample. Most participants (74.8%) belonged to the middle-income group, and none were smokers. Spirometry revealed 56.8% normal, 33.8% restrictive, 8.6% obstructive, and 0.7% mixed ventilatory patterns. Shortness of breath was reported by 39.6% of participants and showed a significant association with both obstructive and restrictive patterns ($p<0.001$). A positive family history of tuberculosis was also significantly associated with pulmonary dysfunction ($p = 0.04$).

Conclusion: A substantial proportion of post-TB patients exhibited persistent pulmonary function impairment, predominantly of the restrictive type. These findings highlight the need for routine post-treatment pulmonary evaluation and the development of context-specific rehabilitation guidelines for tuberculosis survivors in resource-limited healthcare settings.

Keywords: Obstructive ventilatory pattern; Pakistan, Pulmonary Tuberculosis; Pulmonary function impairment; Restrictive ventilatory pattern; Spirometry; Tuberculosis sequelae

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INTRODUCTION

Tuberculosis (TB) remains a major global health concern, with an estimated one-third of the world's population harboring latent Mycobacterium tuberculosis infection.1 According to the World Health Organization (WHO) Global TB Report 2023, approximately 10.6 million new TB cases were reported worldwide, with a prevalence of 7.5 million and 1.30 million TB-related deaths, highlighting the urgent need for strengthened control strategies.[2] In Pakistan, the burden of TB is substantial and affects both genders almost equally, with no significant male–female difference ($p = 0.23$). The disease burden was comparable across age groups, with a slight but non-significant predominance in the 26–40 years group (29.74%).[3]

Infection with Mycobacterium tuberculosis often leads to both pulmonary and extrapulmonary complications, many of which persist even after microbiological cure.[4] Structural lung damage resulting from the infection can cause long-term impairment of pulmonary function.[5] Lema RE. *et al*.[6] reported abnormal pulmonary function in nearly half of the patients at treatment completion. Patients with recurrent tuberculosis had a 2.8–3.0 times higher likelihood of developing abnormal lung function at treatment completion compared with those experiencing their first episode of TB.[7] Patel *et al.*[8] documented abnormalities in 70% of symptomatic and 54% of asymptomatic post-TB cases. Obstructive dysfunction was the predominant pattern among both symptomatic (42%) and in symptomatic (32%) post-tuberculosis (post-TB) patients, while restrictive impairment was observed in 10% of cases.

Despite the high global prevalence of post-tuberculosis lung impairment, data from high-burden countries like Pakistan remain limited.[7,8] Most available studies originate from tertiary or specialized

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centers in high-income countries, which do not reflect the realities of resource-limited healthcare systems. In Pakistan, where most tuberculosis patients are managed at secondary-level hospitals, such evidence has been particularly scarce. Only a small, sampled study from Quetta has previously explored abnormal radiological changes and their impact on pulmonary function in post-tuberculosis patients.[9]

Against this background, this study was undertaken to determine the patterns of obstructive and restrictive pulmonary function among post-TB patients at a secondary care hospital in Kohat city of Khyber Pakhtunkhwa province of Pakistan. The findings provide valuable insights into the burden, patterns, and determinants of post-TB lung impairment and offer essential evidence for developing locally relevant guidelines for follow-up, rehabilitation, and long-term management of patients recovering from tuberculosis.

METHODOLOGY

This cross-sectional study was conducted from September 2024 to January 2025, in the Department of Medicine, Divisional Headquarters Teaching (DHQ) Hospital, Kohat, a secondary care hospital located in Kohat city, Khyber Pakhtunkhwa province, Pakistan.

The study was conducted following approval of the research synopsis by the College of Physicians and Surgeons Pakistan and ethical clearance from the Ethical Committee of Khyber Medical University, Institute of Medical Sciences (KMU-IMS), Kohat (Ref. No. KIMS-REC/ECC/24/2/R; dated 25 June 2024).

The sample size was calculated using the WHO sample size calculator, based on an anticipated frequency of 10% for restrictive ventilatory patterns among post-tuberculosis patients, as reported by Patel et al.8 With a 5% absolute precision and a 95% confidence level, the required sample size was 139.

Inclusion Criteria: Patients of either gender with age ranging from 25 to 70 years, presenting with a history of pulmonary tuberculosis who had completed a full course of anti-tuberculosis therapy and achieved microbiological cure, confirmed by negative sputum smear and/or culture results, were included in the study.

Exclusion Criteria: Patients with extrapulmonary TB, interstitial or autoimmune lung diseases, neuromuscular disorders affecting respiration, or pleural pathology as well as individuals who were unable or unwilling to perform acceptable and reproducible spirometry per ATS/ERS standards were excluded from the study.

After selecting patients from the Outpatient Department of DHQ Hospital, Kohat, through a consecutive sampling technique, data collection commenced. Written informed consent was obtained from all participants following an explanation of the study objectives and procedures.

Baseline demographic and clinical information, including age, sex, weight, height, body mass index (BMI), marital status, education, occupation, area of residence, socioeconomic status, smoking history, family history of tuberculosis, nutritional status, environmental exposures, and relevant medical history, were recorded on a structured proforma.

Each participant underwent spirometry under the supervision of a consultant physician with a minimum of five years of post-fellowship experience Pulmonary function testing was performed using a portable MiniSpir S spirometer (Serial No. C13588; Medical International Research, Italy), validated for Spirometric evaluation in accordance with the American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines.10 Data acquisition and analysis were carried out using WinSpiroPRO 2.0 software (Model C11). Based on Spirometric results, participants were categorized into normal, obstructive, restrictive, or mixed ventilatory patterns. All data were reviewed for completeness and accuracy before entry.

For the study purpose post-tuberculosis patient was defined as an individual who had completed the recommended course of anti-tuberculosis therapy for active pulmonary TB and achieved microbiological cure (negative sputum smear or culture). Pulmonary function tests included measurement of airflow parameters, including Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV_1), using spirometry to determine the volume and flow of air exhaled after maximal inhalation. Spirometric patterns were defined according to standard criteria. A normal pattern was identified when the FEV_1/FVC ratio exceeded 70% and the FVC was greater than 80% of the predicted value. An obstructive pattern was characterized by an FEV_1/FVC ratio below 70% with an FVC greater than 80% of the predicted value. A restrictive pattern was considered when the FEV_1/FVC ratio was above 70% but the FVC was less than 80% of the predicted value, while a mixed pattern was defined by both an FEV_1/FVC ratio below 70% and an FVC less than 80% of the predicted value.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using graphical methods and distribution characteristics. Normally distributed continuous variables, including age, weight, height, body mass index (BMI), Forced Vital Capacity (FVC), and Forced Expiratory Volume in one second (FEV_1), were summarized as mean ± standard deviation (SD). Categorical variables, including sex, age groups, marital status, education level, occupation, monthly income, smoking status, family history of tuberculosis, environmental exposure, sputum test type, side effects, cough, sputum production, sputum colour, access to healthcare, shortness of breath, and pulmonary function patterns (normal, obstructive, restrictive, mixed), were summarized as frequencies and percentages.

RESULTS

Out of 139 post-tuberculosis patients were included in the study, 75 (54.0%) were females and 64 (46.0%) were males. The mean age was 52.9 ± 13.5 years, with most participants (n=55; 39.6%) were ranging in age from 41 to 60 years.

The majority (n=104; 74.8%) belonged to the middle-income group (Rs. 20,000–50,000 per month) and over half (n=79; 56.8%) were uneducated. None of the participants reported a history of smoking. A positive family history of tuberculosis was found in 20 (14.4%) individuals (Table-I).

Regarding occupational exposure, around two-thirds of the participants were engaged in non-hazardous jobs, while small proportions worked as farmers, coal miners, construction, or metal workers. Only 4 (2.9%) patients reported specific environmental exposures such as dust or industrial fumes. The mean BMI was 26.1 ± 4.3 kg/m², with most participants being overweight or obese.

Pulmonary function testing revealed that 79 (56.8%) of participants had normal patterns, 47(33.8%) exhibited restrictive, 12(8.6%) obstructive, and one (0.7%) patient had mixed ventilatory defects.

Shortness of breath was reported by 55(39.6%) participants and was significantly associated with both obstructive and restrictive patterns ($p < 0.001$). The family history of tuberculosis also showed a statistically significant association with pulmonary dysfunction ($p = 0.04$) [Table II).

Table-I: Socio-Demographic and Clinical Characteristics of the Study Participants (n=139)

	Variables	Frequency (%age)
Age Groups	25-40 years	35(25.2%)
	41-60 years	55(39.6%)
	>60 years	49(35.3%)
Gender	Male	64(46.0%)
	Female	75(54.0%)
Marital status	Married	124(89.2%)
	Single	1(0.7%)
	Widow	14(10.1%)
Monthly income (PKR)	≤10,000–20,000	22(15.8%)
	20,000–50,000	104(74.8%)
	>50,000–200,000	13(9.4%)
Education Status	Uneducated	79(56.8%)
	Primary	50(36.0%)
	Secondary	7(5.0%)
	Graduate	3(2.2%)
Smoking status	Yes	0(0.00%)
	No	139(100.0%)
Family History of Tuberculosis	Yes	20(14.4%)
	No	119(85.6%)
Occupation	Coal miner	8(5.8%)
	Construction	8(5.8%)
	Farmer	16(11.5%)
	Metal	5(3.6%)
	Wood cooking	10(7.2%)
	Other	92(66.2%)
Environmental exposures	Yes	4(2.9%)
	No	135(97.1%)
Pulmonary function pattern	Normal	79(56.8%)
	Obstructive	12(8.6%)
	Restrictive	47(33.8%)
	Mixed	1(0.7%)
Shortness of breath	Yes	55(39.6%)
	No	84(60.4%)
Dietary restriction	No	139(100.0%)
	Yes	0(00.0%)
Sputum test types (at the time of diagnosis)	AFB	4(2.9%)
	Gene expert	135(97.1%)
Access level	Easy	27(19.4%)
	Moderate	100(71.9%)
	Difficult	12(8.6%)

PKR: Pakistani Rupees; AFB: Acid fast bacilli; ATT: Anti-tuberculosis Therapy

Other sociodemographic and clinical variables, including age, BMI, marital status, occupation, education, income level, and environmental exposure,

Table-II: Association of Socio-Demographic and Clinical Characteristics with Pulmonary Function Patterns

Variables		Pulmonary function pattern					*p*-value
		Normal n=79 [n (%)]	Obstructive n=12 [n (%)]	Restrictive n=47 [n (%)]	Mixed n=1 [n (%)]	Total (n=139) [n (%)]	
Age Groups	25-40 years	18 (22.8)	3 (25.0)	13 (27.7)	1 (100.0)	35	0.22
	41-60 years	27 (34.2)	5 (41.7)	23 (48.9)	0 (0.0)	55	
	>60 years	34 (43.0)	4 (33.3)	11 (23.4)	0 (0.0)	49	
Body Mass Index	Under weight	1 (1.3)	0 (0.0)	4 (8.5)	0 (0.0)	5	0.44
	Normal	21 (26.6)	6 (50.0)	12 (25.5)	0 (0.0)	39	
	Overweight	51 (64.6)	6 (50.0)	28 (59.6)	1 (100.0)	86	
	Obese	6 (7.6)	0 (0.0)	3 (6.4)	0 (0.0)	9	
Marital status	Married	69 (87.3)	10 (83.3)	44 (93.6)	1 (100.0)	124	0.88
	Single	1 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	1	
	Widow	9 (11.4)	2 (16.7)	3 (6.4)	0 (0.0)	14	
Occupation	Coal miner	5 (6.3)	0 (0.0)	3 (6.4)	0 (0.0)	8	0.58
	Construction	4 (5.1)	0 (0.0)	4 (8.5)	0 (0.0)	8	
	Farmer	9 (11.4)	1 (8.3)	5 (10.6)	1 (100.0)	16	
	Metal	4 (5.1)	1 (8.3)	0 (0.0)	0 (0.0)	5	
	Wood cooking	5 (6.3)	1 (8.3)	4 (8.5)	0 (0.0)	10	
	Other	52 (65.8)	9 (75.0)	31 (66.0)	0 (0.0)	92	
Education Status	Uneducated	47 (59.5)	7 (58.3)	25 (53.2)	0 (0.0)	79	0.30
	Primary	30 (38.0)	3 (25.0)	16 (34.0)	1 (100.0)	50	
	Secondary	1 (1.3)	2 (16.7)	4 (8.5)	0 (0.0)	7	
	Graduate	1 (1.3)	0 (0.0)	2 (4.3)	0 (0.0)	3	
Family History of Tuberculosis	Yes	8 (10.1)	2 (16.7)	9 (19.1)	1 (100.0)	20	0.04
	No	71 (89.9)	10 (83.3)	38 (80.9)	0 (0.0)	119	
Environmental exposures	Yes	3 (3.8)	0 (0.0)	1 (2.1)	0 (0.0)	4	0.86
	No	76 (96.2)	12 (100.0)	46 (97.9)	1 (100.0)	135	
Monthly income (PKR)	≤10,000–20,000	12 (15.2)	2 (16.7)	8 (17.0)	0 (0.0)	22	0.95
	20,000–50,000	61 (77.2)	8 (66.7)	34 (72.3)	1 (100.0)	104	
	50,000–200,000	6 (7.6)	2 (16.7)	5 (10.6)	0 (0.0)	13	
Shortness of breath	Yes	12 (15.2)	10 (83.3)	32 (68.1)	1 (100.0)	55	< 0.001
	No	67 (84.8)	2 (16.7)	15 (31.9)	0 (0.0)	84	
Access level	Easy	16 (20.3)	1 (8.3)	9 (19.1)	1 (100.0)	27	0.18
	Moderate	59 (74.7)	10 (83.3)	31 (66.0)	0 (0.0)	100	
	Difficult	4 (5.1)	1 (8.3)	7 (14.9)	0 (0.0)	12	

**at the time of completion of Anti-tuberculosis treatment; PKR: Pakistani Rupees; AFB: Acid-Fast Bacilli*

did not demonstrate significant associations with pulmonary function patterns. Similarly, no significant relationship was observed with type of sputum test [GeneXpert vs. acid-fast bacilli (AFB)], reported side effects, or level of healthcare access.

Most participants underwent GeneXpert testing (n=135; 97.1%), and only a small proportion were tested for AFB for confirmation of diagnosis and assessment of cure. Side effects during tuberculosis treatment were infrequent (n = 9; 6.5%), with anorexia being the most reported adverse effect (n = 6; 4.3%), followed by jaundice (n = 3; 2.2%). After completing tuberculosis treatment, persistent cough was reported by 27 participants (19.4%), while 17(12.2%) continued to produce sputum, which was predominantly clear in appearance. Nearly three-quarters of the participants reported having moderate access to healthcare services.

DISCUSSION

Our study evaluated lung function in post-tuberculosis patients who had completed anti-TB treatment at a secondary care hospital in Kohat, showing that a substantial proportion of individuals developed lasting pulmonary impairment despite microbiological cure, most commonly with a restrictive pattern, followed by obstructive and mixed defects. These results highlight the long-term respiratory sequelae of tuberculosis, emphasizing the importance of continued follow-up of patients even after treatment completion.

In our study, approximately 43% of patients exhibited abnormal Spirometric patterns despite completing anti-TB therapy and elimination of pathogens. This finding aligns with international reports indicating that nearly half of all patients successfully treated for tuberculosis develop post-TB lung disease by the end of treatment.10 This substantial proportion highlights the significant impact of post-tuberculosis lung impairment on patients' quality of life (QoL). Similar findings were reported by Daniels et al., who observed that South African patients with microbiologically cured pulmonary tuberculosis continued to experience reduced health-related QoL, diminished exercise capacity, and persistent abnormalities in lung function.[11] Post-TB morbidities, further compounded by adverse psychological and socioeconomic conditions, markedly reduce QoL and are associated with a three- to four-fold higher mortality compared with the general population.[12]

In post-tuberculosis patients, both obstructive and restrictive pulmonary function patterns reflect the chronic structural and immunological consequences of healed infection. The obstructive defects are primarily attributed to airway remodeling, bronchial fibrosis, bronchiectasis, and residual inflammation leading to fixed airflow limitations. While restrictive abnormalities result mainly from parenchymal fibrosis, pleural thickening, or lung volume loss due to scarring and atelectasis. Persistent immune activation and dysregulated repair mechanisms, including increased matrix metalloproteinase activity and fibrotic remodeling, further contribute to chronic airflow and compliance impairment.[13,14]

In our study, a restrictive ventilatory pattern was the most frequently observed abnormality, identified in 33.8% of patients, whereas an obstructive pattern was noted in only 8.6%. These findings are consistent with those reported by Satti SA *et al.*[9], who observed a predominance of restrictive impairment (43.3%) among post-tuberculosis patients. However, our results contrast with several regional studies that have documented obstructive defects as the dominant pattern. Hussain R. *et al*. documented 26.4% restrictive and 56.3% obstructive patterns among post-tuberculosis patients in Karachi, [15] while Baig I.M. *et al*.[16] similarly reported 55.3% obstructive impairment in post-TB cases from the same region.

The predominance of restrictive patterns in our study, unlike other regional studies reporting mainly obstructive defects, may be explained by several factors. These include differences in patient characteristics such as the absence of smokers and higher female representation, variation in the time interval since TB treatment completion, and use of different Spirometric reference values or diagnostic thresholds. Additionally, disease severity, extent of parenchymal scarring, and the predominance of fibrotic rather than airway lesions in our population may have contributed to the higher frequency of restrictive abnormalities. This variation may also be attributed to the multifactorial nature of post-TB lung disease, and emphasizes the comprehensive evaluation approach based on symptoms, radiological and functional evaluation for precision management of post-TB patients.[17]

A positive family history of tuberculosis showed a significant association with pulmonary dysfunction in our study. This finding may reflect shared environmental exposures, delayed diagnosis due to household clustering, or underlying genetic susceptibility influencing immune and inflammatory responses to Mycobacterium tuberculosis.[18] Recurrent or prolonged exposure to infected family members can also lead to repeated subclinical infections, compounding lung injury even after treatment. This highlights the importance of family-based screening, preventive therapy, and post-treatment pulmonary follow-up in households with multiple TB cases.

This study adds meaningful evidence on post-tuberculosis pulmonary impairment in Pakistan, demonstrating a higher prevalence of restrictive, rather than obstructive, ventilatory defects among previously treated TB patients. In contrast to many regional studies reporting predominantly obstructive patterns, our findings suggest that restrictive abnormalities may be more common in certain subgroups, particularly non-smokers and female-majority populations. The study also highlights the significance of persistent dyspnea and identifies positive family history of TB as an underexplored but important correlate of impaired lung function. Overall, these findings emphasize the heterogeneity of post-TB lung disease and reinforce the need for routine functional assessment and individualized long-term follow-up of TB survivors.

LIMITATIONS OF STUDY

This study has several limitations that should be acknowledged. Conducted at a single secondary care hospital with a relatively small sample size, the findings may have limited generalizability to post-tuberculosis populations across Pakistan. The cross-sectional design precluded assessment of temporal changes in pulmonary function, thereby limiting evaluation of disease progression or recovery following treatment. Convenience sampling may have introduced selection bias, and the duration since completion of anti-tuberculosis therapy was not stratified, restricting analysis of its relationship with spirometric patterns. Furthermore, radiological correlation and diffusion capacity of the lung for carbon monoxide (DLCO) were not assessed due to the absence of standardized imaging and testing across all participants, limiting structural–functional interpretation. Despite these limitations, the study provides valuable real-world data from a secondary care setting that is often underrepresented in tuberculosis research.

CONCLUSION

A substantial proportion of patients who had completed successful anti-tuberculosis therapy exhibited persistent pulmonary function impairment, most commonly of the restrictive type. These findings highlight the long-term respiratory sequelae of tuberculosis, emphasizing the need for routine post-treatment Spirometric assessment, long-term follow-up, and rehabilitation strategies to improve quality of life. Strengthening awareness among clinicians and integrating lung health monitoring into national TB control programs may help reduce the burden of post-tuberculosis lung disease in resource-limited settings like Pakistan.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

ZU & AS: Data acquisition, data analysis, critical review, approval of the final version to be published.

SFS & MAT: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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