

Evaluation of Spirometry in Diagnosis of Airway Disorders

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Abstract

Introduction: Airway disorders constitute a major global public health problem and are among the leading causes of morbidity, mortality, and healthcare burden worldwide. These disorders encompass a broad spectrum of diseases affecting the conducting airways and are characterized by varying degrees of airflow limitation, airway inflammation, bronchial hyper responsiveness, and structural remodeling. Common airway disorders include bronchial asthma, chronic obstructive pulmonary disease (COPD), chronic bronchitis, emphysema,

bronchiectasis and small airway diseases. Early diagnosis and prompt intervention are essential in reducing disease progression, improving quality of life, and decreasing healthcare expenditure.

Objectives of the study**Primary Objective**

- To evaluate the role of spirometry in the diagnosis and classification of airway disorders among patients attending a tertiary care center.

Secondary Objectives

- To determine the distribution of spirometric patterns: normal, obstructive, restrictive, and mixed.
- To assess severity of airflow obstruction using GOLD and GINA criteria.
- To evaluate bronchodilator reversibility among patients with obstructive airway disease. •
- To correlate spirometric abnormalities with demographic variables, occupational and environmental exposure, and prior tuberculosis.

Material and Method

Study Design: The study was conducted as a hospital-based cross-sectional observational study to evaluate the role of spirometry in the diagnosis of airway disorders among adult patients attending the Department of Respiratory Medicine. The study assessed spirometric abnormalities and their correlation with clinical diagnosis in patients presenting with respiratory symptoms suggestive of airway disease.

Study Period: The study was conducted over a period of 18 months

Place of Study: Department of Respiratory Medicine, Dr Shankarrao Chavan Government Medical College Nanded, Nanded, Maharashtra.

Sample Size: Sample size was 309 participants

Sampling Technique: A consecutive sampling technique was employed. All patients fulfilling the inclusion criteria and attending the Department of Respiratory Medicine during the study period were recruited consecutively until the required sample size was achieved

Result: Among the 309 participants evaluated, abnormal spirometry was observed in 74.8% of cases, indicating a substantial burden of Airway disorders.

Discussion: The predominance of abnormal spirometry among individuals aged above 50 years observed in the present study is consistent with findings from several international epidemiological investigations. This study demonstrates that abnormal spirometry was more common among rural residents and individuals engaged in occupations associated with significant environmental and occupational exposure.

Keywords: Airway Disorders, Pulmonary Disease, Chronic Bronchitis, Emphysema, Bronchiectasis, Dyspnea, Chest Tightness, Sputum Production, Smoking.

Introduction

Airway disorders constitute a major global public health problem and are among the leading causes of morbidity, mortality, and healthcare burden worldwide. These disorders encompass a broad spectrum of diseases affecting the conducting airways and are characterized by varying degrees of airflow limitation, airway inflammation, bronchial hyper responsiveness, and structural remodeling. Common airway disorders include bronchial asthma, chronic obstructive pulmonary disease (COPD), chronic bronchitis, emphysema, bronchiectasis, and small airway diseases. Early diagnosis and prompt intervention are essential in reducing disease progression, improving quality of life, and decreasing healthcare expenditure. Spirometry has emerged as one of the most important non-invasive pulmonary function tests for the diagnosis, assessment, and monitoring of airway disorders.¹

The respiratory system is designed to facilitate gaseous exchange between the external environment and the bloodstream. Normal respiratory function depends on patent airways, adequate lung compliance, intact respiratory musculature, and effective neuromuscular

coordination. Airway disorders primarily affect airflow dynamics and often present clinically with symptoms such as cough, wheezing, dyspnea, chest tightness, and sputum production.²

Airway diseases are broadly categorized into obstructive and restrictive ventilatory disorders based on spirometric patterns. Obstructive airway diseases are characterized by limitation of expiratory airflow resulting from airway narrowing, increased airway resistance, or loss of elastic recoil. Restrictive lung diseases are characterized by reduced lung volumes due to parenchymal, pleural, chest wall, or neuromuscular abnormalities. Spirometry plays a pivotal role in differentiating these ventilatory defects and remains the cornerstone investigation in pulmonary medicine.³

Objectives of the Study

Primary Objective

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- To determine the distribution of spirometric patterns: normal, obstructive, restrictive, and mixed.
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- To evaluate bronchodilator reversibility among patients with obstructive airway disease. •
- To correlate spirometric abnormalities with demographic variables, occupational and environmental exposure, and prior tuberculosis.

Material and Method

Study Setting: The study was carried out in the Department of Respiratory Medicine at tertiary care teaching hospital in Maharashtra department catered to both outpatient and inpatient services and received

referrals from surrounding urban and rural areas. Spirometry was performed in the Pulmonary Function Testing (PFT) laboratory under standardized conditions using a calibrated spirometer according to American Thoracic Society/European Respiratory Society (ATS/ERS) guideline

Study Design: The study was conducted as a hospital-based cross-sectional observational study to evaluate the role of spirometry in the diagnosis of airway disorders among adult patients attending the Department of Respiratory Medicine. The study assessed spirometric abnormalities and their correlation with clinical diagnosis in patients presenting with respiratory symptoms suggestive of airway disease.

Study Population: The study population comprised adult patients attending the outpatient department or admitted to the inpatient wards of the Department of Respiratory Medicine with symptoms suggestive of airway disorders. Patients presenting with complaints such as chronic cough, dyspnea, wheezing, chest tightness, sputum production, or suspected obstructive airway disease were evaluated clinically and subjected to spirometry.

Study Period: The study was conducted over a period of 18 months.

Place of Study: Department of Respiratory Medicine, Dr Shankarrao Chavan Government Medical College Nanded, Nanded, Maharashtra.

Sample Size: Sample size was 309 participants and Assuming the prevalence of previous studies and considering an allowable error of 5% at 95% confidence interval.

The sample size was calculated using the formula for estimation of proportion in cross-sectional studies

$$n = q - p/d$$

Where-

- n = required sample size
- p = prevalence of airway obstruction among symptomatic patients
- $q = 100 - p$
- d = allowable error

Sampling Technique: A consecutive sampling technique was employed. All patients fulfilling the inclusion criteria and attending the Department of Respiratory Medicine during the study period were recruited consecutively until the required sample size was achieved

Inclusion Criteria

Patients fulfilling all the following criteria were included in the study:

- Age greater than or equal to 18 years.
- Patients presenting with respiratory symptoms suggestive of airway disorders such as cough, wheeze, dyspnea, chest tightness, or sputum production.
- Patients willing to participate in the study.
- Patients capable of performing acceptable and reproducible spirometry

Exclusion Criteria

Patients with any of the following conditions were excluded from the study:

- Acute respiratory distress requiring immediate intervention
- Active hemoptysis
- Recent myocardial infarction or unstable cardiovascular disease

- Recent thoracic, abdominal, or ophthalmic surgery
- Pneumothorax
- Active pulmonary tuberculosis
- Pregnancy
- Inability to understand or perform spirometry adequately
- Patients unwilling to provide informed consent

Statistical Analysis

The collected data were compiled and analyzed using Statistical Package for Social Sciences (SPSS) version 25 (IBM Corp., Armonk, NY, USA) or equivalent statistical software. Descriptive statistics were used to summarize demographic and clinical characteristics of the study population. Continuous variables such as age, FEV1, FVC, and FEV1/FVC ratio were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range, depending on data distribution. Categorical variables such as gender, smoking status, and spirometric patterns were expressed as frequencies and percentages. Comparisons between groups were performed using appropriate statistical tests. Student's t-test or Mann-Whitney U test was used for comparison of continuous variables, while Chi-square test or Fisher's exact test was applied for categorical variables. Correlation between spirometric findings and clinical diagnosis was assessed using suitable correlation coefficients. A p-value of less than 0.05 was considered statistically significant.

Observations and Results

Table 1: Demographic Characteristics of Study Population Stratified by Spirometric Status ($n = 309$)

Table 1A: Age distribution of participants with abnormal spirometry ($n = 231$)

Age Group (Years)	Abnormal Spirometry n	% of Abnormal Spirometry (n=231)
18-30	18	7.8
31-40	34	14.7
41-50	27	11.7
51-60	58	25.1
61-70	55	23.8
>70	29	12.6
Total	231	100.0

Observation: Table 1A presents the age-wise distribution of participants with abnormal spirometry (n = 231). The highest proportion of abnormal spirometric findings was observed in the 51–60 years age group, which accounted for 58 participants (25.1%), followed closely by the 61–70 years age group with 55 participants (23.8%). Together, these two age groups contributed nearly half (48.9%) of all abnormal spirometry cases. Participants aged 31–40 years constituted 34 cases (14.7%), while those aged more than 70 years accounted for 29 cases (12.6%). The 41–50 years age group contributed 27 cases (11.7%) of abnormal spirometry. The lowest proportion of abnormal spirometric findings was observed among younger adults aged 18–30 years, comprising 18 cases (7.8%).

Graph 1: Age distribution of participants with abnormal spirometry (n = 231)

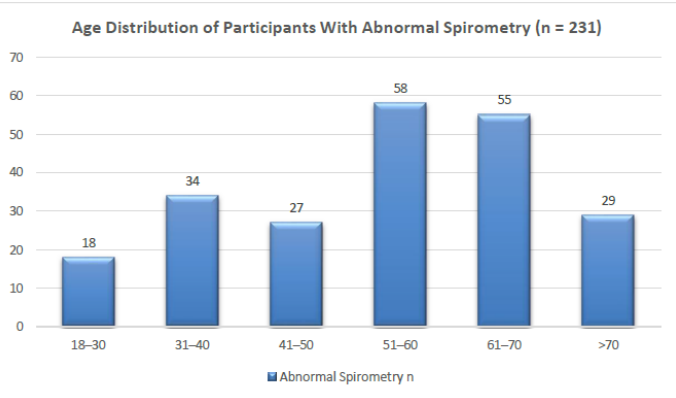


Table 1B: Sex distribution according to spirometric status

Sex	Abnormal Spirometry n (%) (n=231)	Normal Spirometry n (%) (n=78)
Male	148 (64.1)	40 (51.3)
Female	83 (35.9)	38 (48.7)
Total	231 (100.0)	78 (100.0)

Observation: Table 1B shows the sex-wise distribution of participants according to spirometric status. Among participants with abnormal spirometry (n=231), males constituted the majority with 148 cases (64.1%), while females accounted for 83 cases (35.9%). In contrast, among participants with normal spirometry (n=78), the distribution was nearly equal, with 40 males (51.3%) and 38 females (48.7%).

Graph 2: Sex Distribution according to spirometric status

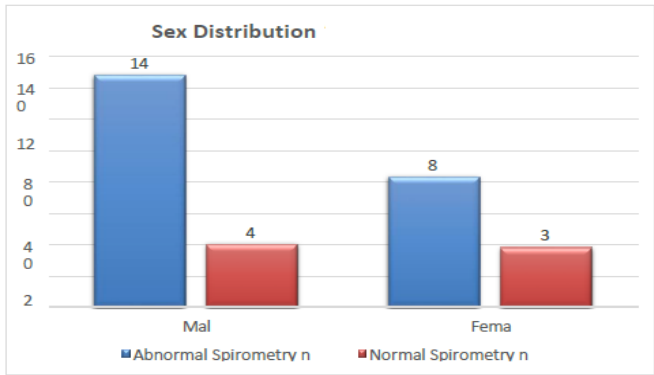


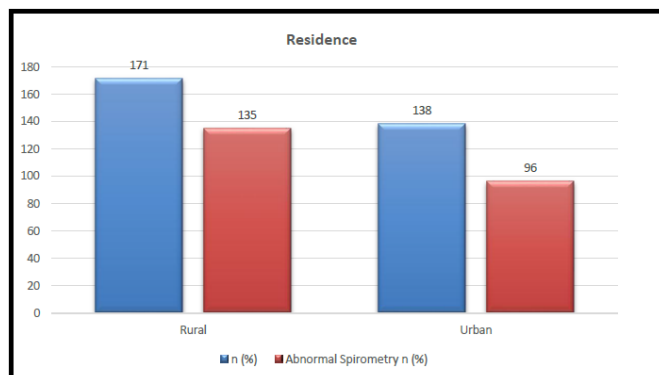
Table 1C: Sociodemographic characteristics among participants with abnormal spirometry (n = 231)

Variable	Category	Abnormal Spirometry n	% of Abnormal Spirometry (n=231)	p-value
Residence	Rural	135	58.4	0.028
	Urban	96	41.6	
Occupation	Industrial/Manual Worker	77	33.3	0.019
	Agriculture	58	25.1	
	Homemaker	47	20.3	
	Office/Service	33	14.3	
	Others	16	6.9	
	Total	231	100.0	

Observation: Table 1C depicts the socio-demographic characteristics of participants with abnormal spirometry (n=231). A majority of participants with abnormal spirometric findings were from rural areas (58.4%), whereas 41.6% belonged to urban areas. The association between place of residence and abnormal spirometry was statistically significant ($p = 0.028$).

Regarding occupation, industrial/manual workers constituted the largest proportion of abnormal spirometry cases (33.3%), followed by participants engaged in agriculture (25.1%) and homemakers (20.3%). Office/service workers accounted for 14.3%, while participants in other occupations represented 6.9% of abnormal spirometry cases. The association between occupation and abnormal spirometric findings was statistically significant ($p = 0.019$).

Graph 3: Sociodemographic- residence



Graph 4: Sociodemographic- occupation

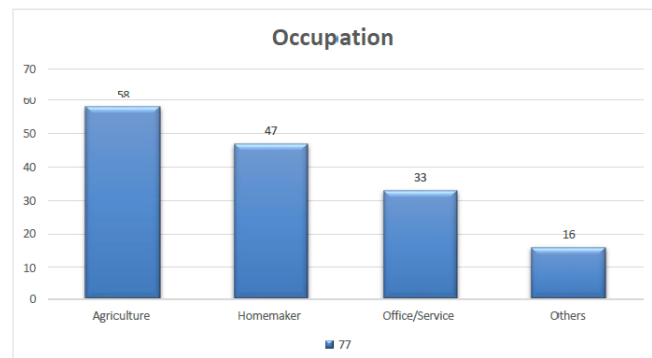


Table 2: Distribution of risk factors and exposure history among study participants (Row-wise Percentages)

Variable	Total n	Normal Spirometry n (%)	Abnormal Spirometry n (%)	p-value
Smoking Status				
Never smoker	124	48 (38.7)	76 (61.3)	<0.0001
Former smoker	72	15 (20.8)	57 (79.2)	0.0126
Current smoker	113	15 (13.3)	98 (86.7)	<0.0001
Smoking Burden (Pack-years)				
<10	39	14 (35.9)	25 (64.1)	—
10–20	61	10 (16.4)	51 (83.6)	0.0318
>20	85	6 (7.1)	79 (92.9)	0.0002
Biomass Fuel Exposure				
Present	74	11 (14.9)	63 (85.1)	0.0007
Absent	235	67 (28.5)	168 (71.5)	
Occupational Dust/Fume Exposure				
Present	88	18 (20.5)	70 (79.5)	0.0018
Absent	221	60 (27.1)	161 (72.9)	
Passive Smoking Exposure				
Present	96	17 (17.7)	79 (82.3)	0.0284
Absent	213	61 (28.6)	152 (71.4)	
Prior Pulmonary Tuberculosis				
Present	58	7 (12.1)	51 (87.9)	0.0031
Absent	251	71 (28.3)	180 (71.7)	

Observation: Table 2 demonstrates the distribution of spirometric status across major respiratory risk factors. A significantly higher proportion of abnormal spirometry was observed among current smokers (86.7%) compared with former smokers (79.2%) and never smokers (61.3%) ($p < 0.0001$). Overall, smoking exposure, increasing smoking burden, biomass fuel exposure, occupational dust/fume exposure, passive smoking, and previous pulmonary tuberculosis were all associated with a higher prevalence of abnormal spirometric findings, indicating their important contribution to respiratory morbidity in the study population.

Graph 5: Population smoking status

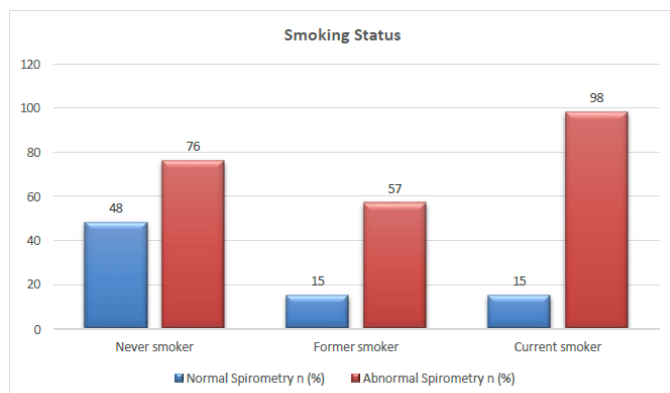


Table 3: Distribution of Spirometric Patterns Among Study Participants (n = 309)

Spirometric Pattern	Total, n (%)	Male, n (%)	Female, n (%)	p-value
Normal pattern	78 (25.2)	40 (51.3)	38 (48.7)	—
Obstructive pattern	161 (52.1)	109 (67.7)	52 (32.3)	<0.0001
Restrictive pattern	46 (14.9)	22 (47.8)	24 (52.2)	0.0036
Mixed pattern	24 (7.8)	17 (70.8)	7 (29.2)	0.0011
Total	309 (100.0)	188 (60.8)	121 (39.2)	—

Observation: Table 3 shows the distribution of spirometric patterns according to sex. Among participants with a normal spirometric pattern, males and females were nearly equally represented, accounting for 51.3% and 48.7%, respectively. In contrast, males predominated among participants with obstructive ventilatory defects, constituting 67.7% of cases compared with 32.3% females.

Graph 6: Distribution of Spirometric Patterns Among Study Participants

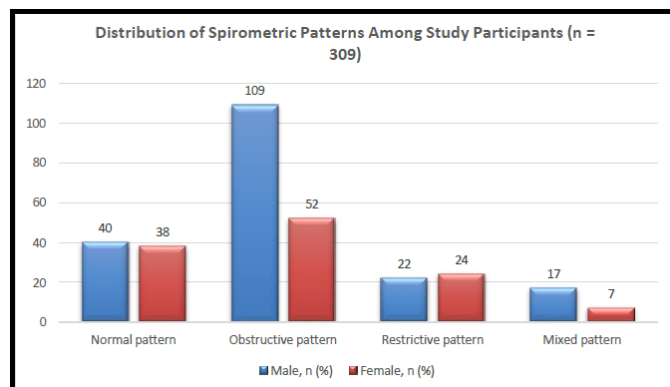


Table 4: Distribution of Participants with Isolated Small Airway Disease Despite Normal Spirometry (n = 78)

Variable	n	%
Normal Spirometry Without SAD	53	67.9
Small Airway Disease (SAD)	25	32.1
Total Normal Spirometry Group	78	100.0

Observation: In this table, Among the 78 participants with normal conventional spirometry, 25 patients (32.1%) demonstrated evidence of isolated small airway disease based on reduced mid-expiratory flow rates, while 53 participants (67.9%) had entirely normal pulmonary function parameters. This finding suggests that a substantial proportion of symptomatic individuals may exhibit early airway involvement despite preservation of standard spirometric indices.

Graph 7: Distribution of Participants with Isolated Small Airway Disease Despite Normal Spirometry

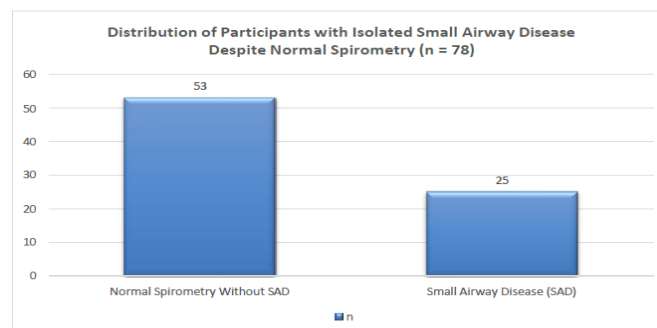


Table 5: Distribution of Radiological Findings Among Study Participants (n = 309)

Radiological Finding	Number of Patients, n (%)
Normal chest radiograph	72 (23.3)
Hyperinflation / increased lung lucency	82 (26.5)
Increased bronchovascular markings	48 (15.5)
Fibrotic changes / post-inflammatory scarring	34 (11.0)
Post-tubercular sequelae	31 (10.0)
Bronchiectatic changes	22 (7.1)
Interstitial infiltrates / ILD-like changes	14 (4.5)
Pleural thickening / pleural fibrosis	6 (1.9)
Consolidation / infective changes	0 (0.0)
Total	309 (100.0)

Observation: In this table, presents the distribution of chest radiographic findings among the study participants. Abnormal radiological findings were observed in the majority of participants, while a normal chest radiograph was seen in 72 patients (23.3%). The most common radiological abnormality was hyperinflation/increased lung lucency, identified in 82 patients (26.5%), followed by increased bronchovascular markings in 48 patients (15.5%). Fibrotic changes or post-inflammatory scarring were observed in 34 patients (11.0%), while post-tubercular sequelae were present in 31 patients (10.0%). Bronchiectatic changes accounted for 22 patients (7.1%), and interstitial infiltrates/ILD-like changes were identified in 14 patients (4.5%). Pleural thickening or pleural fibrosis was the least common finding, observed in 6 patients (1.9%).

Overall, radiological abnormalities were present in 76.7% of participants, with hyperinflation being the predominant finding, reflecting the high burden of obstructive airway disease within the study population.

Discussion

In this study, the 231 participants with abnormal spirometry, the largest proportion belonged to the 51–60 years age group (25.1%), followed closely by the 61–70 years age group (23.8%). Together, these two age categories accounted for nearly half (48.9%) of all abnormal spirometric findings. In contrast, younger adults aged 18–30 years contributed only 7.8% of abnormal spirometry cases. These findings suggest that the burden of pulmonary function impairment increases substantially with advancing age.

This study, evaluated the distribution of spirometric abnormalities according to sex and demonstrated a clear male predominance among participants with abnormal

pulmonary function and the 231 participants with abnormal spirometry, 148 (64.1%) were males, whereas 83 (35.9%) were females. In contrast, among participants with normal spirometry, the sex distribution was relatively balanced, with males accounting for 51.3% and females for 48.7%.

Overall, the demonstrates that males accounted for nearly two-thirds of all abnormal spirometric findings, whereas the normal spirometry group showed an almost equal sex distribution. These findings are consistent with previous international and national studies and likely reflect differences in exposure to smoking, occupational hazards and environmental pollutants.

Radiological Findings Among Study Participants (n = 309), abnormal chest radiographic findings were observed in 237 participants (76.7%), while only 72 participants (23.3%) had normal chest radiographs.

Hyperinflation or increased lung lucency was the most common radiological abnormality, identified in 82 participants (26.5%). The predominance of hyperinflation in the present study corresponds closely with the spirometric findings, where obstructive ventilatory defects constituted the largest category of pulmonary function abnormalities. Similar observations have been reported in COPD cohorts, where hyperinflation is strongly associated with airflow limitation, exercise intolerance, and disease severity.

Increased bronchovascular markings were observed in 48 participants (15.5%) and represented the second most common radiological finding. Although nonspecific, increased Broncho vascular markings are frequently encountered in patients with chronic respiratory symptoms and may represent early structural manifestations of airway pathology.

Fibrotic changes or post-inflammatory scarring were identified in 34 participants (11.0%), while post-tubercular sequelae were observed in 31 participants (10.0%). These findings are particularly relevant in the context of the study population, where previous pulmonary tuberculosis emerged as a significant risk factor for abnormal spirometry. Tuberculosis can result in permanent structural lung damage, including fibrosis, volume loss, airway distortion, and parenchymal destruction. Bronchiectatic changes were identified in 22 participants (7.1%). Radiological evidence of bronchiectasis often correlates with chronic cough, sputum production, recurrent respiratory infections, and mixed ventilatory defects.

Overall, this study demonstrates that radiological abnormalities were present in more than three-fourths of participants, with hyperinflation representing the most common finding. Structural abnormalities related to chronic airway disease, previous pulmonary tuberculosis, fibrosis, and bronchiectasis were also frequently observed. These findings emphasize the importance of integrating radiological assessment with spirometric evaluation to achieve a comprehensive understanding of respiratory disease and its underlying structural basis.

Conclusion

The present study demonstrates that spirometry is an indispensable diagnostic tool in the evaluation of patients presenting with respiratory symptoms and provides objective evidence of pulmonary function impairment that may not be accurately identified through clinical assessment alone. Among the 309 participants evaluated, abnormal spirometry was observed in 74.8% of cases, indicating a substantial burden of Airway disorders. These findings reaffirm

the critical role of spirometry in the early detection, classification, and severity assessment of respiratory diseases in routine clinical practice. The study identified a strong association between abnormal spirometry and several established respiratory risk factors, including smoking, increasing smoking burden, biomass fuel exposure, occupational dust and fume exposure, passive smoking, and previous pulmonary tuberculosis. A progressive increase in pulmonary function abnormalities with increasing smoking exposure was observed, while prior pulmonary tuberculosis emerged as an important contributor to chronic respiratory impairment.

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