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Original Research Article

SIGNIFICANCE OF SPIROMETRY IN DETECTION OF EARLY OBSTRUCTIVE DISEASE IN ASYMPTOMATIC SMOKERS IN TERTIARY CARE HOSPITAL

Gattappagari vinay Kumar[1], Amit Kumar Kushwaha[2], Reshma U[3], Ankita Mandal[4], Akash Jasuja[1]

[1]*Postgraduate Student, Department of Respiratory Medicine, Rajshree Medical Research Institute, Bareilly, Uttar Pradesh, India*
[2]*Professor and Head, Department of Respiratory Medicine, Rajshree Medical Research Institute, Bareilly, Uttar Pradesh, India*
[3]*Associate Professor, Department of Respiratory Medicine, Rajshree Medical Research Institute, Bareilly, Uttar Pradesh, India*
[4]*Assistant Professor, Department of Respiratory Medicine, Rajshree Medical Research Institute, Bareilly, Uttar Pradesh, India*

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Corresponding Author:
Dr. Amit Kumar Kushwaha,
Professor and Head, Department of Respiratory Medicine, Rajshree Medical Research Institute, Bareilly, Uttar Pradesh, India.
Email: dr_amitkushwaha@rediffmail.com

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbidity and mortality worldwide, with tobacco smoking being the most important risk factor. A significant proportion of smokers develop airflow limitation long before the onset of respiratory symptoms, resulting in underdiagnosis and delayed intervention. Spirometry, the gold standard for diagnosing airflow obstruction, provides an opportunity for early detection of subclinical disease in asymptomatic smokers. The objectives is to evaluate pulmonary function test parameters in asymptomatic smokers; to assess peak expiratory flow rate (PEFR); to compare observed spirometric values with predicted values (FEV_1 and FEV_1 /FVC); to identify preserved ratio impaired spirometry (PRISm); and to correlate spirometric parameters with smoking exposure measured in pack-years.

Materials and Methods: This hospital-based cross-sectional study was conducted in the Department of Respiratory Medicine at Rajshree Medical Research Institute, Bareilly, from April 2024 to March 2026. A total of 140 asymptomatic smokers aged ≥40 years with a smoking history of ≥10 pack-years were enrolled. All participants underwent standardized pre- and post-bronchodilator spirometry as per ATS/ERS 2019 guidelines. Parameters analyzed included FEV_1 , FVC, FEV_1 /FVC ratio, FEF_{25-75} %, and PEFR. Spirometric patterns were classified as normal, obstructive, or PRISm. Statistical analysis was performed using SPSS version 23.0.

Results: The majority of subjects belonged to the 40–49-year age group (67.1%). Observed FEV_1 was reduced in 98.6% of participants, and FEV_1 /FVC ratio was reduced in 99.3%, showing a statistically significant difference when compared to predicted values ($p < 0.001$). PRISm was identified in 67.1% of asymptomatic smokers. Reduced FEF_{25-75} % was observed in 50.7%, indicating early small airway dysfunction. A significant dose-response relationship was noted between smoking exposure and decline in spirometric parameters, with worsening lung function observed with increasing pack-years and duration of smoking. Post-bronchodilator values showed partial improvement but did not normalize, suggesting predominantly fixed airflow limitation.

Conclusion: A substantial proportion of asymptomatic smokers exhibit significant spirometric abnormalities, including early airflow obstruction and PRISm, which remain undetected without objective testing. Routine spirometric screening in smokers, particularly those with ≥10 pack-years, can facilitate early diagnosis, timely smoking cessation, and prevention of irreversible lung damage, thereby reducing the future burden of COPD.

Keywords: COPD; Spirometry; Asymptomatic smokers; Airflow obstruction; Pack-years; PRISm.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is an acute health care problem, as it causes a great burden on the healthcare system, economies, and millions of people all over the world. The third most common cause of death across the world is COPD which causes deaths to about 3.5 million in 2021. Currently, the number of affected people is in the range of over 400 million with the projection showing that it may increase to 592 million by 2050. It is assumed that direct and indirect costs will amount up to 4.3 trillion in the period between 2020 and 2050, highlighting the crisis severity.[1]

According to Global Initiative for Chronic Obstructive Lung Disease (GOLD), COPD is a heterogeneous lung disease characterized by the presence of chronic respiratory symptoms including dyspnea, cough, and sputum production, as a result of airway and alveolar abnormalities, which causes persistent and often progressive airflow obstruction.[2] The prevalence of COPD in India is high, thus the second cause of death in this country. A systematic review estimates a prevalence of 7.4 percent combined between the ages of 20 and 64 years in India with great regional differences: 2.4 percent in Southern India and 16.1 percent in Northern India.[3]

The epidemiological transition in India, marked by swift urbanization, an aging population, and ongoing environmental exposures such as tobacco smoke and biomass fuels, has led to a concerning rise in COPD cases. The Global Burden of Disease study indicated that the number of COPD cases in India rose from 28.1 million in 1990 to 55.3 million in 2016. At 8.7% of all fatalities and 4.8% of DALYs, the disease was the second most frequent cause of disease burden, after coronary heart disease.[4]

Without a doubt, smoking cigarettes is the biggest risk factor for getting COPD around the world. It causes about 70–90% of cases in countries with high incomes. The Global Adult Tobacco Survey (GATS) in India from 2016 to 2017 found that 10.38% of adults smoked. This means that tens of millions of people are more likely to get COPD and other smoking-related diseases.[5]

The term "susceptible smokers" has arisen from the observation that only about 25-33% of continuous smokers experience clinically significant airflow obstruction that fulfills COPD diagnostic criteria in their lifetime.[6] One of the most insidious and clinically challenging aspects of COPD is its typically silent progression during early stages. By the time patients experience clinically apparent dyspnea, chronic cough, or other respiratory symptoms, about 50% of their ventilatory reserves have already been irreversibly depleted.[7]

Such late onset of clinical features has far-reaching implications for clinical management and disease outcomes. Research constantly proves that COPD in its undiagnosed form is extremely prevalent, and it is estimated that as many as 70 percent of cases in the world are not diagnosed at all. In populations undergoing spirometry screening, there is a 1.5% to 24% prevalence of previously undiagnosed airflow obstruction among asymptomatic smokers based on age, smoking exposure, and selection criteria.[8]

Recent studies have disputed the classical idea that symptoms represent a prerequisite for adverse respiratory events. The prevalence of subclinical airflow obstruction (SAO)—airflow obstruction confirmed by spirometry in persons without self-reported respiratory symptoms or a diagnosis of respiratory disease—is high, estimated at 13.2% in pooled cohort studies among asymptomatic adults. Most importantly, patients with SAO have 3-5 times higher odds of COPD-related hospitalization and mortality than patients with no airflow obstruction, regardless of smoking history.[9]

Preserved ratio impaired spirometry (PRISm) has emerged as an important intermediate phenotype with higher respiratory morbidity and risk of progression to COPD. PRISm is defined as FEV_1 < 80% predicted with FEV_1 /FVC ratio ≥ 0.70. Evidence indicates that PRISm is associated with a higher number of respiratory symptoms, lower exercise capacity, higher risk of exacerbations, and higher all-cause mortality than persons with normal spirometry. It is estimated that around 7-20% of individuals with PRISm will develop frank airflow obstruction over time.[10]

Spirometry is the classic diagnostic test for COPD, providing objective, reproducible, and physiologically significant measures of airflow limitation. The test measures parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), and the FEV_1 /FVC ratio. GOLD criteria consider COPD diagnosed when the post-bronchodilator FEV_1 /FVC ratio is less than 0.70.[11] Despite being one of the most common and widely used pulmonary function tests globally, spirometry remains underutilized, especially in primary care settings where most patients with respiratory symptoms initially present. This underutilization is particularly high in India and other low- and middle-income nations.[12]

The economic argument for screening high-risk populations with spirometry is growing stronger. Various cost-effectiveness evaluations have revealed that spirometry-based COPD screening programs can be cost-efficient and very cost-effective relative to no screening or questionnaire-based only approaches.[13]

The most significant and scientifically supported strategy for lowering the risk of developing COPD and delaying the rapid deterioration of lung function in smokers is quitting smoking. The Lung Health Study demonstrated that intensive smoking cessation interventions significantly reduce age-related FEV_1 decline from -301 mL per 5 years in continuing smokers to -72 mL per 5 years in sustained quitters.[14]

Despite compelling evidence supporting the role of spirometry in early detection, systematic screening of

asymptomatic smokers remains irregular and poorly implemented. Current recommendations given by the USPSTF do not suggest routine spirometry screening of asymptomatic adults due to the lack of evidence that early diagnosis can positively influence patient outcomes. However, this recommendation has been questioned by accumulating evidence showing that patients with subclinical airflow obstruction have worse respiratory outcomes.[15]

There are peculiar challenges and opportunities for India in addressing the COPD epidemic. A large number of smokers (over 150 million), rapid epidemiological transition, low access to spirometry in primary care, and a high level of underdiagnosis necessitate pragmatic and evidence-based screening strategies in high-risk populations. Determining the level of smoking exposure beyond which spirometry-based screening provides optimal detection rates and cost-efficiency would be valuable for resource allocation in resource-limited settings.

This study was conducted to evaluate the significance of spirometry in detecting early obstructive disease among asymptomatic smokers attending a tertiary care hospital in Northern India, and to correlate spirometric abnormalities with smoking exposure measured in pack-years.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted in the Department of Respiratory Medicine at Rajshree Medical Research Institute, Bareilly, Uttar Pradesh, over a two-year period from April 2024 to March 2026. A total of 140 asymptomatic smokers aged 40 years and above, with a minimum smoking exposure of 10 pack-years, were enrolled after obtaining written informed consent.

The sample size was calculated using a standard prevalence-based formula, considering the smoking prevalence reported by GATS India (2016–17), resulting in a required sample size of 138; 140 participants were ultimately included.

Detailed demographic data, smoking history, and clinical information were collected using a structured proforma. All participants underwent thorough physical and respiratory system examination. Spirometry was performed according to ATS/ERS 2019 guidelines using a calibrated spirometer. Both pre- and post-bronchodilator measurements were recorded following administration of 400 µg salbutamol via a metered-dose inhaler with spacer.

Spirometric parameters analyzed included FVC, FEV_1, FEV_1/FVC ratio, FEF_{25-75}%, and PEFR. PRISm was defined as post-bronchodilator FEV_1 <80% predicted with FEV_1/FVC ≥0.70.

Data were analyzed using SPSS version 23.0. Descriptive statistics were expressed as mean ± standard deviation or percentages. Chi-square test and paired t-test were applied as appropriate, with $p < 0.05$ considered statistically significant. Ethical approval was obtained from the institutional ethics committee.

RESULTS

The majority of participants belonged to the 40–49 years age group (67.1%), followed by 50–59 years (32.9%). This indicates that most asymptomatic smokers with significant smoking exposure were in early middle age.

Table 1: Age-wise Distribution of Participants

Age Group (years)	Number (n)	Percentage (%)
40–49	94	67.1
50–59	46	32.9
Total	140	100.0

Table 2: Occupational Distribution of Study Participants

Occupation	Number (n)	Percentage (%)
Manual labourer	59	42.1
Farmer	29	20.7
Business	19	13.6
Teacher	18	12.9
Sweeper	6	4.3
Tailor	6	4.3
Skilled/Professional	3	2.1
Total	140	100.0

Manual labourers formed the largest occupational group (42.1%), followed by farmers (20.7%). This reflects higher smoking prevalence among individuals engaged in physically demanding and lower socioeconomic occupations.

Table 3: Comparison of Observed and Predicted FEV_1 Values

FEV□ Category	Observed (n)	Predicted (n)	p value
Normal (≥80%)	2	32	<0.001
Reduced (<80%)	138	108	<0.001
Total	140	140	

Observed FEV_1 values were significantly lower than predicted values. While only 1.4% of subjects had normal observed FEV_1, predicted values suggested normal lung function in 22.9%, highlighting marked subclinical reduction in lung function ($\chi^2 = 28.15$, $p < 0.001$).

Table 4: Distribution of Observed FEV_1 Status

Observed FEV_1 Status	Number (n)	Percentage (%)	p value
Normal (≥80%)	2	1.4	<0.001
Reduced (<80%)	138	98.6	<0.001
Total	140	100.0	

An overwhelming majority of participants (98.6%) demonstrated reduced observed FEV_1, indicating extensive subclinical airflow limitation among asymptomatic smokers ($\chi^2 = 132.11$, $p < 0.001$).

Table 5: Distribution of Duration of Smoking

Duration of Smoking (years)	Number (n)	Percentage (%)
10–14	79	56.4
15–19	49	35.0
20–24	10	7.1
25–29	2	1.4
≥30	0	0.0
Total	140	100.0

More than half of the participants had a smoking duration of 10–14 years. Notably, significant spirometric abnormalities were observed even with relatively shorter smoking duration.

Table 6: Comparison of Observed and Predicted FEV_1 /FVC Ratios

FEV_1 /FVC Status	Observed (n)	Predicted (n)	p value
Normal (≥0.70)	3	34	<0.001
Reduced (<0.70)	137	106	<0.001
Total	140	140	

Observed FEV_1 /FVC ratios were significantly reduced compared to predicted values, confirming widespread airflow obstruction among asymptomatic smokers ($\chi^2 = 272.07$, $p < 0.001$).

Table 7: Distribution of FEV_1 /FVC Categories

FEV□/FVC Category	Number (n)	Percentage (%)	p value
Reduced (<0.70)	139	99.3	<0.001
Normal (≥0.70)	1	0.7	<0.001
Total	140	100.0	

Nearly all participants (99.3%) exhibited reduced FEV_1 /FVC ratios, reinforcing the high burden of early obstructive changes.

Table 8: Distribution of FEF_{25-75} % Categories

FEF_{25-75} % Status	Number (n)	Percentage (%)
Reduced (<80%)	71	50.7
Normal (≥80%)	69	49.3
Total	140	100.0

Half of the participants demonstrated reduced FEF_{25-75} %, indicating a high prevalence of small airway dysfunction even in the absence of symptoms.

Table 9: Prevalence of PRISm

PRISm Status	Number (n)	Percentage (%)	p value
Present	94	67.1	<0.001
Absent	46	32.9	<0.001
Total	140	100.0	

PRISm was identified in 67.1% of subjects, indicating that preserved ratio impaired spirometry is highly prevalent among asymptomatic smokers ($\chi^2 = 16.46$, $p < 0.001$).

Table 10: Association of Age with FEF_{25-75} % Reduction

Age Group (years)	Normal (n)	Reduced (n)	Total (n)
<40	5	5	10
40–49	48	51	99
50–59	16	15	31
Total	69	71	140

A statistically significant association was observed between advancing age and reduction in FEF_{25-75} % ($p < 0.001$), suggesting progressive worsening of small airway function with age.

Table 11: PEFR Reduction in Relation to Duration of Smoking

Duration of Smoking (years)	Normal (n)	Reduced (n)	Total (n)
10–19	34	12	46
20–29	32	62	94
Total	66	74	140

A progressive increase in PEFR reduction was observed with longer duration of smoking, reflecting cumulative adverse effects of tobacco exposure.

Table 12: Spirometric Parameters According to Smoking Pack-Years

Pack-years	Pre-FEV_1 (L) Mean±SD	Post-FEV_1 (L) Mean±SD	Pre-FVC (L) Mean±SD	Post-FVC (L) Mean±SD	Pre-FEV_1/FVC	Post-FEV_1/FVC	Pre-FEF_{25-75} (%)	Post-FEF_{25-75} (%)
1–10	2.18±0.39	1.71±0.39	2.61±0.31	2.62±0.34	0.66±0.09	0.65±0.05	70.81±15.64	76.81±16.05
11–20	2.05±0.43	1.77±0.40	2.57±0.29	2.62±0.36	0.67±0.09	0.65±0.04	72.46±15.59	78.97±15.36
21–30	2.01±0.46	1.81±0.27	2.56±0.19	2.63±0.21	0.66±0.08	0.64±0.03	70.97±13.07	76.84±12.98

Increasing smoking exposure was associated with progressive decline in pre-bronchodilator FEV_1, FEV_1/FVC, and FEF_{25-75}%. Post-bronchodilator values showed partial improvement without normalization, suggesting predominantly fixed airflow limitation.

DISCUSSION

This study demonstrates that a substantial proportion of asymptomatic smokers exhibit significant spirometric abnormalities, including reduced FEV_1, reduced FEV_1/FVC ratio, and impaired small airway function as measured by FEF_{25-75}%. The high prevalence of PRISm (67.1%) in our study population is particularly noteworthy, as this intermediate phenotype has been associated with increased risk of progression to overt COPD and higher respiratory morbidity.[10]

Our findings align with previous studies that have highlighted the importance of spirometry in detecting early airflow limitation among asymptomatic smokers. Barthwal and Singh (2014) demonstrated that approximately 26% of asymptomatic smokers had obstructive spirometry, with the majority having mild airflow limitation.[18] The higher prevalence of abnormalities in our study (98.6% with reduced FEV_1 and 99.3% with reduced FEV_1/FVC) may be attributed to our stringent inclusion criteria of ≥10 pack-years and age ≥40 years, as well as the inclusion of sensitive parameters like FEF_{25-75}%.

The age distribution in our study (67.1% in 40-49 years) is consistent with previous Indian studies. Patra et al. (2020) studied 1,000 asymptomatic defense personnel aged 40-55 years and found COPD in 18.7%, with mean age of 51.4±3.4 years.[19] The lower prevalence in their study compared to ours may reflect differences in study populations and diagnostic criteria.

The occupational distribution in our study showed predominance of manual labourers (42.1%) and farmers (20.7%), reflecting the higher smoking prevalence in lower socioeconomic groups. This finding is consistent with the GATS India survey which demonstrated higher tobacco use in lower socioeconomic strata.[16]

The strong association between smoking duration and spirometric abnormalities observed in our study [Tables 5, 11, 12] corroborates the dose-response relationship established in the literature. Abbas et al. (2021) studied 200 asymptomatic male smokers in Baghdad and found that 50.5% had undiagnosed airway obstruction, with significant correlations between spirometric parameters and pack-years of smoking.[20] Participants with 21-40 pack-years had 47.2% obstruction in current smokers and 52.8% in former smokers.

The high prevalence of reduced FEF_{25-75}% (50.7%) in our study indicates early small airway dysfunction, which is a precursor to the development of overt COPD. Gomes et al. (2015) studied 32 asymptomatic smokers in Portugal and found significantly lower FEF_{25-75}% (83.16% versus 97.19% in controls, $p<0.05$).[21] They also identified subclinical COPD in 9.38% of smokers and tobacco-related extrapulmonary disease in 31.2%. The FEF_{25-75}% has been identified as an independent risk factor for COPD development even after adjustment for age, smoking history, and baseline FEV_1/FVC ratio.[22]

The identification of PRISm in 67.1% of our asymptomatic smokers is a crucial finding. Wan et al. (2021) demonstrated that individuals with PRISm have 3-5 times higher odds of COPD-related hospitalization and mortality compared to those with normal spirometry.[9] Wijnant et al. (2020) reported that approximately 25.1% of individuals with PRISm progress to classical COPD over five years.[10] The high prevalence of PRISm in our study population represents a significant opportunity for early intervention.

Our finding of predominantly fixed airflow limitation (partial improvement but no normalization post-bronchodilator) is consistent with the pathophysiology of smoking-related lung damage. The Lung Health Study demonstrated that intensive smoking cessation interventions significantly reduce age-related FEV_1 decline from -301 mL per 5 years in continuing smokers to -72 mL per 5 years in sustained quitters.[14] Chen et al. (2022) in a meta-analysis showed that smoking cessation in COPD patients resulted in significant improvement in

FEV_1 % predicted (mean difference 6.72 percentage points) and FEV_1 /FVC ratio (mean difference 6.82 percentage points).[23]

The economic implications of our findings are substantial. Boers et al. (2023) projected that the global burden of COPD will increase to 592 million by 2050 with associated costs of 4.3 trillion USD between 2020-2050.[1] Mannino et al. (2024) estimated the direct medical cost burden of COPD in the United States at 36 billion USD annually, projected to reach 605 billion USD by 2029.[24] Early detection through spirometry screening in high-risk populations has been shown to be cost-effective, with incremental cost-effectiveness ratios (ICER) of -5,026 to -1,766 per QALY in some studies.[13]

The underutilization of spirometry in Indian healthcare settings, as documented by Aggarwal et al. (2014), remains a significant barrier to early COPD detection.[12] Their survey showed that only 55% of chest physicians, 20% of general physicians, and 10% of general practitioners used spirometry in clinical practice. This underutilization persists despite spirometry being relatively inexpensive, safe, and providing essential diagnostic information.

Our study has several strengths, including strict adherence to ATS/ERS 2019 spirometry guidelines, inclusion of both pre- and post-bronchodilator measurements, and comprehensive assessment of multiple spirometric parameters including small airway function. The sample size was adequately powered to detect significant differences in key parameters.

Limitations

- The study was conducted at a single center, which may limit generalizability to other settings
- Selection bias may have been introduced by including only patients willing to undergo spirometry
- Other risk factors for COPD such as biomass fuel exposure, air pollution, and occupational exposures were not formally quantified
- The cross-sectional design precludes assessment of disease progression over time
- Spirometry requires significant patient effort and technician expertise; despite standardization, some variability may exist
- Patients unable to perform acceptable spirometry were excluded, potentially excluding those with more severe disease.

CONCLUSION

This study demonstrates that marked abnormalities in pulmonary function are extremely common among asymptomatic smokers despite the absence of overt respiratory symptoms. Spirometry revealed significant reductions in FEV_1 , FEV_1 /FVC ratio, and FEF_{25-75} %, indicating early airflow limitation and small airway dysfunction. The high prevalence of PRISm (67.1%) among asymptomatic smokers represents an important early spirometric phenotype, suggesting that many symptom-free smokers are already on a trajectory toward chronic obstructive pulmonary disease.

A significant dose-response relationship was observed between smoking exposure (duration and pack-years) and declining lung function. Post-bronchodilator measurements showed partial improvement but did not normalize, indicating predominantly fixed airflow obstruction characteristic of smoking-related lung damage.

These findings underscore the inadequacy of symptom-based screening for early detection of smoking-related lung disease. Routine spirometric evaluation in smokers, particularly those aged ≥40 years with ≥10 pack-years of smoking history, can facilitate early diagnosis, prompt smoking cessation interventions, and implementation of preventive measures that may alter the natural history of chronic airflow limitation.

Spirometry is a simple, non-invasive, and cost-effective tool for detecting subclinical lung function impairment in asymptomatic smokers. Its systematic incorporation into clinical practice, especially in primary care settings, can significantly contribute to the prevention and management of smoking-related chronic respiratory diseases, reducing the future burden of COPD on individuals, healthcare systems, and society.

Recommendations

- Routine Spirometry Screening: Spirometry should be performed in all smokers aged ≥40 years with a minimum of 10 pack-years or high smoking index to detect early airway obstruction.
- Strengthen Primary Care Capacity: Spirometers should be provided at primary health centers, and healthcare providers should receive training in spirometry performance and interpretation according to ATS/ERS guidelines.
- Integrate Spirometry with Smoking Cessation: Spirometric results should be used as a motivational tool for smoking cessation, with periodic spirometric monitoring for individuals with early abnormalities.
- Regular Monitoring of At-Risk Individuals: Smokers with PRISm or mild obstruction should undergo repeat spirometry every 6-12 months to track disease progression.
- Increase Public and Occupational Awareness: Community and workplace-based awareness and screening programs should be organized, particularly targeting high-risk occupational groups.
- Promote Cost-Effective Screening Policies: Healthcare policymakers should promote spirometry screening as a COPD prevention strategy, given its low cost and high diagnostic utility.
- Further Research: Larger longitudinal studies are needed to assess progression patterns, evaluate additional early markers (such as impulse oscillometry and imaging biomarkers), and refine screening thresholds for Indian populations.

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