



Exploration Of Lung Function And Its Correlation With Health Status Of Cope Patients In A Tertiary Care Centre, Kanpur, Uttar Pradesh.

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Abstract

Introduction: Chronic Obstructive Pulmonary Disease (COPD) is a major public health burden in northern India. While post-bronchodilator spirometry remains essential for confirming persistent airflow obstruction, objective spirometric parameters often do not align with patient-reported symptoms, functional capacity, and health-related quality of life (HRQOL). This study aims to assess lung function profiles and evaluate their correlation with health status using the COPD Assessment Test (CAT) and the modified Medical Research Council (mMRC) dyspnoea scale among patients with stable COPD in Kanpur, Uttar Pradesh. **Methods:** A hospital-based cross-sectional observational study was conducted over 6 months in the Department of Pulmonary Medicine at a tertiary care centre in Kanpur. A total of 150 stable COPD patients (post-bronchodilator FEV₁/FVC<0.70) aged 40 years or older were enrolled. Spirometric indices (FVC, FEV₁, FEV₁% predicted) were recorded following ATS/ERS criteria. Health status was measured using the validated CAT questionnaire and mMRC dyspnoea scale. Bivariate correlation (r, rho) and multivariable linear regression analyses were performed (p < 0.05). **Results:** The mean age was 61.4 ± 9.2 years, with male predominance (78.7%). Tobacco smoking was reported in 72.0% and domestic biomass fuel exposure in 24.7% (predominantly females, 81.3%). By GOLD spirometric classification, 12.0% were GOLD 1, 41.3% were GOLD 2, 32.7% were GOLD 3, and 14.0% were GOLD 4. The mean post-bronchodilator FEV₁% predicted was 51.8±17.6%, and the mean CAT score was 19.4±7.1. A statistically significant moderate negative correlation was found between FEV₁% predicted and CAT score (r = -0.548, p < 0.001), as well as mMRC grade (rho = -0.492, p < 0.001). Multivariable regression identified FEV₁% predicted (beta = -0.488, p < 0.001), cumulative smoking (p = 0.021), and biomass exposure (p = 0.039) as independent predictors of CAT scores. **Conclusion:** Spirometric airflow limitation demonstrates a moderate inverse correlation with symptomatic health impairment. However, substantial symptom heterogeneity across identical spirometric stages indicates that spirometry alone is insufficient for assessing total disease burden. Routine integration of patient-reported tools like the CAT is vital for comprehensive clinical management.

Keywords: Chronic Obstructive Pulmonary Disease; Spirometry; FEV₁; COPD Assessment Test; Health Status; Airway Obstruction.



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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is one of the leading global causes of preventable morbidity, hospitalization, and mortality [1]. According to the Global Burden of Disease (GBD) study, chronic respiratory diseases contribute substantially to non-communicable disease DALYs (Disability-Adjusted Life Years) across low- and middle-income countries, with India accounting for more than 32% of global respiratory DALYs [2]. Within India, northern states, particularly Uttar Pradesh, exhibit some of the highest mortality rates and epidemiological burdens of COPD [2,3].

Kanpur, a major industrial and commercial hub in central Uttar Pradesh, is characterized by high ambient particulate matter concentrations, industrial airborne toxicants, widespread use of domestic biomass fuel (chulhas) in peri-urban fringes, and extensive tobacco use [3,4]. This convergence of environmental and behavioural exposures exacerbates respiratory vulnerability in the local population [4].

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) establishes spirometry as the gold standard for COPD diagnosis, characterized by a persistent, post-bronchodilator forced expiratory volume in 1 second to forced vital capacity

ratio (FEV1/FVC<0.70) [1]. Traditionally, severity staging and therapeutic escalation relied almost entirely on the post-bronchodilator percentage of predicted FEV1(FEV1% predicted) [1,5].

However, COPD is a complex, heterogeneous syndrome with systemic manifestations where physiological airflow limitation reflects only a single domain of disease burden [5,6]. Patients with identical degrees of spirometric obstruction frequently present with starkly different levels of dyspnea, exercise intolerance, anxiety, sleep disturbances, and impairment in daily life [6,7]. Consequently, modern COPD management frameworks emphasize patient-reported outcome measures alongside physiological indices [1].

The COPD Assessment Test (CAT)—an 8-item multidimensional instrument—was developed to quantify the overall impact of COPD on health status and daily well-being [7,8]. While globally validated, empirical evidence exploring the concordance between objective spirometric parameters and patient-reported health status among North Indian cohorts exposed to both tobacco and non-tobacco biomass fuels remains limited [9,10,12]. Therefore, this study was conducted to evaluate lung function profiles and correlate them with health status among stable COPD patients in a tertiary care setting in Kanpur, Uttar Pradesh.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional observational study was carried out in the Department of Pulmonary Medicine at a tertiary care teaching hospital in Kanpur, Uttar Pradesh, over a 6-month duration (March 2026 to September 2026). Informed written consent was obtained from all participants before enrolment in accordance with the Declaration of Helsinki.

Study Population and Eligibility Criteria

Consecutive patients aged 40 years and above attending the outpatient and inpatient services of the pulmonary medicine department with confirmed or suspected COPD were screened.

Inclusion Criteria:

- Age 40 years and more
- Spirometry-confirmed post-bronchodilator FEV1/FVC < 0.70
- Clinically stable condition with no history of acute exacerbations, hospitalization, or respiratory tract infections in the preceding 4 weeks.
- Ability to understand the study questionnaire and perform acceptable spirometric maneuvers.

Exclusion Criteria:

- Primary coexisting respiratory diagnoses (bronchial asthma, active pulmonary tuberculosis, bronchiectasis, interstitial lung disease, thoracic malignancies).
- Significant left-sided congestive cardiac failure, unstable coronary artery disease, or neuromuscular disorders.
- Contraindications to spirometry (e.g., recent eye surgery, aneurysm, recent myocardial infarction).
- Refusal or inability to give informed consent.

Sample Size Calculation

The sample size was estimated based on an expected correlation coefficient (r) of -0.30 to -0.50 between FEV1% predicted and CAT scores based on previous literature [8,10]. With a two-sided significance level (alpha) of 0.05, a power (1-beta) of 90%, and a minimum expected correlation coefficient (r) of 0.30, the sample size required was calculated as 112 patients. To account for non-interpretable spirograms and data attrition, a total sample size of 150 patients was enrolled.

Data Collection and Operational Definitions

- Socio-Demographic and Clinical Data: A pre-tested semi-structured proforma captured age, sex, residence, occupational exposure, smoking history (quantified in pack-years), and domestic biomass fuel exposure (chulha usage quantified in hour-years: hours/day $\times$ total years cooked). Height and weight were measured using standard protocols to compute Body Mass Index (BMI, kg/m²)
- Pulmonary Function Testing (Spirometry): Standardized spirometry was performed using an electronic dry rolling-seal spirometer calibrated daily, following ATS/ERS standardization protocols [11]. Pre-bronchodilator baseline values were obtained, followed by post-bronchodilator evaluation 15–20 minutes after inhalation of 400ug salbutamol via a metered-dose inhaler with a valve-holding spacer. FVC, FEV₁, and FEV₁/FVC were recorded. Predicted values were computed from validated South Asian reference equations. Airflow obstruction severity was staged per GOLD 2026 criteria [1]:
- GOLD 1 (Mild):FEV1 equal and more than 80% predicted

- GOLD 2 (Moderate): 50% equal and more than FEV1 < 80% predicted
- GOLD 3 (Severe): 30% equal and more than FEV1 < 50% predicted
- GOLD 4 (Very Severe): FEV1 < 30% predicted
- Health Status Assessment (CAT): The CAT contains 8 items: cough, phlegm, chest tightness, breathlessness going up hills/stairs, activity limitation at home, confidence leaving home, sleep quality, and energy [7]. Each item is scored from 0 to 5 (total score range: 0–40). Clinical impact was graded as Low (< 10), Medium (10-20), High (21-30), and Very High (> 30) [7]. The validated Hindi version of the CAT was administered [12].
- Dyspnea Assessment (mMRC): Functional breathlessness was graded on a scale from 0 to 4 using the modified Medical Research Council dyspnea scale [1].

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics were expressed as mean±standard deviation (SD), medians with interquartile ranges (IQR), or frequencies and percentages. Differences across GOLD stages were evaluated using one-way ANOVA with Tukey's post hoc tests or Kruskal-Wallis tests. Bivariate relationships were assessed using Pearson's correlation coefficient (r) for continuous normal variables and Spearman's rank correlation (rho) for ordinal variables. Multivariable linear regression was conducted to determine the independent association of spirometric parameters with CAT scores after controlling for potential confounders. A two-tailed p-value < 0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Characteristics

The study included 150 stable COPD patients. The mean age was 61.4 ± 9.2 years (range: 41–82 years). Men constituted 78.7% (n=118) and women 21.3% (n=32). Tobacco smoking was present in 72.0% (n=108) with a mean exposure of 28.4±14.1 pack-years. Biomass fuel smoke exposure was documented in 37 patients (24.7%), of whom 26 were female (81.3% of female participants).

Table 1: Socio-demographic, Clinical, and Exposure Characteristics (N = 150)

Characteristic	Frequency / Mean ± SD	Percentage (%)
Age Groups (years)		
40-49	16	10.7
50-59	44	29.3
60-69	61	40.7
70 and above	29	19.3
Gender		
Male	118	78.7
Female	32	21.3
Body Mass Index (BMI, kg/m²)	21.8±4.1	—
Underweight (< 18.5)	34	22.7
Normal (18.5-22.9)	71	47.3
Overweight/Obese (23.0 and above)	45	30.0
Primary Exposure History		
Tobacco Smokers (Bidi/ Cigarette)	108	72.0
Biomass Fuel Combustion	37	24.7
Occupational/ Environmental Dusts	21	14.0
Duration of Illness (years)	6.8±4.3	—
Exacerbations in Past 12 Months (Median, IQR)	1.0 (0–2)	—

Spirometric Staging and Health Status

The mean post-bronchodilator FEV1% predicted was 51.8±17.6%, and the mean post-bronchodilator FEV1/FVC was 0.54±0.09. GOLD Stage 2 (moderate obstruction, 41.3%) and GOLD Stage 3 (severe obstruction, 32.7%) were the most prevalent categories.

The overall mean CAT score was 19.4±7.1 (range: 5–36). A high symptom impact (CAT} more or equal to 10) was identified in 84.0% (n = 126) of the study cohort. Mean CAT scores and mMRC dyspnea grades increased significantly across progressive GOLD stages (p < 0.001).

Table 2: Spirometric Profile, CAT Scores, and mMRC Dyspnea Grades across GOLD Severity Stages

GOLD Severity Stage	Patients n (%)	Post-BD FEV1% Pred (Mean±SD)	Mean CAT Score (Mean ± SD)	Mean mMRC Grade (Mean±SD)	CAT Score ≥21, n (%)
GOLD 1 (Mild)	18 (12.0)	83.6 ±3.2	10.8 ± 4.2	1.1 ±0.6	1 (5.6)
GOLD 2 (Moderate)	62 (41.3)	63.1 ± 7.8	16.2 ±5.1	1.7 ± 0.8	15 (24.2)
GOLD 3 (Severe)	49 (32.7)	40.5 ± 5.7	23.1 ±5.4	2.5 ±0.7	32 (65.3)
GOLD 4 (Very Severe)	21 (14.0)	24.1 ± 3.9	28.3± 4.9	3.3 ±0.6	19 (90.5)
ANOVA / Test Value (F/chi2)	—	F = 412.6	F = 56.84	chi2= 68.32	chi2= 54.12
p-value	—	< 0.001	< 0.001	< 0.001	< 0.001

Correlation Between Lung Function and Health Status

Bivariate correlation analysis demonstrated a statistically significant, moderate inverse relationship between FEV1% predicted and total CAT score ($r = -0.548$, $p < 0.001$), and between FEV1% predicted and mMRC grade ($\rho = -0.492$, $p < 0.001$). CAT score and mMRC grade showed a strong positive correlation ($\rho = 0.684$, $p < 0.001$).

Table 3: Correlation Matrix Between Pulmonary Function Indices and Health Status Metrics

Correlated Parameters	Coefficient (r / ρ)	Statistical Significance (p-value)	Interpretation
FEV1% predicted vs. Total CAT Score	$r = -0.548$	< 0.001	Moderate negative correlation
Absolute FEV1 (L) vs. Total CAT Score	$r = -0.512$	< 0.001	Moderate negative correlation
FEV1/FVC Ratio vs. Total CAT Score	$r = -0.384$	< 0.001	Weak-to-moderate negative correlation
FVC% predicted vs. Total CAT Score	$r = -0.312$	< 0.001	Weak negative correlation
FEV1% predicted vs. mMRC Dyspnea Grade	$\rho = -0.492$	< 0.001	Moderate negative correlation
Total CAT Score vs. mMRC Dyspnea Grade	$\rho = 0.684$	< 0.001	Strong positive correlation

Multivariable Regression Analysis

Multivariable linear regression was performed to evaluate the independent association of FE 1% predicted with CAT scores, adjusting for age, sex, BMI, smoking pack-years, and biomass fuel exposure.

Table 4: Multivariable Linear Regression Model for Predictors of Total CAT Score

Variable	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized β	t-value	p-value	95% Confidence Interval
Constant	31.42	3.82	—	8.22	< 0.001	23.87 to 38.97
FEV1% Predicted	-0.198	0.029	-0.488	-6.82	< 0.001	-0.255 to -0.141
Age (years)	0.094	0.051	0.123	1.84	0.067	-0.007 to 0.195
BMI (kg/m2)	-0.218	0.112	-0.127	-1.95	0.053	-0.439 to 0.003
Smoking (Pack-Years)	0.082	0.035	0.164	2.34	0.021	0.013 to 0.151
Biomass Exposure	1.842	0.884	0.141	2.08	0.039	0.095 to 3.589

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Model Parameters: $R = 0.642$, $R^2 = 0.412$, Adjusted $R^2 = 0.392$, $F = 20.17$, $p < 0.001$.

FEV1% predicted was the strongest independent predictor of CAT score ($\beta = -0.488$, $p < 0.001$). In addition, smoking pack-years ($p = 0.021$) and biomass exposure ($p = 0.039$) remained significant independent predictors of worse health status.

DISCUSSION

This study evaluated the degree of lung function impairment and its correlation with patient-reported health status among 150 stable COPD patients in a tertiary care teaching hospital in Kanpur, Uttar Pradesh. The primary finding is a statistically significant, moderate inverse correlation between post-bronchodilator FEV1% predicted and CAT score ($r=-0.548$, $p<0.001$), alongside a moderate correlation with mMRC dyspnea grade ($\rho=-0.492$, $p<0.001$).

Demographic Context and Exposure Profiles

The mean age of 61.4 ± 9.2 years and the male predominance (78.7%) in our cohort are consistent with demographic distributions documented across hospital-based COPD cohorts in India [9,10,13]. While tobacco smoking remains the major risk factor in men (72.0%), biomass fuel exposure accounted for disease in over 80% of female patients. This finding reflects the ongoing epidemiological pattern in northern India, where women in rural and peri-urban households face sustained exposure to wood, crop residue, and dung-cake smoke in poorly ventilated kitchens [2,4]. Furthermore, ambient particulate pollution in industrial hubs like Kanpur acts as an additional environmental stressor that accelerates chronic respiratory decline [3,4].

Concordance Between Spirometry and Health Status (CAT)

The moderate correlation observed between FEV1% predicted and CAT score ($r=-0.548$) agrees with national and international studies. Initial validation studies by Jones et al. [7] and Papaioannou et al. [8] reported baseline correlation coefficients of -0.45 to -0.58 between FEV1 and CAT scores. Similar findings were reported in North Indian populations by Aggarwal et al. [9,12] and Kaur et al. [10], as well as in recent international cohorts by Al Wachami et al. [14] ($r=-0.33$, $p<0.001$).

Despite a clear population-level trend of worsening CAT scores across advancing GOLD stages, substantial symptom heterogeneity was observed within each spirometric bracket. In GOLD Stage 2, 24.2% of patients had high impact scores ($CAT>21$), whereas some patients in GOLD Stage 3 maintained lower symptom impact ($CAT<15$). This divergence explains why the correlation is moderate rather than strong ($r>0.80$). Spirometry primarily measures forced expiratory flow dynamics in central and intermediate airways, whereas health status is influenced by dynamic hyperinflation, peripheral muscle dysfunction, systemic inflammation, nutritional status, and psychological comorbidities (such as depression and anxiety) [5,6,15].

CAT vs. mMRC in Primary and Tertiary Care

In our study, CAT scores demonstrated a strong positive correlation with mMRC dyspnea grades ($\rho=0.684$, $p<0.001$), reflecting that breathlessness is a major component of disease perception. However, while the mMRC scale focuses strictly on exertional dyspnea, the CAT questionnaire captures a broader spectrum of systemic manifestations—including cough, sputum production, chest tightness, sleep disturbances, fatigue, and loss of psychological confidence [7,16]. For community health and outpatient triage, the CAT provides a more comprehensive assessment of daily functional impairment [16,17].

Public Health and Clinical Implications

These findings highlight the clinical risk of relying exclusively on spirometric values to make therapeutic decisions or track disease progression. In clinical and public health practice across Uttar Pradesh, patients with moderate spirometric impairment may be undertreated despite severe symptomatic disability. Integrating the Hindi-validated CAT questionnaire into routine pulmonary and community health clinic workflows enables clinicians to identify highly symptomatic individuals who require intensified pharmacological therapy (e.g., dual LABA/LAMA bronchodilator regimens), pulmonary rehabilitation, smoking cessation support, and household environmental mitigation [1,12,17].

Limitations

1. Cross-Sectional Design: The observational nature of this study precludes evaluating longitudinal health status changes over time or assessing responsiveness to specific therapeutic interventions.
2. Physiological Measurements: Static lung volumes (e.g., residual volume, TLC) and diffusing capacity of the lung for carbon monoxide (DLCO) were not measured due to equipment constraints, which might have explained additional variance related to gas exchange and lung hyperinflation.
3. Setting: As a tertiary hospital-based study, there may be a referral bias toward more symptomatic individuals compared to the general community population.

CONCLUSION

This study confirms a statistically significant, moderate inverse correlation between objective spirometric parameters (FEV1% predicted) and patient-reported health status (CAT and mMRC scores) among COPD patients in Kanpur, Uttar Pradesh. However, the presence of substantial symptom variation within identical spirometric stages indicates that

spirometry alone does not capture the overall health status of COPD patients. Comprehensive clinical management must pair objective spirometric grading with structured patient-reported tools like the CAT to optimize treatment strategies.

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