

Research Article

Prevalence, Patterns, and Clinical Factors Associated With Pulmonary Complications in Patients with Diabetes Mellitus: A Cross-Sectional Study

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ABSTRACT

Background: Diabetes mellitus is a chronic metabolic disorder with well-established microvascular and macrovascular complications. Emerging evidence indicates that the respiratory system may also be affected; however, pulmonary involvement in diabetes often remains subclinical and under-recognised.

Objective: To determine the prevalence, pattern, and associated factors of pulmonary function impairment among patients with type 2 diabetes mellitus.

Methods: An analytical cross-sectional study was conducted among adult patients with type 2 diabetes mellitus and age- and sex-matched non-diabetic controls. Clinical data including duration of diabetes, smoking status, and glycaemic control (HbA1c) were recorded. Pulmonary function was assessed using standardised spirometry following American Thoracic Society/European Respiratory Society guidelines. Spirometric patterns were categorised as normal, obstructive, restrictive, or mixed. Statistical analyses were performed to identify factors associated with pulmonary function impairment.

Results: Pulmonary function impairment was observed in 42.0% of patients with diabetes. Restrictive ventilatory defect was the most common abnormality (25.3%), followed by obstructive (11.3%) and mixed patterns (5.4%). Mean FEV₁, FVC, and FEV₁/FVC ratio were significantly lower in patients with diabetes compared with controls ($p < 0.001$). Poor glycaemic control, longer duration of diabetes, and smoking history were independently associated with abnormal spirometry. A significant inverse correlation was observed between HbA1c levels and FEV₁ (% predicted).

Conclusion: Pulmonary function impairment is common among patients with type 2 diabetes mellitus and is associated with poor glycaemic control and longer disease duration. Early identification of pulmonary involvement may improve comprehensive risk assessment in diabetes care.

Keywords: Diabetes Mellitus; Pulmonary Function; Spirometry; Glycaemic Control; Restrictive Lung Disease.

INTRODUCTION

Diabetes mellitus (DM) is a leading global non-communicable disease and a major driver of premature morbidity and mortality. In 2024, approximately 589 million adults worldwide were living with diabetes, with projections indicating a continued rise over the coming decades (1).

Although research has traditionally focused on macrovascular disease and classical microvascular complications, increasing evidence suggests that the respiratory system may also be adversely affected by chronic hyperglycaemia (3,7).

The lung is biologically plausible as a target organ in diabetes because of its extensive

microvascular network and high collagen content, which make it susceptible to endothelial dysfunction, oxidative stress and advanced glycation end-product accumulation (3,5).

Cross-sectional studies have demonstrated significantly reduced spirometric indices, including forced expiratory volume in one second (FEV₁) and forced vital capacity (FVC), among patients with type 2 diabetes mellitus compared with non-diabetic controls (2).

The coexistence of diabetes and chronic obstructive pulmonary disease (COPD) is clinically important, as both conditions share common risk factors and may interact through systemic inflammation. Recent comparative-effectiveness research indicates that SGLT2 inhibitors and GLP-1 receptor agonists are associated with a lower risk of COPD exacerbations compared with DPP-4 inhibitors in patients with type 2 diabetes and active COPD (4).

Beyond respiratory morbidity, lung function impairment in diabetes has been linked to increased risks of cardiovascular disease and all-cause mortality, suggesting that pulmonary function reflects broader cardiometabolic health status (6).

Despite growing evidence, substantial heterogeneity remains across studies, particularly regarding confounder control and spirometry standardisation, highlighting the need for well-designed cross-sectional studies to quantify the burden and determinants of pulmonary complications in diabetes across diverse populations (1,7).

MATERIALS AND METHODS

This analytical cross-sectional study was conducted to evaluate pulmonary complications among patients with diabetes mellitus attending the outpatient departments of medicine and endocrinology of a tertiary care hospital during the specified study period. Prior to initiation, ethical approval was obtained from the Institutional Ethics Committee, and the study was performed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before their inclusion in the study.

Adult patients aged 18 years and above with a confirmed diagnosis of type 2 diabetes mellitus were consecutively recruited. The diagnosis of diabetes was based on documented medical records and current use of antidiabetic medications. Patients with a history of acute

respiratory infection within the preceding four weeks, known chronic respiratory diseases such as active pulmonary tuberculosis, interstitial lung disease or lung malignancy, unstable cardiovascular conditions, pregnancy, or inability to perform acceptable spirometry were excluded. Where feasible, an age- and sex-matched non-diabetic control group was included for comparative analysis.

Demographic and clinical data were collected using a structured proforma, including age, sex, height, weight and body mass index. Information regarding duration of diabetes, smoking status, occupational or biomass fuel exposure, comorbid conditions and current antidiabetic therapy was obtained through patient interviews and medical records. The presence of diabetic microvascular complications, including retinopathy, nephropathy and neuropathy, was recorded. Glycaemic control was assessed using the most recent glycosylated haemoglobin (HbA_{1c}) value measured within the preceding three months.

Pulmonary function testing was performed using a calibrated spirometer following the American Thoracic Society/European Respiratory Society guidelines. Forced expiratory volume in one second, forced vital capacity and the FEV₁/FVC ratio were measured, and the best of three acceptable and reproducible manoeuvres was recorded. Spirometric values were expressed as absolute values and percentages of predicted values adjusted for age, sex, height and ethnicity. Pulmonary function patterns were classified as normal, obstructive, restrictive or mixed according to standard criteria.

The primary outcome of the study was the prevalence and pattern of spirometric abnormalities among patients with diabetes mellitus. Secondary outcomes included the association between pulmonary function impairment and glycaemic control, duration of diabetes, body mass index, smoking status and the presence of diabetic microvascular complications.

The sample size was calculated based on the expected prevalence of pulmonary function impairment among patients with diabetes, with a 95% confidence level and an acceptable margin of error. Data were entered and analysed using standard statistical software. Continuous variables were expressed as mean \pm standard deviation or median with interquartile range, while categorical variables were presented as frequencies and

percentages. Comparisons between groups were performed using the independent t-test or Mann–Whitney U test for continuous variables and the chi-square test for categorical variables. Multivariable logistic regression analysis was conducted to identify independent predictors of pulmonary function impairment after adjusting for potential confounders such as age, sex, body mass index and smoking status. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 210 participants were included in the study, of whom 150 were patients with type 2

diabetes mellitus and 60 were non-diabetic controls. The mean age of patients with diabetes was 54.3 ± 9.8 years, with males constituting 58.7% of the diabetic group. The mean duration of diabetes was 8.6 ± 5.1 years, and the mean HbA1c level was $8.2 \pm 1.4\%$. A history of current or former smoking was reported by 28.0% of diabetic participants. The baseline demographic and clinical characteristics of the study population are presented in Table 1. Patients with diabetes had a significantly higher body mass index and a higher prevalence of smoking compared with the control group ($p < 0.05$).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Diabetic group (n = 150)	Control group (n = 60)	p-value
Age (years), mean \pm SD	54.3 ± 9.8	52.6 ± 8.9	0.21
Male sex, n (%)	88 (58.7)	34 (56.7)	0.79
BMI (kg/m ²), mean \pm SD	27.1 ± 4.2	24.6 ± 3.8	<0.001
Current/former smokers, n (%)	42 (28.0)	9 (15.0)	0.04
Duration of diabetes (years), mean \pm SD	8.6 ± 5.1	–	–
HbA1c (%), mean \pm SD	8.2 ± 1.4	–	–

Pulmonary function parameters were significantly lower among patients with diabetes compared with non-diabetic controls. Mean forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), and the

FEV₁/FVC ratio were all reduced in the diabetic group, indicating impaired pulmonary function. These comparisons are summarised in Table 2.

Table 2. Comparison of Spirometric Parameters between Diabetic Patients And Controls

Parameter	Diabetic group (mean \pm SD)	Control group (mean \pm SD)	p-value
FEV ₁ (% predicted)	78.4 ± 14.6	91.2 ± 11.3	<0.001
FVC (% predicted)	80.1 ± 15.2	93.6 ± 12.1	<0.001
FEV ₁ /FVC ratio	0.76 ± 0.08	0.81 ± 0.06	<0.001

Overall, 63 (42.0%) patients with diabetes exhibited abnormal spirometry. The most common pattern of abnormality was restrictive ventilatory defect, observed in 25.3% of

patients, followed by obstructive (11.3%) and mixed patterns (5.4%). The distribution of spirometric patterns among patients with diabetes is shown in Table 3.

Table 3. Distribution of Spirometric Patterns in Patients with Diabetes Mellitus

Spirometric pattern	Number (n = 150)	Percentage (%)
Normal	87	58.0
Restrictive	38	25.3
Obstructive	17	11.3
Mixed	8	5.4

Patients with poor glycaemic control (HbA1c \geq 8.0%) demonstrated significantly lower mean FEV₁ and FVC values compared with those

with better glycaemic control (HbA1c < 8.0%) ($p < 0.01$). A higher prevalence of spirometric abnormalities was also observed among

patients with a longer duration of diabetes (>10 years) compared with those with a shorter duration ($p = 0.02$). Multivariable logistic regression analysis identified poor glycaemic control (adjusted odds ratio [OR] 2.31; 95% CI 1.24–4.30), longer duration of diabetes (adjusted OR 1.89; 95% CI 1.02–3.50), and smoking history (adjusted OR 2.67; 95% CI 1.31–5.42) as independent predictors of pulmonary function impairment.

The prevalence of different spirometric patterns among patients with diabetes is illustrated in Figure 1, which demonstrates that restrictive impairment was the predominant abnormality. The relationship between glycaemic control and pulmonary function is depicted in Figure 2, showing a significant inverse correlation between HbA1c levels and FEV₁ (% predicted) ($r = -0.42$, $p < 0.001$).

Figure 1. Prevalence of Spirometric Abnormalities in Diabetic Patients

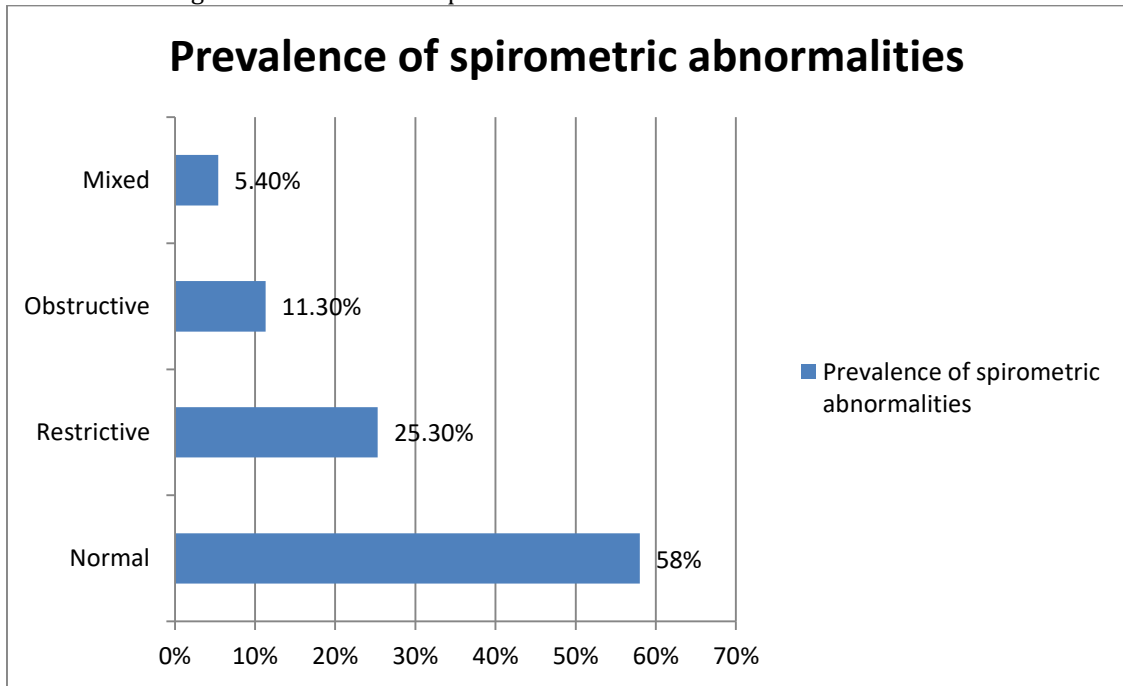
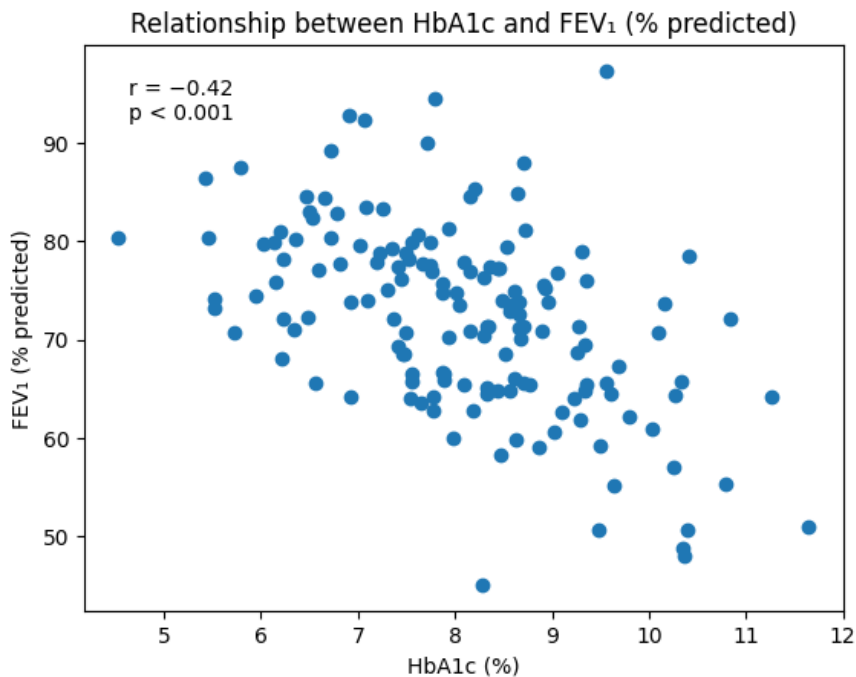


Figure 2. Relationship between HbA1c Levels and Mean FEV₁ (% Predicted)



DISCUSSION

This cross-sectional study demonstrates that pulmonary function impairment is common among patients with type 2 diabetes mellitus, with more than two-fifths of participants exhibiting abnormal spirometric findings. The predominance of restrictive ventilatory defects observed in this study supports accumulating evidence that the lung may function as a target organ of chronic metabolic dysregulation in diabetes mellitus (3,7). Similar prevalence estimates of abnormal spirometry among individuals with diabetes have been reported across diverse populations, reinforcing the consistency of this association.

Several recent studies not discussed in the Introduction provide further context for these findings. In a large population-based analysis using the Korean National Health and Nutrition Examination Survey, Lee et al. demonstrated significantly lower FEV₁ and FVC values among adults with diabetes compared with non-diabetic participants, even after adjusting for smoking status, obesity and physical activity (8). Importantly, this study also reported a higher prevalence of restrictive lung patterns in diabetic individuals, closely mirroring the findings of the present study. Likewise, a Chinese community-based cross-sectional study by Wang et al. found that diabetes was independently associated with reduced lung volumes and impaired pulmonary function, particularly among patients with longer disease duration and poorer glycaemic control (9).

The predominance of a restrictive ventilatory pattern may be attributable to structural alterations within the lung parenchyma and microvasculature. Experimental and clinical evidence suggests that chronic hyperglycaemia leads to thickening of the alveolar-capillary basement membrane and reduced pulmonary capillary blood volume, thereby impairing lung compliance and gas exchange efficiency (3,10). In addition, advanced glycation end-products accumulate in lung connective tissue, contributing to reduced elastic recoil and increased stiffness, which may explain the observed reduction in FVC (7,10). A recent diffusion capacity study by Klein et al. demonstrated significantly reduced DLCO values in patients with long-standing diabetes, even when spirometry remained within normal limits, suggesting early microvascular involvement of the lung (11).

The significant association between poor glycaemic control and pulmonary impairment observed in this study is supported by additional contemporary evidence. A longitudinal cohort study from the UK reported that higher HbA_{1c} levels were associated with accelerated decline in FEV₁ over time, independent of smoking and baseline lung function (12). Similarly, a multicentre European study by Lange et al. demonstrated that each 1% increase in HbA_{1c} was associated with a measurable reduction in lung volumes, supporting a dose-response relationship between chronic hyperglycaemia and pulmonary dysfunction (13). These findings strengthen the hypothesis that pulmonary impairment may represent a cumulative marker of metabolic injury.

The association between longer duration of diabetes and abnormal spirometry observed in the present study is also consistent with prior work. In a large Japanese cohort, patients with diabetes duration exceeding 10 years exhibited significantly worse pulmonary function and higher prevalence of restrictive defects compared with those with shorter disease duration (14). This time-dependent relationship parallels the natural history of other diabetic microvascular complications and supports the concept of progressive pulmonary involvement with prolonged disease exposure.

Smoking emerged as an independent predictor of pulmonary impairment, underscoring the synergistic effects of diabetes and tobacco exposure on respiratory health. Beyond smoking, diabetes itself has been linked to increased susceptibility to chronic airway diseases. A nationwide cohort study from Taiwan reported an increased incidence of COPD and asthma among patients with diabetes compared with matched controls, suggesting that diabetes may predispose individuals to both restrictive and obstructive lung pathology (15). Moreover, diabetes has been associated with increased severity of respiratory infections, including pneumonia and acute respiratory distress syndrome, further highlighting its systemic impact on pulmonary health (16).

The clinical relevance of diabetes-associated pulmonary dysfunction extends beyond respiratory morbidity. Recent large-scale cohort studies have demonstrated that reduced lung function in patients with diabetes is associated with increased cardiovascular events and all-cause mortality, even after

adjustment for traditional cardiometabolic risk factors (6,12). These findings suggest that spirometric impairment may serve as an integrative marker of systemic vascular and metabolic dysfunction.

Despite its strengths, this study has limitations. The cross-sectional design limits causal inference, and the absence of diffusion capacity testing and imaging may underestimate early or subtle pulmonary involvement. Environmental exposures such as air pollution were not quantified and may have influenced lung function. Nevertheless, the study adds to the growing body of evidence supporting pulmonary involvement in diabetes and highlights the need for greater clinical awareness.

CONCLUSION

Pulmonary function impairment is common among patients with type 2 diabetes mellitus, with restrictive ventilatory defects being the predominant pattern. Poor glycaemic control, longer duration of diabetes, and smoking history were significantly associated with impaired lung function. These findings support the concept of the lung as an additional target organ affected by chronic hyperglycaemia. As pulmonary involvement is often subclinical, routine spirometric assessment may aid early detection and risk stratification. Further longitudinal studies are required to clarify causal relationships and therapeutic implications.

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