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Evaluating the Lung Function Parameters of the Residents of Delhi: A Cohort Study

Mongjam Meghachandra Singh[1,2], Govind Mawari[2], Naresh Kumar[2], Mradul Kumar Daga[3], Akshithanand Kuzhikkat Jayaprakasan[1], Parth Sharma[1]

Abstract

Background: Chronic lung diseases contribute significantly to the global disease burden, with air pollution being a major risk factor. This study aimed to assess changes in lung function parameters among permanent residents of Delhi, one of the world's most polluted capital cities. **Methods**: A cohort study was conducted with 190 participants. Lung function parameters were evaluated using spirometry during October-November 2019 (baseline) and October-November 2021 (follow-up). Forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio were measured, and subgroup analysis was done based on the participant's age, gender, and smoking status. **Results**: The study found an overall decline in lung function parameters between 2019 and 2021. The reduction in FVC was statistically significant across both genders, regardless of smoking history and particularly notable in the 41-60 years age group. **Conclusions**: The study demonstrated a significant decline in lung function parameters, particularly FVC, among Delhi residents over two years. These findings highlight the need for air quality monitoring, screening programs in highly polluted urban environments, and targeted interventions for vulnerable populations. **Categories**: Public Health, Pulmonology, Environmental Health.

Keywords: Air pollution, lung function tests, spirometry, Delhi, India

[1]Department of Community Medicine, Maulana Azad Medical College, New Delhi -110002, India

[2]Department Center for Occupational and Environment Health, Maulana Azad Medical College, New Delhi-110002, India

[3]Department of Internal Medicine and Infectious Disease, Institute of Liver and Biliary Sciences, New Delhi, India

Corresponding Author: Dr Akshithanand Kuzhikkat Jayaprakasan, Junior Resident, Department of Community Medicine, Maulana Azad Medical College, New Delhi, India

Email: askhisainik@gmail.com

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Introduction

Chronic lung diseases accounted for 10.6% of the global disease burden, with smoking and air pollution being major risk factors [1]. Air pollution, both indoor and outdoor, can harm our lungs. Air pollution from particulate matter, ozone, and nitrogen oxides exacerbate pulmonary diseases with a higher impact on vulnerable populations. Together, these pollutants lead to serious health issues, including asthma, lung infections, chronic diseases like Chronic Obstructive Pulmonary Disease (COPD), and even lung cancer [2,3].

Lung function tests are useful for assessing an individual's respiratory health. These tests can detect compromised lung health long before any signs or symptoms of chronic respiratory diseases appear [4]. Correlating lung function parameters directly with air pollution is difficult, and information regarding the direct impact of air pollution on the health of the respiratory system in the Indian population is lacking. The period from October to November specifically is known for high pollution levels, attributed to factors such as stubble burning, firecracker use due to Diwali, and thermal inversion, in addition to vehicular pollution, burning of fossil fuels, and emissions from thermal power plants [5].

Materials And Methods

A cohort study was conducted to assess lung function parameters of permanent residents of Delhi. Participants were selected using convenient sampling.

Inclusion Criteria were:

(1) Permanent resident of Delhi;
(2) Age 18 years or older;
(3) Ability to perform spirometry;
(4) Willingness to participate in follow-up assessments;

Exclusion Criteria included:

(1) Known respiratory conditions;
(2) Active respiratory infection;

Baseline lung function evaluation was tested from October to November 2019 and subsequent evaluations were done for the same

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population between October and November 2021. Spirometry was chosen to assess the lung function of the study population, and a MIR Spirolab spirometer was used [6]. Forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) were measured and the FEV1/FVC ratio was calculated. Looking at FEV1, FVC and FEV1/FVC ratio together gives a better assessment and helps to classify the pathologies as obstructive or restrictive patterns. Ethics approval was obtained from the Institutional Ethics Committee. A total of 190 apparently normal adults were enrolled after obtaining written informed consent and were followed up. Participants with any identified severe disease were excluded from the study and referred to the linked hospital for further management.

Results

Our study population comprised 190 participants with a mean age of 43.15 ± 15.73 years. There were 91 (47.9%) participants who were aged less than 40 years, 70 (36.8%) who were in the age group 41-60 years, and 29 (15.3%) who were over 60 years, with an age range of 18 to 82 years. The demographic distribution showed 103 females (54.2%) and 87 males (45.8%). Among the participants, 156 (82.1%) were non-smokers and 34 (17.9%) were current or former smokers. Participants reported spending a median of 5 hours (Inter quartile range (IQR): 2.5, 8.9) outdoors daily.

From the baseline assessment in 2019, a drop in FEV1, FVC, and FEV1/FVC was noticed in 2021 in the study population (Table 1). However, only the reduction in FVC was found to be statistically significant. The lung function parameters of the participants were evaluated and analysed after segregating the data according to age, gender, and smoking status (Table 1).

A declining trend for FEV1 and FVC was noticed even when segregating for age, gender, and smoking status. The decline in FVC was statistically significant across both genders, irrespective of their smoking history. The decline in FVC was also found to be significant in the age group 41 to 60 years. The declining trend in FEV1 was statistically significant overall, but sub-group analysis across gender, age groups, and smoking history did not give statistically significant results.

Discussion

In this study, we found a general trend of declining lung function parameters. On subgroup analysis, a significant decline in FVC was detected in the 41 to 60 years age group, and gender-wise analysis revealed both males and females showing significant FVC decline. The declining trend in lung function parameters observed in our study can be attributed to several factors. In their study, Arora S et.al. reported that women were particularly vulnerable to indoor air pollution. Their study also found that decreased lung function was associated with both tobacco smoking and vehicular pollution exposure [7].

Studies from across the world have linked air pollution to deranged lung function parameters. A study from Sweden found that exposure to traffic-related air pollution, especially in males, is associated with reduced lung function [8]. Among children, higher levels of air pollution were linked to significant retardation in lung growth rates, which was more among boys compared to girls [9]. Studies among school children from China found that prolonged exposure to ambient air pollution had an association with wheezing and cough. PM10 had a notable association with these disease conditions and with deranged pulmonary function [10,11].

The significant decline in FVC across various subgroups is particularly noteworthy. FVC tends to decrease with age due to various anatomical and physiological changes in the respiratory system [12]. A systematic review by Thomas et.al. (2019) consistently showed that lung function measured by FEV1 and FVC declines with age. Men showed a faster decline in absolute values compared to women, and an age-specific analysis revealed that the rate of decline increased every decade [13].

Kelkar et.al. (2019) found that people who lived in Delhi for more years had poorer lung function parameters. Those who used closed transportation like cars and air-conditioned buses had better lung function than those who used open transportation like non-air-conditioned buses and scooters. People living near factories that produce smoke also leads to lower lung function. Additionally, both active smokers and people exposed to second hand smoke from family members had significantly poorer lung function compared to non-smokers [4].

The meta-analysis of multi-centric cohort data by Adam et.al. (2015) revealed that higher exposures to nitrogen oxides and PM10 were linked to significantly lower cross-sectional levels of FEV1 and FVC, with traffic density near residences also associated with decreased FEV1. Meanwhile, no association was detected between air pollution and a longitudinal decline in lung function from the analysis. The authors points out that this lack of longitudinal association may be due to several methodological issues, including the differences of measuring changes in lung function over time and potential limitations in the ability to accurately assess air pollution exposure throughout the study period. Also, external influences like seasonal and diurnal variations, changing the spirometer used as technology advanced, and other individual-level confounding factors may have affected any real effects of chronic pollution exposure on the decline in lung function over time. [14].

As per the World Air Quality Report 2023, India ranked as the third most polluted country, and Delhi as the most polluted capital city with an average Air Quality Index (AQI) ranging from 234 to 312 between October and November 2019 and an AQI of 173 to 377 during the same period in 2021. These consistently high pollution levels likely play a significant role in the declining lung health of the population [15,16]. A recent study by Chen Y (2025) highlights that particulate matter pollution in Delhi, particularly PM1, may be significantly underestimated. This underestimation stems from the hygroscopic growth of PM1 particles, which is affected by environmental humidity and chloride content. This leads to notable fluctuations based on season, time of day and surrounding conditions. The author comments that such bias is considerably much smaller on PM2.5 and PM10 as compared to PM1 [17].

The study by Feng et.al. (2022) in China followed college students from 2019 to 2020, including the COVID-19 lockdown period, to examine how changes in air pollution affected lung function. It was found that lung function parameters improved over time and were associated with a decrease in average values of PM 2.5 and PM 10. The results remained consistent after accounting for indoor air pollution. Also, no significant difference was found between male and female population [18].

Study Limitations and Future Directions

Despite relevant findings, this study had a few limitations. Firstly, the sample size of the cohort was small, and the follow-up period was short due to limited resources. However, being the first cohort study assessing change in lung function tests in highly polluted areas in India, this study generates crucial evidence to guide future studies. Secondly, the change in lung function can only be attributed to air pollution in Delhi and not directly correlated to it, as the

Table 1: Changes in Lung Function Parameters (2019-2021) by Demographic Characteristics

Variable (N = 190)(100%)	Mean ± SD 2019	Mean ± SD 2021	p-value
FEV1	2.2497 ± 0.6535	2.1675 ± 0.6699	0.028
FVC	2.7318 ± 0.7580	2.5829 ± 0.7519	<0.001
FEV1/FVC	81.0288 ± 10.0647	81.3816 ± 8.0495	0.633
Males (n = 87) (45.8%)			
FEV1	2.5144 ± 0.6289	2.4269 ± 0.7019	0.129
FVC	3.0986 ± 0.6920	2.9314 ± 0.7295	0.015
FEV1/FVC	79.0675 ± 11.7040	79.9575 ± 8.1450	0.474
Females (n = 103) (54.2%)			
FEV1	2.0261 ± 0.5896	1.9483 ± 0.5569	0.115
FVC	2.4220 ± 0.6702	2.2885 ± 0.6386	0.018
FEV1/FVC	82.6854 ± 8.1335	82.5845 ± 7.8062	0.908
Smokers (n = 34) (17.9%)			
FEV1	2.4297 ± 0.5911	2.3374 ± 0.6109	0.144
FVC	3.0626 ± 0.7310	2.8553 ± 0.6970	0.023
FEV1/FVC	77.2079 ± 14.6979	80.3971 ± 5.0022	0.204
Non-smokers (n = 156) (82.1%)			
FEV1	2.2104 ± 0.6616	2.1304 ± 0.6782	0.066
FVC	2.6597 ± 0.7467	2.5235 ± 0.7524	0.006
FEV1/FVC	81.8615 ± 8.5806	81.5962 ± 8.5687	0.712
Age ≤ 40 years (n = 91) (47.9%)			
FEV1	2.5100 ± 0.5319	2.4193 ± 0.5553	0.102
FVC	2.9526 ± 0.6624	2.8724 ± 0.6046	0.225
FEV1/FVC	84.2495 ± 7.0471	83.2495 ± 7.1063	0.199
Age 41 to 60 years (n = 70) (36.8%)			
FEV1	2.1417 ± 0.6309	2.0557 ± 0.68103	0.119
FVC	2.6857 ± 0.7164	2.4457 ± 0.7809	<0.001
FEV1/FVC	77.7896 ± 12.0639	80.2243 ± 7.8630	0.125
Age > 60 years (n = 29)(15.3%)			
FEV1	1.6934 ± 0.6498	1.6469 ± 0.6138	0.685
FVC	2.1503 ± 0.8303	2.0055 ± 0.6886	0.162
FEV1/FVC	78.7414 ± 10.0069	78.3138 ± 9.9125	0.803

study's primary objective was to assess only the change in lung function. Lastly, information related to COVID-19 infection was not collected, which could have been a confounder of our study.

The findings of this study highlight the need to undertake measures to protect the health of the people. Better control measures to mitigate harmful exposures, especially in heavily polluted cities like Delhi. Conducting screening camps for early detection of declining lung functions and implementing interventions, especially for vulnerable groups like children and the elderly, will help improve the health outcomes of the people. The study may shed evidence on air pollution induced health effects in a broader aspect.

Conclusions

Our study showed an overall decline in lung function parameters measured using spirometry, and the decline in FVC has been found to be statistically significant. This can be attributed to many factors, and air pollution is expected to play a significant role. Future studies should correlate the impact of air pollution - with a continuously monitored Air Quality Index (AQI) on lung function tests.

Declaration of patient consent

The all authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Data Access Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. The datasets shall be made available from the corresponding author on request.

Conflict of Interest:	Author declare no COI
Ethics:	There is no ethical violation as it is based on voluntary anonymous interviews
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