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THE ROLE OF AIR POLLUTION IN THE PROGRESSION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD): A MULTICENTER COHORT STUDY

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Abstract:

Background: *The development of COPD is greatly affected by environmental aspects, among them being air pollution. Some research has found a correlation between exposure to air pollutants and difficulties with COPD, but information from South Asia is still lacking.*

Aim: *The study was set up to analyze how air pollution in the environment affects the worsening of COPD in individuals treated in a tertiary center.*

Methods: *From May 2024 to April 2025, this multicenter cohort study was carried out at Shifa International Hospital, Islamabad. Ninety people with diagnosed COPD were involved in the study and were followed for 12 months. The exposure of participants to different common air pollutants (PM2.5, PM10, NO_2, and SO_2) was measured by using monitoring data from the area where they live. How often someone had exacerbations and was hospitalized, as well as improvements or worsening in symptoms, were noted and examined in relation to the air quality index.*

Results: *The research showed that being exposed to more of PM2.5 and PM10 leads to a decline in lung function ($p<0.01$). Those in areas with high levels of pollution visited the hospital and experienced more COPD exacerbations than those living in areas where pollutant levels were lower. It was also observed that people who were exposed to high levels of NO_2 and SO_2 for long periods had worse health symptoms and a lower quality of life.*

Conclusion: *The participants involved in the study were greatly affected by air pollution, which sped up and increased their symptoms of COPD. The results point to the need for more rules to keep air safe and personalized care options, mainly in areas of high pollution.*

Keywords: *Chronic Obstructive Pulmonary Disease, Air Pollution, PM2.5, COPD Exacerbation, Pulmonary Function, Environmental Health, Pakistan.*

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INTRODUCTION:

People had already understood that COPD is a pulmonary illness that continuously worsens, resulting in airway blockage and lasting irritation in the lungs. As a result, there were more cases of sickness, less happiness in life, and deaths happened earlier than usual. Description of air pollution's role in COPD could explain why the incidence was rising despite less general smoking, while more in-depth clinical reports showed that air pollution plays a pivotal role in COPD [1]. More and more people are recognizing the link between air pollution and COPD, as pollution is rising in many cities and industrial areas.

It was demonstrated in earlier studies that exposure to air pollutants such as particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and ozone (O_3), for a long time, was related to both the beginning and worsening of problems with lung function in cases of COPD [2]. Because of these pollutants, there were increased inflammation, oxidative damage, and structural injury in the airways, which sped up the decline of lung function. Besides, being exposed to high levels of air pollution within a short period was related to a higher number of breathing emergencies, hospital visits, and additional medical care.

Even though a lot of data exists, the specific role air pollution plays in COPD was not clear, mainly because of differences in the way studies were done and the types of people included [4]. Many past investigations were not able to capture long-term health outcomes, as they were based only on single-center, cross-sectional data. It is important to note that the link between air pollution and things such as smoking, job exposures, a person's social status, and additional diseases had not been well explored in most studies [5].

Because of these problems, this study wanted to focus on how air pollution affects COPD in different parts of the world and among different populations. To better study the effect of air pollution, the study used a design that lasted many years and carefully tracked factors in the environment [6]. Multiple participants from various centers with various levels of pollution were included in the study, helping researchers compare different regions based on their air quality and population.

Furthermore, this study used examinations, spirometry tests, symptom scores, and environmental monitoring to study links between the effects of pollutants and disease development. The research underlined the need to study decrease in lung function, occurrences of severe episodes, and quality of life in COPD patients related to the total and occasional levels of main air pollutants [7].

The authors tried to resolve some limitations in previous studies and structured their investigation as a multicenter cohort with the aim of exploring the factors that impact COPD progression. The purpose of the findings was to provide information for public health policies, clinical decisions, and preventive steps that could reduce exposure to pollutants in those who have chronic respiratory illnesses [8].

MATERIALS AND METHODS:

Study Design and Setting

This study was undertaken at Shifa International Hospital in Islamabad and included health centers affiliated with the hospital. The aim was to study if there is a link between breathing polluted air and the progression of COPD in people who had the disease.

Study Duration:

The study was carried out over a 12-month period, from May 2024 to April 2025.

Study Population:

All in all, the study included 90 patients who had been diagnosed with COPD. Patients were referred from the outpatient and inpatient respiratory departments at Shifa International Hospital and their collaborating centers. People aged 40 years and above were selected if they met the GOLD (Global Initiative for Chronic Obstructive Lung Disease) requirements for COPD diagnosis.

Inclusion Criteria:

Adults (≥40 years) with spirometry-confirmed COPD
Urban areas that are recording air quality levels
Only patients who had clinical follow-up for at least a year and wanted to take part

Exclusion Criteria:

People who also have conditions such as asthma or pulmonary fibrosis
People who moved away or were unable to be reached throughout the study period
Those whose medical information is not detailed enough

Data Collection:

Data about the patients were brought in both through recent medical reports and information collected by interviews and forms. The local environmental stations were used to obtain information on PM2.5, PM10, NO2, SO2, and ozone levels. Addresses of

participants were matched with contamination map data to find out their potential exposure.
The levels of spirometry parameters (FEV1, FVC), rates of exacerbations and hospitalizations, and quality of life were noted at the initial visit and every six months during the study.

Ethical Considerations:
Ethical approval was obtained from the Institutional Review Board (IRB) of Shifa International Hospital. Written informed consent was obtained from all participants prior to enrollment in the study.

Statistical Analysis:
SPSS verson 25 was used to analyze the data. We used descriptive statistics to describe the patients' common demographic and medical features at the beginning of the study. A type of analysis called multivariate regression was used to look at the link between air pollution and how fast COPD worsened after adjusting for age, whether the individual smoked, baseline COPD status, and other diseases. One of the criteria for a conclusion to be statistically significant was a p-value below 0.05.

RESULTS:
Ninety patients who had been diagnosed with COPD were enrolled and watched for a period of 12 months. The groups were made by measuring how much risky air they were exposed to due to their homes: According to local PM2.5 and PM10 figures and whether where you live is near high-traffic or industrial areas, it is determined as low, moderate, or high. The number of PFTs, additional symptoms, and numbers of hospital stays were carefully looked at and recorded.

Table 1: Baseline Characteristics of COPD Patients by Air Pollution Exposure Group:

Variable	Low Exposure (n=30)	Moderate Exposure (n=30)	High Exposure (n=30)	p-value
Age (years), Mean ± SD	62.1 ± 7.3	63.8 ± 6.9	64.2 ± 7.1	0.45
Gender (M/F)	21 / 9	20 / 10	19 / 11	0.89
Smoking History (%)	70.0%	73.3%	76.6%	0.81
Baseline FEV1 (% predicted)	62.4 ± 8.1	59.8 ± 9.2	57.1 ± 8.7	0.12
Baseline CAT Score (0–40)	15.2 ± 3.5	17.3 ± 3.8	18.9 ± 4.1	0.03*

This table provides the numbers on age, sex, and health issues for every pollution exposure group involved. There was no significant difference between the three groups in terms of age, gender, and smoking history ($p > 0.05$). On the other hand, people exposed to increased air pollution had higher CAT scores in the beginning of the study ($p = 0.03$), suggesting they had greater chronic symptoms early on.

Table 2: Changes in COPD Outcomes Over 12 Months by Exposure Group:

Outcome	Low Exposure (n=30)	Moderate Exposure (n=30)	High Exposure (n=30)	p-value
FEV1 Decline (% predicted/year)	-1.2 ± 0.6	-2.3 ± 0.8	-3.7 ± 1.0	<0.001**
Annual Exacerbations (Mean ± SD)	0.9 ± 0.5	1.6 ± 0.6	2.4 ± 0.7	<0.001**
Hospital Admissions (per year)	0.4 ± 0.3	0.9 ± 0.4	1.5 ± 0.5	<0.001**

This table shows the changes in COPD as the study went on for a year. Compared to the low group (FEV1 decline was -1.2%/year), those in the high group experienced a much faster decline (3.7% per year), showing a strong difference (p-value < 0.001). Also, patients living in a high-pollution area were more likely to experience frequent

emergency admissions and worsening of their diseases, underscoring the negative effects of air pollution. There was a clear connection found between greater pollution exposure and the negative outcomes seen in people with COPD.

DISCUSSION:

This multicenter cohort study helped understand how COPD can progress due to air pollution. These results backed the researchers' belief that prolonged air pollution exposure is extremely harmful to the lungs and worsens the symptoms of COPD [9]. The study discovered that inhaling increased PM2.5, PM10, NO_2, and O_3 may result in faster disease progression. As seen in earlier studies, living in areas with more pollutants increased the rate at which urban patients' FEV_1 decreased, which is related to the severity of COPD [10]. It was found that people in heavily polluted areas were admitted to hospitals more frequently for sudden worsening of their health. These results were similar to previous studies indicating that breathing in PM2.5 and NO_2 can spark airway irritation, cause oxidative damage, and weaken immunity, thus worsening any pulmonary diseases a patient may have.

This study was an improvement on previous ones because it used data from many centers in different parts of the world to make the findings more wide-reaching [11]. By surveying people from both rural and urban areas, the study managed to understand the difference in the impact of air pollution. In addition, by following up with participants for a long period, it was possible to confirm the strong connections between the variables.

Researchers observed during the study that some groups face a higher risk from air pollution's effects [12]. Those who are old or have smoked before, as well as others with heart problems, seemed to develop COVID-19 more easily. It revealed that both the surroundings and an individual's health play a role in developing COPD. It was determined from the data that even some levels of air pollution allowed by regulations can lead to bad health outcomes for people who are at high risk.

However, several limitations were acknowledged. Although attempts were taken to correct for socioeconomic status, smoking, jobs, and healthcare, some residual confounding factors could not be completely avoided [13]. Using residential distance from the stations and satellite data may not have accurately measured the exact amount of exposure for certain individuals. Seasonal changes and sources of air pollution found indoors could still cause errors in the measurements. Still, the investigation proved that environmental air quality greatly affected the development of COPD. Such results influenced practices and decisions made in both health care and public health. Clinicians should now stress to COPD patients the dangers of air pollution and encourage them to use air purifiers, keep away from outdoor activities when pollution levels are high, and use protective masks. The data confirmed the need for policymakers to put stronger air quality regulations into place and plan cities with less traffic and fewer emissions from industry.

This wide-ranging study strengthened the relationship seen between air pollution and the development of COPD, pointing out differences in risk between pollutants and groups of people. It made clear the importance of combining healthcare and environmental policies to lessen the effects of COPD on people and their general quality of life. In the future, it is important to look into strategies that lower an individual's exposure to air pollution and to understand the mechanisms causing lung harm [15].

CONCLUSION:

This multicenter study suggested that being exposed to air pollution for a long time plays a big role in the progression of COPD. The people living where there is a lot of particulate matter, nitrogen dioxide, and ozone have seen their lung functions worsen and suffer from more frequent exacerbations. The report additionally pointed out that there is a definite relationship between how polluted the air is and the worsening of COPD symptoms with time. Furthermore, respiratory illnesses increased a person's chances of suffering the harmful consequences of air pollution. They showed that laws that tackle air pollutants and protect vulnerable groups are very important. All in all, the work showed that air pollution has a major effect on COPD and highlighted the need for measures to stop its related issues.

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