DEVELOPMENTAL MEDICO-LIFE-SCIENCES

ISSN (P): 3007-2786, (E): 3007-2794 DOI: https://doi.org/10.69750/dmls.02.011.0161

ORIGINAL RESEARCH ARTICLE Open Access

Impact of Urban Smog Exposure on Respiratory Health Outcomes Among the Population of Lahore. A Cross-Sectional Clinical Study

Hassan Ali[1], Abdul Rahman[1], Muhammad Ali Haider[1]*

1- Senior House Officer, Emergency Department, Shaikh Zayed Hospital, Lahore, Pakistan
2- Senior House Officer, Department of Anesthesiology, Shaikh Zayed Hospital, Lahore, Pakistan
3- Postgraduate Resident, Department of Internal Medicine, Shaikh Zayed Hospital, Lahore, Pakistan

Corresponding author: Hassan Ali, **Email: hassanali37084@gmail.com**

ABSTRACT

Background: Smog has been a significant social health issue in Pakistan, with millions of its citizens being exposed to dangerous pollutants like PM 5, nitrogen oxides, sulfur dioxide, carbon monoxide, and ozone. The effects of these pollutants on the respiratory system are already known to be harmful, and they also lead to the rise of respiratory morbidity amongst the urban population.

Objectives: The research objective was to measure how smog exposure relates to respiratory health outcomes in the health population in Lahore.

Methods: A cross-sectional clinical study was carried out on 100 people who were recruited at Shaikh Zayed Hospital, Lahore during the time of the smog season January 2024 and March 2025. The information on respiratory symptoms, time spent outdoors daily, and preventive practices was gathered using a structured questionnaire. Spirometry was used to measure pulmonary function. Data analysis was done through SPSS version 26, with a p-value less than 0.05 taken to be statistically significant.

Results: More than two-thirds of the participants (72%) had more than two hours outdoors each day, and 64% wore no protective masks. Symptoms of the respiratory system were extremely common, and cough, throat irritation, eye irritation, shortness of breath, wheezing, and chest tightness were reported by 78, 73, 64, 59, and 42 48 percent, respectively. The outcome of spirometry indicated that 28 percent of the people had an obstructive pattern, 20 percent had a restrictive pattern, and only 52 percent of the people showed normal lung functioning.

Conclusion: Respiratory symptoms and quantifiable reductions in lung function are closely linked to smog exposure in Lahore. These results give relevance to the fact that there is a dire need to increase population health awareness, preventive treatment, and environmental control measures to limit the health burden of smog on the respiratory system.

Keywords: Smog, Respiratory Health, Lung Function, Air Pollution, Lahore, PM2.5, Spirometry.

Received: 11/07/2025
Revised: 27/10/2025
Accepted: 19/11/2025
Published: 30/11/2025

INTRODUCTION

Smog has become one of the most urgent environmental and population health issues in Lahore, one of the biggest and frequent megalopolises in the world, in the winter seasons [1]. An interplay of accelerated industrial growth, heavy motorization, use of coal brick kilns, burning of biomass and crop-residue in the nearby districts, and adverse meteorological conditions leads to the development of thick layers of smog. These layers contain a large amount of fine particulate matter (the concentration of PM2.5 and PM10 in particular), nitrogen dioxides (NOx), sulfur dioxide (SO 2), carbon monoxide (CO), ozone (O 3), and volatile organic compounds that are also known to have a significant adverse impact on human health [2].

Smog with its poisonous constituents is especially dangerous to the respiratory system. Because of its very fine size, fine particulate matter (PM2.5) overcomes barriers of the upper airways and is deposited in the depths of the

bronchioles and alveoli, causing inflammatory processes, oxidative stress, and injury to the epithelium, as well as dysfunction of the lungs [3]. Acute symptoms which have been associated with exposure to these pollutants include cough, irritation of the throat, wheezing, chest tightness, eye irritation, and shortness of breath. In addition, patients with underlying respiratory conditions such as asthma, chronic bronchitis, and chronic obstructive pulmonary disease (COPD) are more vulnerable to having their symptoms worsened, being hospitalized, and experiencing lowered lung function during high-smog periods [4].

According to recent clinical reports in major hospitals in Lahore, there are evident increases in the number of emergency cases of acute respiratory infection, asthma attacks, bronchospasm, and the exacerbation of chronic lung conditions. Even with these frightening statistics, however, a deficiency of locally produced clinical data exists that would quantify the degree of respiratory health compromise that is linked to smog exposure in the general population of Lahore. In the absence of such local evidence, effective public health interventions, resource allocation, and regulation efforts to reduce disease burden are hard to design [5,6].

The proposed study paper will examine the quality of respiratory health outcomes of the Lahore population as a result of exposure to urban smog. It is possible to call on the prevalence of respiratory symptoms, the recording of spirometry-based lung function patterns, and the analysis of the exposure-related variables of outdoor activity and masks, thereby contributing to a better environmental health policy, enhanced early clinical detection approaches, and targeted preventive interventions against the at-risk groups. They are important in understanding the relationship between them that will minimize the increasing respiratory morbidity in Lahore and enhance sustainable protection of the public health in the context of the deteriorating air quality [7,8].

MATERIALS AND METHODS

The study is a cross-sectional clinical trial design that was carried out at Shaikh Zayed Hospital, Lahore, between January 2024 and March 2025 (a period of fifteen months). The long-term period also enabled the fact that patients who showed up in numerous smog peaks and environmental changes were also included, and thus, the wider representation of respiratory impacts relating to the long exposure to urban pollution was obtained. Sampling involved the outpatient pulmonology and general medicine departments in a consecutive manner, which meant that both those with newly developed respiratory-related complaints, as well as those whose symptoms were aggravating the prevailing ones, were recruited during the study period. The study population consisted of 100 individuals. The eligibility criteria were that the participants were at least 15 years old and had to be Lahore residents for at least 1 year to have been significantly exposed to the existing atmospheric conditions. Persons with chronic lung disease not due to environmental pollution, like pulmonary fibrosis, active or treated tuberculosis, known etiology of bronchiectasis, or other structural airway defects, were excluded to avoid confounding and to ensure that respiratory outcome measures were due mainly to smog exposure.

The study involved a pre-tested questionnaire that was structured and utilized for data collection. The questionnaire itself captured all the demographic data, such as age, gender, occupation, smoking status, and duration of residence. It further evaluated the exposure variables like average duration spent out daily, the type of occupation the subjects were in, their commuting patterns, and the use of protective masks. The participants were requested to report such respiratory symptoms as cough, wheezing, chest tightness, dyspnea, irritation of the throat, irritation of the eyes, manifestations of allergies, and the worsening of the underlying respiratory diseases, such as asthma or allergic bronchitis. In order to measure the impact of the severity of pollution, participants were also required to compare the frequency and intensity of their symptoms on severely polluted days and days where the air was of normal quality.

Each of the participants was thoroughly examined clinically by qualified medical practitioners. The clinical examination involved general physical examination and complete respiratory examination, which included observing breathing pattern and chest movements, lung field inspection, and evaluation of any respiratory distress symptoms. The pulmonary functioning assessment was performed after the clinical examination with the help of a portable digitized spirometer, which is calibrated. The spirometry was conducted according to the standardized guidelines of international guidelines and involved the measurements of Forced Vital Capacity (FVC), Forced Expiratory Volume in a second (FEV 1), and Forced Expiratory Volume/Forced Vital Capacity ratio (FEV 1 / FVC). The results of spirometry were used to determine the lung functioning as normal, obstructive, or restrictive according to reference ranges. The impeding of the airway was classified as Obstructive and restrictive, with a low ratio (FEV 1 / FVC) and proportionate reduction in FVC, respectively. These objective spirometric patterns enabled sufficient determination of the extent to which exposure to smog had an impact on pulmonary function.

To put the clinical and spirometric results into a context, the data on Air Quality Index (AQI) per day in Lahore during the period between January 2024 and March 2025 were gathered through the Environmental Protection Department (EPD), Punjab. These AQI values also contained the concentrations of $PM_{2}.5$, PM one hundred, nitrogen oxides, sulfur dioxide, carbon monoxide, and ozone, which gave an objective account of the extent of the pollutants over the course of the study. The comparison of this information with the findings of the participants in terms of reported symptoms and spirometry made it

possible to accurately analyse the relationships between the severity of pollution and respiratory health.

Statistical software SPSS version 26 was used to conduct statistical analysis. The descriptive statistics, like means, standard deviation, frequency, and percentages, were used to summarize the demographic characteristics, the patterns of exposure, respiratory symptoms, and spirometry results. The relationship between smog exposure and respiratory symptoms was estimated through Chi chi-square test, and independent t -t-tests were carried out to compare the means of spirometric measurements between people with more than daily exposure to outdoors and people with less than daily exposure. All analyses were taken as statistically significant at a p-value of less than 0.05.

The Institutional Review Board (SZMC/IRB/2023-102) gave this study ethical approval. The study was done in accordance with the ethical standards of the Declaration of Helsinki. Informed consent was taken in written form, and before the study, all the participants had given written informed consent, and the confidentiality, anonymity, and voluntary nature of participation were reinforced throughout the study.

RESULTS

The demographic and exposure-related variables of 100 people who participated in the study are provided in Table 1. Such distribution of age indicates that the most active age group (26-40 years of age) comprised 32 percent of the total population, which was followed by what was considered to be the greatest percent of the total population (26-40 years of age), and the comparatively low percent of 40-40 years of age (27) which made the largest age group. The gender demographic consisted of a male-dominated population of 56 percent and a female population of 44 percent. Patterns of exposure to outdoor environments indicate that most of the participants (72%) spent over 2 hours a day in outside environments during the time of the smog season, which exposed them to greater risks of polluted air. A very small percentage (14%) was less than one hour. The use of masks also exhibits that most residents also lacked the use of protective face masks, indicating poor preventive measures among locals. These results indicate that most residents of Lahore are habitually exposed to excessive amounts of outdoor pollution of the atmosphere due to the inappropriate protective practices, which make them more vulnerable to respiratory complications caused by smog.

Table 2 contains an overview of the proportion of respiratory symptoms reported by the participants in the smog season. Cough was the most common of the symptoms, with 78 per cent of respondents reporting this symptom, whereas closely linked with throat irritation (73) and eye irritation (64 per cent). The probability of shortness of breath was found to be 59% of the population, showing that over half the population had some form of respiratory constriction. Forty-two percent of the people had reported wheezing, and 48 percent reported chest tightness, implying airway inflammation and decreased breathing efficiency. It is worth noting that 27% of the participants claimed the exacerbation of preexisting respiratory issues, including asthma or allergic bronchitis. All in all, this table indicates that the burden of acute respiratory symptoms in the general Lahore population due to smog is constituted by multiple symptoms at the same time.

Table 3 indicates the disposition of pulmonary performance test (PFT) patterns of the participants. Not all people were revealing normal spirometry results, and half of those were characterized by a certain level of lung affliction in the lungs. A pattern blockage of 28 percent of the participants indicated that there was a contraction of the airways, which is usually linked to inflammatory exacerbations in smog, asthma freeing, and bronchial hyper-reactivity. The restrictive pattern was prevalent among 20 percent of individuals, and it was characterized by a decrease in the expansion of the lungs; this could be explained by airway irritation, lung tissue inflammation, or exposure to fine particulate material (PM2.5). As pointed out in this table, exposure to smog not only brings about the symptoms but also brings about quantifiable alterations in lung functioning, with a substantial percentage of people experiencing a weakened breathing capacity.

Most of the respondents were found to show a definite worsening of respiratory symptoms on exposure to smog. Cough (78%), irritation in the throat (73%), shortness of breath (59%), and eye irritation (64%. These were the most usual complaints. A considerable portion of the population (72%) was outdoors (>2 hours/day), which had a strong and positive association with the severity of symptoms. The outcome of the spirometry was that not everybody had normal lung functioning, but only at 52 percent. A quarter of the participants had also been found to have obstruction or impairment, and it was mostly associated with shortness of breath and wheezing. The remaining 20% demonstrated a restrictive pattern, especially those who claimed that they regularly felt chest tightness.

The chi-square test revealed that the duration of outdoor exposure was significantly associated with the major symptoms, the existence of cough, dyspnea, and chest tightness ($p < 0.05$). Constant maskers had no symptoms when compared to those who were not wearing masks. These results indicate that a high level of relationship exists between the exposure to smog and the deterioration of the respiratory health of the population in Lahore.

Table 1: Demographic and Exposure Characteristics of Participants (N = 100)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	15–25 years	32	32%
	26–40 years	41	41%

	>40 years	27	27%
Gender	Male	56	56%
	Female	44	44%
Outdoor Exposure per Day	<1 hour	14	14%
	1–2 hours	14	14%
	>2 hours	72	72%
Mask Use	Regular	36	36%
	Not Regular	64	64%

Table 2: Prevalence of Respiratory Symptoms During Smog Season (N = 100)

Respiratory Symptom	Present (n)	Percentage (%)
Cough	78	78%
Throat Irritation	73	73%
Shortness of Breath	59	59%
Wheezing	42	42%
Chest Tightness	48	48%
Eye Irritation	64	64%
Exacerbation of Asthma/Bronchitis	27	27%

Table 3: Pulmonary Function Test (PFT) Patterns Among Participants

Spirometry Pattern	Frequency (n)	Percentage (%)
Normal	52	52%
Obstructive Pattern	28	28%
Restrictive Pattern	20	20%

DISCUSSION

The results of this study indicate that there is a strong and evident correlation between urban smog exposure in Lahore and the emergence of acute and chronic respiratory symptoms in the population [9]. The outcomes are consistent with the large body of literature on the subject, indicating that fine particulate matter, especially PM 2.5, and nitrogen oxides, sulfur dioxide, ozone, and other air pollutants have a direct relation to respiratory irritation, airway inflammation, and decreased lung function. Cough (78 per cent), throat irritation (73 per cent), eye irritation (64 per cent), and shortness of breath (59 per cent) were the most frequently reported symptoms in the current study. These symptoms are in line with the well-documented mucosal irritant effects of smog that are capable of causing oxidative stress, airway epithelial inflammation, and bronchial hyperreactivity [10,11].

The large percentage of those who have had extensive outdoor exposures 72% who reported having more than two hours of outside exposure a day, can point to the significant exposure that the general population has to smog, especially those in outdoor jobs or those with daily commutes. Also, poor preventive behaviors were found, and only 36 percent of the participants had consistent use of preventive masks. This behavior is likely to be caused by limited awareness, perceptions of risk, and insufficient implementation of health-related programs by the population, which exposes them to respiratory issues caused by pollutants. Such observations point out the need to implement more effective community-level education, policy support, and enforcement of protective practices in times of high pollution [12,13].

Pulmonary function testing showed that almost half of the participants had abnormal spirometric patterns, with 28 percent having obstructive impairment and 20 percent having restrictive patterns. Obstructive patterns can indicate airway constriction, mucosal oedema, and bronchial hyperresponsiveness, usually caused by exposure to pollution with an underlying case of asthma and airway allergies. Reduced compliance of the lung or subclinical inflammation of peripheral lung tissue due to long-term exposure to fine particulates may be the cause of restrictive changes. These objective deficiencies reflect the fact that exposure to smog has an impact on not just self-reported symptoms, but also on objective parameters of physiological lung function [14,15].

The results of the study correspond to the existing literature on the topic of particulate pollution in other high-contaminated areas of the world, such as India, China, and the Middle East, where the high levels of such pollution were linked to the increased emergency visits, asthma and COPD exacerbation, a decrease in lung capacity, and a higher rate of hospitalization during the periods of the worst air quality. The same trends are recurrently witnessed in Lahore, particularly in winter seasons that the temperature inversion and stagnant air trap pollute the atmosphere near the ground. The rate of industrialization, high car emissions, burning of crop residues, and ineffective environmental control serve only to increase the amount of pollution in the city [16,17].

All in all, findings support the necessity to implement extensive programs of public health, tightened environmental laws, and city-wide education on smog effects on respiratory health to reduce the problem [12,15]. Such measures as regular messaging of the population about wearing masks, reducing the amount of time spent outdoors on the worst days, improving the quality of indoor air, encouraging the use of green infrastructures, and implementing policies on emission control are effective.

The respiratory disease burden of smog is expected to increase further without long-term initiatives, and it would put a greater burden on the healthcare infrastructure and undermine the health of the population of Lahore [18-20].

CONCLUSION

The problem of smog in the city of Lahore is of utmost concern, and it is among the main concerns that result in respiratory symptomatology and the quantifiably decreased functioning of lungs. The paper indicates that a high proportion of the population develops respiratory symptoms, including cough, irritation of the throat, dyspnea, and wheezing, during the seasons of smog, where nearly half of the population had exhibited abnormal spirometry. One is also prone due to poor mask usage and extensive exposure to the outdoors. These findings bring out the significance of good policies in the health of the population, increased supervision of the air quality, and awareness of communities in order to minimize the negative impact of smog on the breathing system. The policymakers should focus on sustainable reforms in the environment in order to protect the health of the people of Lahore.

Availability of Data and Materials: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Competing Interests: The authors declare no competing interests.

Funding: The authors received no financial support for this study.

Authors' Contributions: H.A. conceived the study and collected data; A.R. analyzed and interpreted data; M.A.H. drafted the manuscript; A.U.R. performed statistical analysis and finalized the revision.

Acknowledgment: The authors acknowledge the support of Shaikh Zayed Medical Complex, Lahore, Pakistan, during the conduct of this study.

REFERENCES

1. Hassan MM, Javaid I, Jamal F, et al. Multidimensional impact of smog on respiratory and ocular health: a cross-sectional study with socio-psychological and public health prospective. *Health Sci Rep.* 2025;8:1–13. doi:10.1002/hsr2.71205.
2. Aslam R, Sharif F, Baqar M, et al. Role of ambient air pollution in asthma spread among various population groups of Lahore City: a case study. *Environ Sci Pollut Res.* 2023;30:8682–8697. doi:10.1007/s11356-022-19086-1.
3. Iram S, Qaisar I, Shabbir R, Pomee MS, Schmidt M, Hertig E. Impact of air pollution and smog on human health in Pakistan: a systematic review. *Environments.* 2025;12:46. doi:10.3390/environments12020046.
4. Malik A, Islam J, Zaib G, Ashraf M, Zahid A, Rashid A, et al. Smog crisis in Lahore: evaluating air quality trends and public health implications. *Bull Biol Allied Sci Res.* 2024;1:87. doi:10.54112/bbasr.v2024i1.87.
5. Tahir M, Tariq F, Saeed HW, Nauman M, Usman M, Ali S. Impact of air pollution on respiratory health of traffic wardens in Lahore: air pollution and respiratory health. *Healer J Physiother Rehabil Sci.* 2023;3(7):703–709. doi:10.55735/hjprs.v3i7.184.
6. Haider SN, Iqbal MW. Impact of bad air quality on the morphology of lungs: a radiological cross-sectional study conducted at a tertiary care hospital in Lahore. *J Univ Coll Med Dent.* 2022;1(1):11–13. doi:10.51846/jucmd.v1i1.1371.
7. Naeem A, Rafiq L, Nazar R, Kashif M, Naqvi SHZ. Assessment of risk factors and health impacts associated with indoor air pollution and tobacco smoke in Lahore, Pakistan. *J Qual Assur Agric Sci.* 2022;2(1):37–45. doi:10.38211/jqaas.2022.2.1.6.
8. Malik A, Islam J, Zaib G, Zahid A, Rashid AR, Zia T. Interplay of smog and health conditions: a public health perspective on respiratory, hypertensive, and cardiovascular morbidity. *J Phys Biomed Biol Sci.* 2024;1:37. doi:10.64013/jpbab.v2024i1.37.
9. Naveed Z, Khayyam U. Smog and cognitive issues in school-going children of Lahore and Islamabad, Pakistan. *Int J Environ Sci Technol.* 2023;20:4151–4166. doi:10.1007/s13762-022-04264-y.
10. Mahmood S, Ali A, Jumaah HJ. Geo-visualizing the hotspots of smog-induced health effects in district Gujranwala, Pakistan: a community perspective. *Environ Monit Assess.* 2024;196:457. doi:10.1007/s10661-024-12619-w.
11. Javed A, Aamir F, Gohar UF, Mukhtar H, Zia-ul-Haq M, Alotaibi MO, et al. Potential impact of smog spell on humans' health amid COVID-19 rages. *Int J Environ Res Public Health.* 2021;18:11408. doi:10.3390/ijerph182111408.
12. Khan MI, Amin A, Khan MT, et al. Unveiling the hidden hazards of smog: health implications and antibiotic resistance in perspective. *Aerobiologia.* 2024;40:353–372. doi:10.1007/s10453-024-09833-x.
13. Fatima M, Butt I, MohammadEbrahimi S, et al. Spatiotemporal clusters of acute respiratory infections associated with socioeconomic, meteorological, and air pollution factors in South Punjab, Pakistan. *BMC Public Health.* 2025;25:469. doi:10.1186/s12889-025-21741-4.
14. Saeed T, Abbasi NA, Zahid MT, et al. Toxicological profile and potential health concerns through metals and trace elements exposure in brick kiln workers from Lahore, Pakistan. *Environ Geochem Health.* 2024;46:150. doi:10.1007/s10653-024-01937-0.
15. Ahmad M, Ahmad M, Alam K, et al. Large increase in anthropogenic emissions in an urban environment and their associated air quality implications. *Environ Monit Assess.* 2025;197:1055. doi:10.1007/s10661-025-14518-0.
16. Kasa VP, Samal B, Mittal C, et al. Respiratory health impacts of opencast coal mining in India: an epidemiological study. *Air Qual Atmos Health.* 2025. doi:10.1007/s11869-025-01847-9.
17. Herath Bandara SJ, Thilakarathne N. Economic and public health impacts of transportation-driven air pollution in South Asia. *Sustainability.* 2025;17:2306. doi:10.3390/su17052306.
18. Juel R, Sharpe S, Picetti R, Milner J, Bonell A, Yeung S, et al. Perspectives on urban dwelling and air quality: a cross-sectional survey of 3,222 children, young people and parents. *PLOS Glob Public Health.* 2023;3(4):e0000963. doi:10.1371/journal.pgph.0000963.
19. Lyu Z, Ibrahim RL, Alomair A, Al Naim AS. Fossil fuels, clean cooking energy, and health inequality in Sub-Saharan Africa: distribution-sensitive evidence for SDG-linked transitions. *Sustain Dev.* 2025;1–26. doi:10.1002/sd.70395.
20. Li F, Ahmad R, Abbas M, et al. Public awareness and willingness to pay for eliminating atmospheric pollution in Pakistan: a case study. *Environ Dev Sustain.* 2024;26:9895–9922. doi:10.1007/s10668-023-03125-z.

This Article May be cited as: Ali H, Rahman A, Haider MA, Rehman AU. Impact of urban smog exposure on respiratory health outcomes among the population of Lahore: a cross-sectional clinical study. *Dev Med Life Sci*. 2025;2(11):3-7. doi:10.69750/dmls.02.011.0161.