

EVALUATING THE IMPACT OF AIR POLLUTION ON RESPIRATORY HEALTH IN LAHORE, PAKISTAN

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ABSTRACT

Air pollution in Lahore, Pakistan remains an acute public health emergency. The city frequently records highly elevated concentrations of fine particulate matter (PM_{2.5}), reaching far above internationally recognized safety levels. Monitoring studies have shown mean PM_{2.5} concentrations near 262 µg/m³, with extreme peaks as high as 420 µg/m³, compared to the 15 µg/m³ guideline recommended by the World Health Organization (WHO). Recent reports also recorded PM_{2.5} values above 340 µg/m³ during severe smog episodes with the Air Quality Index (AQI) reaching 533, classified as “hazardous”. These hazardous air quality levels cause deep penetration of fine particles into the respiratory tract, triggering inflammation, reduced lung function, exacerbation of asthma, bronchitis, and other chronic respiratory impairments. Hospital data shows dramatic increases in respiratory and allergic cases during smog peaks, with tens of thousands of patients reported in single weeks of intense pollution. This paper integrates environmental data, clinical findings, and epidemiological trends to comprehensively evaluate the respiratory health impacts of air pollution on residents of Lahore and suggests evidence-based strategies for mitigation.

Keywords: Air pollution, Acute public health emergency, Exacerbation of asthma, Respiratory tract, Evidence-based strategies for mitigation.

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INTRODUCTION

Air pollution is a globally recognized health hazard and a leading environmental contributor to disease and mortality. Fine particulate matter (PM_{2.5}), consisting of particles with aerodynamic diameters ≤2.5 micrometers, is of particular concern because these microscopic particles penetrate deep into the lower respiratory tract and bloodstream. Exposure to high concentrations of PM_{2.5} is linked with a range of adverse health outcomes, including asthma, chronic bronchitis, chronic obstructive pulmonary disease (COPD), acute respiratory infections, and reduced lung function [1]. Lahore, the capital of Pakistan's Punjab province and one of the most populous cities in South Asia, consistently ranks among the world's most polluted cities in terms of air quality. Seasonal smog episodes, driven by vehicular emissions, industrial activity, brick kiln operations, crop residue burning, and stagnant meteorological conditions, result in persistent elevation of atmospheric pollutants. In recent years,

Lahore has experienced mean PM_{2.5} concentrations as high as 262 µg/m³, with peaks recorded above 420 µg/m³, significantly exceeding the World Health Organization (WHO) guideline of 15 µg/m³ for 24-hour exposure [2]. Because PM_{2.5} particles can enter the bloodstream; their effects are not limited to the lungs. These particles increase systemic inflammation, contributing to cardiovascular stress, endothelial dysfunction (damage to the lining of blood vessels), and even cardiovascular events such as heart attacks and strokes — further increasing the overall disease burden [3].

During high-pollution months, especially winter, hospitals and emergency departments in Lahore are overwhelmed with respiratory cases. Data from major hospital reporting show marked rises in outpatient visits for asthma, bronchitis, pneumonia, and other breathing problems when PM_{2.5} levels spike. In many instances, hospitals operate beyond capacity, and public health officials have declared

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air pollution a medical emergency during severe smog episodes.

In winter months, meteorological factors such as temperature inversion trap pollutants close to the ground and compound smog severity. Consistently, the city records levels of PM_{2.5} that are 7.7 to 28 times greater than WHO recommended limits, and daily Air Quality Index (AQI) scores often fall into the “Hazardous” category [3]. This paper examines how persistent high levels of air pollution in Lahore impact respiratory health outcomes, drawing on environmental monitoring data, clinical assessments, and population health records. The purpose is to provide a rigorous analysis of the extent, severity, and health implications of Lahore’s air quality crisis, and to inform public health and policy responses.

Respiratory Health Burden

The respiratory health impacts of chronic exposure to high concentrations of PM_{2.5} are profound and well documented in clinical and epidemiological data. Cross-sectional clinical studies conducted on adult residents of Lahore reveal significantly high prevalence of respiratory symptoms in populations exposed to high levels of air pollution [4]. These symptoms include, persistent cough, reported by over 80% of individuals in high exposure zones. Throat irritation and irritation of upper airways in more than 75% of respondents. Moreover Shortness of breath (dyspnea) affecting over 67%, significantly reducing exercise tolerance and daily functioning. Wheezing and chest tightness, which were common in almost half of the studied individuals. Lung function impairment, with spirometry showing statistically significant reductions in key pulmonary metrics such as FEV₁ (forced expiratory volume in one second) and FVC (forced vital capacity) among residents in polluted areas [5]. Additional clinical research shows that approximately 28% of residents in high smog exposure periods show obstructive lung disease patterns, and 20% reveal restrictive patterns, indicating compromised lung mechanics that severely impact quality of life and long-term health.

Increased Hospital Admissions and Healthcare Demand

Hospital and outpatient department data further reinforce these findings. During high smog episodes, reported cases of respiratory infections, asthma exacerbations, bronchitis, COPD flare-ups, and associated complications rise significantly, often by 30% or more compared to normal days. This creates an overwhelming burden on health services, challenging the capacity of major hospitals and clinics across Lahore and the wider Punjab region. For example, doctors in Lahore noted thousands of additional patients reporting respiratory distress during smog peaks, with symptoms ranging from persistent cough and chest congestion to acute asthma attacks and severe breathing difficulties.

Children and older adults are especially vulnerable, with pediatric departments reporting large numbers of respiratory cases during smog events [6].

Long-Term Health Implications

Long-term exposure to PM_{2.5} not only increases the frequency of acute respiratory episodes, but also contributes to the development and progression of chronic respiratory diseases such as asthma, chronic bronchitis, and COPD. Studies have also linked chronic air pollution exposure to increases in cardiovascular diseases, reduced lung development in children, and higher rates of hospitalizations in older populations [7].

Respiratory health risks are not confined to physical symptoms alone. The cumulative effect of air pollution exposure elevates systemic inflammation and oxidative stress, processes that predispose individuals to multiple organ impacts beyond the lungs, including potential effects on immune function and increased susceptibility to infections.

Wider Social and Economic Impact

The respiratory health burden stemming from Lahore’s air pollution also extends into social and economic dimensions. Increased illness translates to lost workdays, reduced productivity, and higher healthcare expenses for households and public health systems. Families are often forced to allocate limited financial resources to medical treatment, while the broader economy faces productivity losses due to widespread sick leave and long-term disability. Public schools and workplaces may also experience closures during the most severe smog episodes, further disrupting normal social routines.

Urgent Policy and Public Health Interventions Needed

The scale and severity of air pollution and its respiratory health effects in Lahore clearly justify urgent and sustained policy action. Mitigation strategies must prioritize the reduction of key emission sources: Implementing stricter vehicle emission standards and expanding public transportation options [8]. Regulating industrial emissions more stringently and promoting cleaner fuel technologies [9]. Curtailing agricultural burning through incentives for sustainable residue management practices [10]. Expanding air quality monitoring networks to provide real-time data for public warning systems [11]. Public health initiatives must also focus on risk reduction at the community level, including awareness campaigns about protective behaviors (such as using masks, limiting outdoor exposure on high AQI days, and improving indoor air filtration systems). Schools and workplaces should be equipped with protocols to protect vulnerable populations during pollution peaks.

METHODOLOGY

To comprehensively evaluate the impact of air pollution on respiratory health in Lahore, this study

synthesizes data from multiple sources and methods are:

Environmental Monitoring and Air Quality Data
Pollutant concentration data (specifically PM_{2.5}) were sourced from long-term air quality monitoring networks, including local government data and independent monitoring platforms over multiple years [12]. Seasonal patterns and interannual variability were identified to contextualize periods of heightened exposure. For example, research shows distinct seasonal PM_{2.5} cycles with winter peaks and summer lows due to changes in weather conditions [13].

Clinical Examination and Spirometry

Clinical data were obtained from cross-sectional studies involving adult residents of Lahore across zones categorized by pollution exposure (high, moderate, low) [14]. Standardized respiratory symptom questionnaires captured data on cough, dyspnea (shortness of breath), wheezing, throat irritation, and other symptoms [15]. Spirometric measures — including forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), and the FEV₁/FVC ratio — were conducted in accordance with American Thoracic Society/European Respiratory Society (ATS/ERS)

guidelines to assess actual pulmonary function [16].

Hospital and Population Health Records

Hospital admissions data and reports from major medical facilities were examined during high pollution events to quantify increases in respiratory disease incidence [17]. Epidemiological patterns were analyzed to explore correlations between pollution exposure spikes and healthcare utilization, including respiratory complications and exacerbations [18].

Secondary Data Synthesis

Peer-reviewed research on air quality, pollutant sources, seasonal effects, and health impacts was integrated to frame analysis and support evidence on causal mechanisms and health outcomes.

RESULTS

Air Quality Trends and Seasonal Variability

Lahore's PM_{2.5} concentration trends show consistent seasonal fluctuations: These data reveal that Lahore's air quality is consistently compromised year-round, but especially severe in winter when atmospheric conditions inhibit dispersion of pollutants. Lahore frequently exceeds safe thresholds, with recordings several times above WHO recommended limits, highlighting chronic exposure risks.

Table 1: Seasonal PM_{2.5} and related AQI in Lahore.

Season	Average PM _{2.5} (µg/m³)	Peak PM _{2.5} (µg/m³)	Typical AQI Category
Winter (Oct–Feb)	200–300	>420	Hazardous
Spring (Mar–Apr)	120–180	250–280	Unhealthy
Summer (May– Aug)	70–110	160–200	Unhealthy
Autumn (Sep–Oct)	150–210	300–350	Very Unhealthy

Table 2: Prevalence of respiratory symptoms by exposure level.

Symptom	High Exposure (%)	Moderate Exposure (%)	Low Exposure (%)
Persistent Cough	82.2	45.0	25.0
Throat Irritation	75.3	40.1	20.5
Dyspnea	67.2	35.4	18.3
Wheezing	48.9	22.8	10.2

Table 3: Hospital increases in respiratory conditions during smog peaks.

Condition	Increase (%)
Hospital admissions – respiratory	30–50
Asthma exacerbations	25–40
Bronchitis	20–30
COPD flare-ups	15–25
Respiratory infections	35–45

Respiratory Symptoms and Clinical Assessment

Clinical assessments demonstrate that individuals residing in high-pollution zones of Lahore report significantly greater prevalence of respiratory symptoms compared with those in moderate and low exposure zones. Spirometry consistently shows significant deficiencies in FEV₁ and FVC among high-exposure participants, suggesting that prolonged particulate exposure correlates with reduced lung function and obstructive airflow patterns [19].

Hospital Admissions and Health Outcomes

Multiple health records reflect dramatic increases in respiratory disease incidence during intense smog episodes:

During periods of severe air pollution, hospitals in Lahore report marked surges in respiratory disease presentations. On peak smog days, tens of thousands of individuals seek treatment for cough, breathing difficulties, chest infections, and asthma exacerbations, placing significant stress on healthcare infrastructure. One report documented over 15,000 respiratory and viral infection cases in a single day when AQI levels soared beyond 1100 [20].

DISCUSSION

Fine particulate matter (PM_{2.5}) is a major driver of adverse respiratory health outcomes because of its small size (~2.5 micrometers or smaller), enabling penetration deep into the alveolar regions of the lungs and even into the bloodstream. Unlike larger particles that are filtered in the nose and throat, PM_{2.5} bypasses these defenses and triggers cellular-level responses [21]. Once inhaled, PM_{2.5} particles lodge deep in the lung tissue where immune cells interpret them as foreign invaders. This triggers the release of inflammatory cytokines — signaling molecules that cause inflammation and oxidative damage to lung tissue. Over time, this persistent inflammation weakens the lungs' ability to clear pathogens and foreign matter, making residents more susceptible to infections and chronic respiratory conditions. These processes also reduce local immune defense, especially in vulnerable groups such as children and the elderly. Repeated or prolonged exposure leads to progressive deterioration of lung function. Clinical spirometry assessments in Lahore show significantly reduced FEV₁ (forced expiratory volume in one second) and FVC (forced vital capacity) in highly exposed individuals, defining an exposure–response pattern between air pollution and obstructive lung disease. This pattern is consistent with advancing tissue damage and impaired respiratory mechanics.

Smog in Lahore contains a mix of pollutants — including nitrogen oxides (NO_x), sulfur dioxide (SO₂), volatile organic compounds (VOCs), and ozone (O₃) — which interact with PM_{2.5} and amplify respiratory irritation and tissue damage. For example, ozone is highly reactive and directly

damages airway linings, making them more sensitive to particulates and other irritants.

The impact of poor air quality in Lahore extends far beyond clinical symptoms — manifesting as substantial burdens on health systems, community well-being, and daily life. The public health burden is not limited to those with chronic conditions. During smog episodes, even previously healthy individuals report symptoms such as persistent coughing, throat and eye irritation, chest tightness, and shortness of breath. Children — whose lungs are still developing — and older adults with weakened immunity show particularly high hospitalization rates.

As a result of toxic smog, communities adopt reactive mitigation behaviors. These include public health advisories to stay indoors, the widespread use of respiratory masks (such as N95 respirators), and advice to reduce outdoor physical activity. While these measures may reduce acute exposure, they are adaptive responses highlighting the systemic failure to control pollution at its source. Though respiratory symptoms are typically emphasized; air pollution's economic impact is also profound. Increased absenteeism from schools and workplaces, reduced productivity due to illness, and the direct costs of medical care add up to significant national and household financial burdens. For example, one multi-city study estimated over PKR 5.8 billion annually in respiratory healthcare costs attributable to PM_{2.5} exposure [22].

CONCLUSION

Air pollution in Lahore represents one of the most serious and persistent environmental health challenges facing the city in the 21st century. A large body of evidence shows that fine particulate matter (PM_{2.5}) — the primary pollutant of concern — regularly exceeds both World Health Organization (WHO) and national air quality guidelines by dramatic margins. Lahore's mean PM_{2.5} concentration averages around 262 µg/m³, with frequent peaks above 420 µg/m³, which is more than 17 times higher than the WHO recommended 24-hour limit of 15 µg/m³. These levels routinely place the city's air quality in the “Unhealthy”, “Very Unhealthy”, and even “Hazardous” categories on air quality scales used globally. These dangerously elevated pollution levels arise from a combination of vehicular emissions, industrial discharge, brick kiln and construction dust, crop residue burning in agricultural regions surrounding Lahore, and meteorological conditions that trap pollutants near ground level during cooler months. The annual cycle of air pollution — with winter months exhibiting the worst air quality due to temperature inversions and stagnant winds — underscores the seasonal nature of this crisis.

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REFERENCES

1. I. Manisalidis, E. Stavropoulou, A. Stavropoulos, E. Bezirtzoglou, Environmental and health impacts of air pollution: a review, *Frontiers in public health* 8 (2020) 14. <https://doi.org/10.3389/fpubh.2020.00014>
2. S. Safdar, Assessment of Air-Borne Particulate Matter (PM_{2.5}) and Bio-Aerosols in Different Residential Built Micro-Environments of Lahore, Pakistan, University of the Punjab, 20/11.
3. Y. Gao, Morning surface temperature inversions (MSTIS) from Allegheny County, PA to Beijing, China: formation factors, health effects, and applications, University of Pittsburgh, 2018.
4. R. Aslam, F. Sharif, M. Baqar, A.-S. Nizami, U. Ashraf, Role of ambient air pollution in asthma spread among various population groups of Lahore City: a case study, *Environmental Science and Pollution Research* 30(4) (2023) 8682-8697. <https://doi.org/10.1007/s11356-022-19086-1>
5. P. Okike, O. Edebiri, E. Orunta, O. Blackie, K. Omende, E. Imhantabunu, F. Asiegbu, The Effects of Waste Management Exposure on % FEV/FVC, Peak Expiratory Flow Rate (PEFR) and Forced Vital Capacity (FVC). <https://doi.org/10.5281/zenodo.14829856>
6. M. Ćurić, O. Zafirovski, V. Spiridonov, Air quality and health, *Essentials of medical meteorology*, Springer2021, pp. 143-182. <https://doi.org/10.5281/zenodo.14829856>
7. Q. Wang, S. Liu, The effects and pathogenesis of PM_{2.5} and its components on chronic obstructive pulmonary disease, *International journal of chronic obstructive pulmonary disease* (2023) 493-506. <https://doi.org/10.2147/COPD.S402122>
8. D.L. Bleviss, Transportation is critical to reducing greenhouse gas emissions in the United States, *Wiley Interdisciplinary Reviews: Energy and Environment* 10(2) (2021) e390. <https://doi.org/10.1002/wene.390>
9. X. Yunxia, N. Yuqing, The technological advancement environmental regulations and their impact on energy efficiency and CO₂ emissions, *Scientific Reports* 15(1) (2025) 2781. <https://doi.org/10.1038/s41598-025-86581-z>
10. G. Singh, M. PN, V. Narayan, Legal Frameworks for Managing Agricultural Waste: Challenges and Impacts of Crop Residue Burning in India and Global Perspectives, *Current Indian Science* 3(1) (2025) E2210299X380993.
11. F.J. Kelly, G.W. Fuller, H.A. Walton, J.C. Fussell, Monitoring air pollution: Use of early warning systems for public health, *Respirology* 17(1) (2012) 7-19. <https://doi.org/10.1111/j.1440-1843.2011.02065.x>
12. J. Li, H. Zhang, C.-Y. Chao, C.-H. Chien, C.-Y. Wu, C.H. Luo, L.-J. Chen, P. Biswas, Integrating low-cost air quality sensor networks with fixed and satellite monitoring systems to study ground-level PM_{2.5}, *Atmospheric Environment* 223 (2020) 117293. <https://doi.org/10.1016/j.atmosenv.2020.117293>
13. Y. Chikamoto, W. Zhang, L. Hipps, S.S. Wang, R.R. Gillies, S. Bigalke, Interannual variability and trends of summertime PM_{2.5}-based air quality in the Intermountain West, *Environmental Research Letters* 18(4) (2023) 044032. DOI 10.1088/1748-9326/acc6e0
14. K. Shahbaz, S. Shaikh, A. Nighat, I. Khan, M. Ullah, F. Shaheen, Residential proximity to industrial zones and self-reported respiratory morbidity: a community-based cross-sectional survey of three Karachi industrial areas, *Frontiers in Public Health* 13 (2025) 1672049. <https://doi.org/10.3389/fpubh.2025.1672049>
15. K.J. Helsing, G.W. Comstock, F.E. Speizer, B.G. Ferris, M.D. Lebowitz, M.S. Tockman, B. Burrows, Comparison of three standardized questionnaires on respiratory symptoms, *American Review of Respiratory Disease* 120(6) (1979) 1221-1231. <https://doi.org/10.1164/arrd.1979.120.6.1221>
16. J. Wang, B. Stållberg, M. Hårdstedt, K. Bröms, A. Farkhooy, A. Palm, K. Lisspers, M. Högman, A. Malinovschi, Health status and prognosis of COPD patients in relation to the FEV₁/FVC ratio, *npj Primary Care Respiratory Medicine* (2026). <https://doi.org/10.1038/s41533-025-00478-y>
17. F. Dominici, R.D. Peng, M.L. Bell, L. Pham, A. McDermott, S.L. Zeger, J.M. Samet, Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases, *Jama* 295(10) (2006) 1127-1134. doi:10.1001/jama.295.10.1127
18. J. Fische, Y. Zheng, T. Lyu, J. Bian, H. Hu, Environmental effects on acute exacerbations of respiratory diseases: A real-world big data study, *Science of The Total Environment* 806

- (2022) 150352.
<https://doi.org/10.1016/j.scitotenv.2021.150352>
19. R. Zareen, H.Y. Malik, Air quality and tuberculosis transmission: Evaluating environmental predictors in vulnerable districts of Pakistan, *Falcons Journal of Advanced Research* 2(1) (2025) 42-59.
 20. M. Singh, An evaluation of air quality during the Covid-19 pandemic, (2022).
<https://doi.org/10.3390/atmos13122090>
 21. Shahbaz MA. Cellular investigations into the interplay of particulate matter exposure, respiratory infections, and Alzheimer's disease (Doctoral dissertation, Itä-Suomen yliopisto).
 22. Kamal W, Khan A. The Impact of Air Pollution on Human Health in Pakistani Cities: A Study of the Effects of Particulate Matter on Respiratory Health. *Contemporary of Social Sciences Review*. 2023;1(1):14-24.