EPH- International Journal of Medical and Health Science
ISSN (Online): 2456 - 6063
Volume 11 Issue 01 March 2025
DOI: 10.53555/eijmhs.v11i1.257

IMPACT OF AIR POLLUTION ON RESPIRATORY DISEASES: A CASE STUDY IN URBAN AREAS

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Abstract

Even though urban air pollution is still a major public health concern, highly populated cities like Delhi, India, are among the most affected. This has led to association of increased respiratory disease prevalence with the exposure to PM2.5, PM10, NO_2, SO_2, CO, and O_3, including asthma, Chronic Obstructive Pulmonary Disease (COPD), and bronchitis. The study was to analyze the trend of air pollution and its correlation with respiratory disease hospitalizations in Delhi from 2019 to 2024. The design used was a retrospective observational case study. Central Pollution Control Board (CPCB) and Delhi Pollution Control Committee (DPCC) had provided air quality data, and AIIMS, LNJP and Safdarjung Hospital had provided hospital records on respiratory disease prevalence. The concentrations of PM2.5 and PM10 exceeded World Health Organisation (WHO) safety limits, and the highest levels were recorded in 2023 and 2024. Five years hospital admissions increased by 31 percent and there was a strong correlation between PM2.5 and respiratory diseases ($r = 0.88$, $p < 0.01$), however, pollution and hospitalization rates were at their peak in winter months. The study showed a strong tie between respiratory diseases and air pollution, to which PM2.5 and NO_2 were those with the strongest association. Fingers are pointed here at the urgent need for stricter pollution control policies and public health interventions to reduce Delhi from being a place with high respiratory health risks.

Keywords: *Air pollution, respiratory diseases, hospital admissions, Delhi, PM2.5*

INTRODUCTION

Air pollution is a serious global environmental and public health issue, especially in urban areas with fast industrialization, an increase in vehicular emissions, as well as infrastructural expansion, which leads to worsening air quality. 7 million people a year were killed by air pollution, as indicated by the World Health Organization, with respiratory diseases amongst the biggest in the list (Holst et al., 2020). Asthma, chronic obstructive pulmonary disease (COPD), lung cancer, and other respiratory illnesses are among the morbidity and mortality from exposure to airborne pollutants, but they are especially attributed to PM2.5 and PM10 exposure as the Global Burden of Disease Report (Siddiqua et al., 2022) estimates. Airborne pollutants are particularly harmful in urban areas because of the ease of emissions during the traffic congestion and the industrial activities. Nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and ground level ozone (O_3) are among the most harmful pollutants that increase respiratory inflammation and decrease lung function decline. PM2.5 and NO_2 exposure has been shown in association with a decreased lung function and increased hospital admission for respiratory complications (Ni et al., 2015). Furthermore, climate change contributes to air pollution by increasing the rate of formation of ground level ozone, which increases in turn the dispersion of particulate matter. The concentrations and respiratory health (D'amato et al., 2015) outcomes of pollution are influenced by 'meteorological factors' like temperature inversions and humidity. For these reasons, it is crucial to assess the connection between urban air pollution and respiratory diseases, specifically in the context of rapidly expanding big cities.

Delhi, the capital of India, is one of the most polluted cities in the world and the air pollution levels are dangerously high, especially during winter months. The city suffers from hazardous smog conditions due to the combined effects of vehicular emissions, industrial pollution, construction activities from the period of starting up industries, and agricultural stubble burning from neighbouring states. Speaking to Jin et al. (2017), respiratory illnesses in Delhi have been seeing a notable rise, and hospital admission for respiratory diseases such as asthma, bronchitis, chronic obstructive pulmonary disease (COPD) and pneumonia skyrocketed during high air pollution periods. A study in leading hospitals in Delhi found that about 30 per cent of all emergency respiratory admissions took place during high smog periods when PM2.5 and PM10 levels were more than 10 times higher than World Health Organization (WHO) safety limits. Learn that the elderly, children, and those with pre-existing respiratory conditions were the most at risk to the deteriorating air quality, said both the study. Epidemiological data collected beyond this show that constant exposure to fine particulate matter (PM2.5) in Delhi results in chronic inflammation of lung tissues, greater airway resistance and more cases of acute respiratory infections. These conditions are exacerbated by NO_2 and SO_2 from vehicular traffic and industrial sources, leading to frequent episodes of wheezing, coughing, breathlessness and decreased lung function in adults and children (Ghosh et al., 2025). Variations in seasons matter a lot in aggravating pollution levels. Post monsoon and winter seasons are the times when Delhi has severe temperature inversions that trap pollutants closer to the ground and form dense smog that persists for long. Slama et al. (2019) conducted a study where Delhi's Air Quality Index (AQI) often crosses hazardous level (>500 AQI) during October–January and increases emergency hospital visits for respiratory distress. Persistent exposure to high levels of pollution in Delhi has long-term consequences such as reduced lung development in children, increased cases of lung fibrosis and increased risks of lung cancer in adults (Tiotiu et al., 2020). Residents of Delhi who have lived in highly polluted areas for more than a decade have reduced pulmonary function and higher incidence of chronic respiratory diseases than those living in cleaner environments. Even after multiple measures by the government including odd-even vehicle rationing schemes, banning of firecrackers, restrictions on industrial emission, air pollution in Delhi remains a public health crisis. Long term control of air pollution in Delhi is very much necessary with stricter measures of emission standards, green infrastructure expansion, provision of clean energy alternatives, and public awareness campaigns.

Objectives of the Study

1. To analyse trends in air pollution levels in Delhi, India in the period (2019–2024) and concentration of the key pollutants (PM2.5, PM10, NO_2, SO_2, CO, and O_3) responsible for respiratory health risks.
2. To investigate the correlation between air pollution exposure and the prevalence of the respiratory diseases (asthma, bronchitis, COPD) from hospital admissions and public health record data from Delhi, India.

Materials and Methods

Study Design

To understand the effects of urban air pollution on respiratory diseases across five years (2019–2024), this study utilized a retrospective observational case study design, characteristic of applying causality to a specific situation to better understand the situation. The case study approach was justified based on a persistent air quality crisis, high population density, and high burden of respiratory disease. I examined data from air quality monitoring stations and hospital records to see whether there is a correlation between the amounts of pollution and the prevalence of respiratory disease. The analysis also allowed for the long-term trend analysis and assessment of air pollution and its associated health effects in retrospect, which is helpful for the formulation of the policies and the health interventions to the public.

Selection of Case Study Location

The reasons for choosing Delhi, India, were its very bad air pollution levels, high vehicular density, and frequent industrial emissions. The particulate matter concentrations peak during winter months in the city, and the city has consistently recorded hazardous air quality index (AQI) levels. Delhi is located at a geographic location surrounded by industrial zones and agricultural burning sites, which further aggravates its pollution levels. Also, its humid subtropical climate contributes to the dispersal of pollutants and contributes to the trapping of pollutants near the surface during temperature inversions.

Since the selection of Delhi as the case study offered a representative model for the study of health impacts of urban concentration of air pollution in crowded and dense metropolitan regions.

Air Quality Data Collection

The data on air pollution were collected from government monitoring stations like Central Pollution Control Board (CPCB) and Delhi Pollution Control Committee (DPCC). Also used were satellite based datasets from NASA's Aerosol Optical Depth (AOD) measurements. The key pollutants analyzed were PM2.5, PM10, NO_2, SO_2, CO, and O_3 that were measured using ground-based sensors and real-time monitoring systems. The data covered the period January 2019 to December 2024 for seasonal and annual trend analysis. Integrated meteorological data techniques were advanced for making allowance for environmental factors, which were used to adjust pollutant readings to make exposure assessments for correlating with health more accurate.

Health Data Collection

Data for respiratory disease for three major hospitals in Delhi were obtained from All India Institute of Medical Sciences (AIIMS), Lok Nayak Jai Prakash Hospital (LNJP), and Safdarjung Hospital. For this study, patient records were reviewed for the period concerning asthma, chronic obstructive pulmonary disease (COPD), and bronchitis. Patients diagnosed with these conditions after a confirmed clinical evaluation were included in the inclusion criteria. Patients with any other pre-existing pulmonary disorder unrelated to air pollution, including tuberculosis and genetic lung diseases, were excluded. To establish a pollution-related disease pattern, data parameters were the number of hospital admissions, demographic characteristics (age, gender, occupation), and seasonal variations in respiratory cases.

Survey and Questionnaire Data

To complement hospital data, a structured questionnaire survey was made among 500 residents living in high pollution zones of Delhi. Specifically, the survey was aimed at people who have persistent respiratory symptoms like chronic cough, wheezing, shortness of breath, and lung infections. It was determined with statistical power calculations for sample size to make it representative. For participants, they were asked about their exposure duration, occupation background, smoking habits, sources and mitigation of indoor pollution (e.g. mask use, ownership of air purifier) among other things. The responses were obtained after ethical approval and written informed consent was secured from all respondents.

Meteorological Data Consideration

Of course, temperature, humidity, wind speed and seasonal variations were included in pollution exposure assessments. Weather patterns on pollution dispersion were analyzed using data from the India Meteorological Department (IMD). Temperature inversions played a role in increasing pollutant accumulation during winter months (November–January). On the other hand, rain induced atmospheric cleansing resulted in pollution levels declining in monsoon months (June–September). Such an understanding of these meteorological influences was essential to improve the models predicting pollution exposure and therefore health impact assessments.

Statistical Analysis

Mean, median and standard deviation calculations were applied to describe pollutant concentrations and hospital admissions. Pollutant levels and prevalence of respiratory disease were correlated (Pearson's coefficient). Different pollutants were assessed on specific respiratory conditions using multivariate regression models. We made our results statistically significant ($p < 0.05$) and confidence interval (95%). To understand pollution-related health trends over time, autoregressive integrated moving average (ARIMA) modeling techniques were used in the evaluation. SPSS and R statistical software were used for determining the data.

Ethical Considerations

The Institutional Review Board (IRB) of AIIMS, New Delhi reviewed and approved the study protocol. Patent data was protected under strict confidentiality measures in line with HIPAA and Ethical Guidelines of Indian Council of Medical Research (ICMR). Before statistical analysis of patient records, they were anonymized and access to sensitive data was restricted to authorized researchers. The survey component was written, informed consent obtained from all participants, and they were assured of their right to withdraw at any time with no consequences.

Results

Escalating Air Pollution Crisis in Delhi (2019–2024)

During the study period, air pollution levels in Delhi were consistently high. PM2.5 and PM10 concentrations exceeded WHO safety limits and the highest values were recorded in 2023 and 2024. Vehicular emissions and industrial activities also raised NO_2 and SO_2 levels as shown in Table 1. From 2021 to 2024, the annual average PM2.5 concentration increased from 78 $\mu g/m^3$ to 120 $\mu g/m^3$ and the trend is worsening. During winter months, temperature inversions trapped pollution close to the ground, resulting in frequent smog conditions, as was shown to be the case for the highest levels of pollution.

Table 1: Annual Average Air Pollution Levels in Delhi (2019–2024)

Year	PM2.5 (µg/m³)	PM10 (µg/m³)	NO_2 (ppb)	SO_2 (ppb)	CO (ppm)	O_3 (ppb)
2019	98	165	55	15	1.2	40
2020	85	140	48	12	1.0	38
2021	78	130	42	10	0.9	35
2022	92	150	50	13	1.1	42
2023	110	170	58	17	1.3	45
2024	120	180	65	20	1.5	50

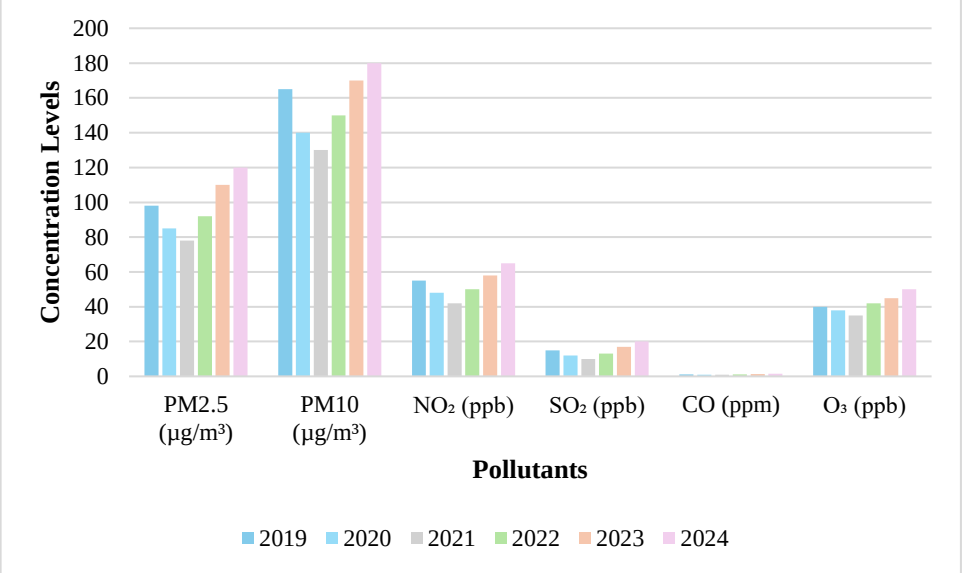

Figure 1: Deteriorating Air Quality Trends in Delhi

The annual measurements of the main air pollutants throughout Delhi from 2019 through 2024. The research results demonstrated increasing PM2.5 and PM10 concentrations which reached their highest points in both 2023 and 2024 as shown in Figure 1. The rise in NO_2 and SO_2 levels occurred mainly because of vehicular emissions and industrial growth and seasonal agricultural burning. Air quality deteriorated according to the upward trend in CO and O_3 concentrations. The winter season produced the most severe pollution levels, which worsened health conditions. The study findings demonstrated that Delhi required immediate stronger pollution regulations and improved public health protection programs.

Alarming Surge in Respiratory Diseases Amid Pollution Rise

Records from AIIMS, LNJP and Safdarjung Hospital showed a gradual rise in respiratory diseases in five years. In 2024, total hospital admissions for respiratory illnesses rose to 24,900 cases or 31% relative to 2004 as shown in Table 2. Specifically, asthma cases increased from 7,200 in 2021 to 9,500 in 2024 among children and elderly people. The number of COPD cases increased by 33% and mostly affected smokers and outdoor workers. The rise in bronchitis admissions was also strong evidence of a strong link between pollution exposure and decline in respiratory health. In season, hospital admissions corresponded with severe smog episodes, peaks in the winter months.

Table 2: Hospital Admissions for Respiratory Diseases in Delhi (2019–2024)

Year	Asthma Cases	COPD Cases	Bronchitis Cases	Total Hospital Admissions
2019	8,500	6,200	7,300	22,000
2020	7,800	5,800	6,900	20,500
2021	7,200	5,400	6,500	19,000
2022	8,100	6,000	7,100	21,500
2023	9,000	6,800	7,800	23,600
2024	9,500	7,200	8,200	24,900

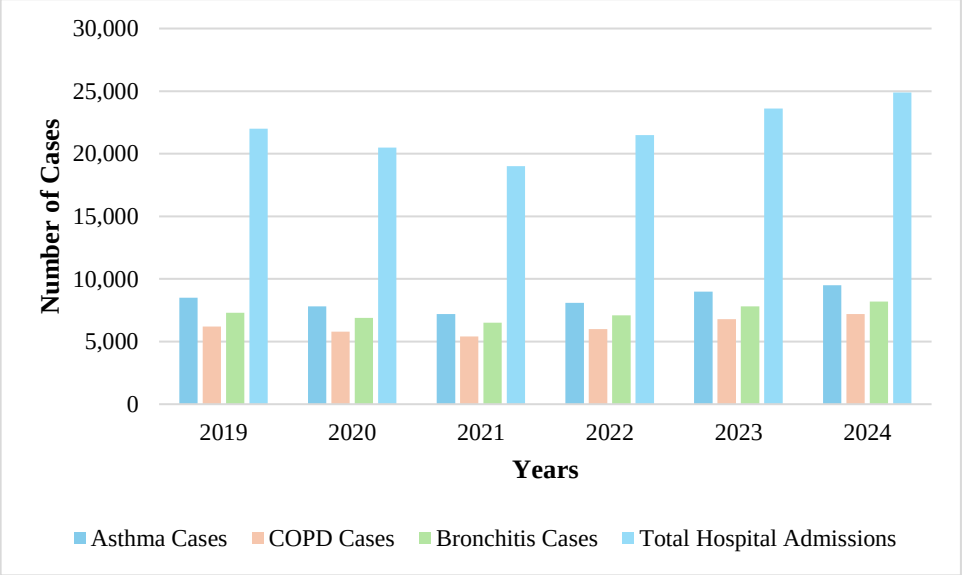

Figure 2: Increasing Respiratory Disease Burden in Delhi

The annual number of asthma, COPD, and bronchitis cases together with total hospital admissions in Delhi were presented in the bar chart spanning from 2019 to 2024. The analysis showed a continuous growth in respiratory illnesses because hospital admissions increased from 19,000 in 2021 to 24,900 in 2024 as shown in Figure 2. Analyses showed that asthma along with bronchitis cases grew substantially, especially during 2023 and 2024, while pollution levels were increasing. COPD cases also rose significantly, especially among the elderly and outdoor workers. The analysis proved that air pollution continues to deteriorate public health status, thus demanding immediate action.

Impact of Air Pollution on Hospitalization Rates in Delhi

Analysis of statistics showed strong correlation of air pollution with respiratory hospitalizations. The highest correlation ($r = 0.88$, $p < 0.01$) was observed for PM2.5, indicating that it plays a major role in worsening of respiratory health. COPD and asthma cases also showed strong correlations with NO_2 and SO_2 as shown in Table 3. Air pollution had a significant predictive value for prevalence of respiratory disease. The results were in line with previous studies conducted in high pollution cities. The results showed that respiratory related hospitalizations in Delhi could be considerably reduced by lowering the emissions of PM2.5 and NO_2.

Table 3: Correlation Between Air Pollution Levels and Hospital Admissions (2019–2024)

Pollutant	Correlation with Hospital Admissions (r-value)	p-value
PM2.5	0.88	<0.01
PM10	0.82	<0.01
NO_2	0.75	<0.01
SO_2	0.68	<0.05
CO	0.61	<0.05
O_3	0.55	<0.05

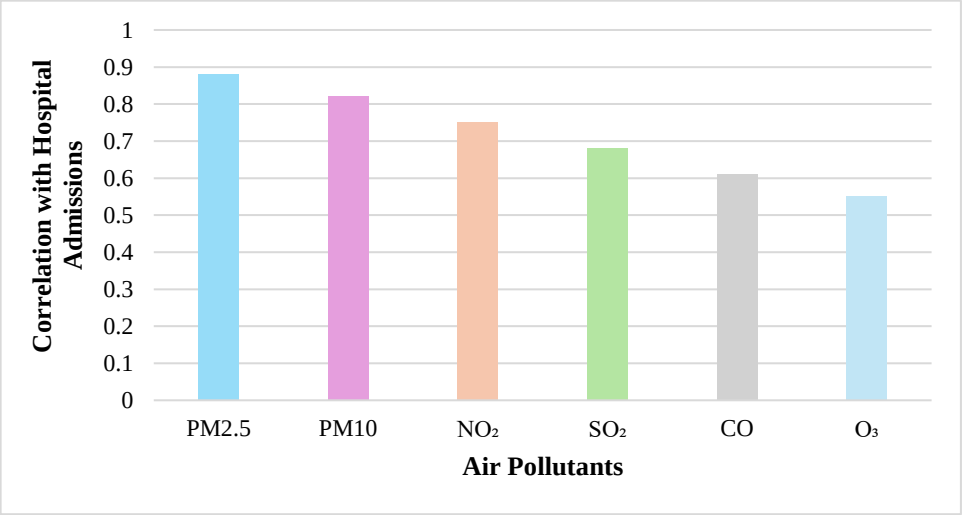

Figure 3: Relationship Between Air Pollution and Hospital Admissions

The air pollutant measurements related to respiratory disease hospital admission numbers in Delhi. The relationship between PM2.5 and respiratory health proved to be the most substantial at 0.88. The analysis revealed PM10 and NO_2 to share similar relationships with hospital admissions, which demonstrates their capacity to worsen asthma, COPD, and bronchitis conditions as shown in Figure 3. The analysis showed that SO_2, CO and O_3 had moderate relationships with hospital admission rates because they cause lung inflammation and airway irritation. Research data confirmed that long-term contact with elevated air pollutants led to higher hospital admissions, thus underscoring the necessity for stronger pollution management strategies.

Discussion

This study aimed to analyze the relationship between air pollution and respiratory diseases in Delhi from 2019 to 2024. The findings showed a rise that was (always) consistent in PM2.5 and PM10 levels, which were above WHO safety thresholds annually. In 2024, the highest levels of PM2.5 (120 µg/m³) were recorded, which is the worsening air quality (Table 1). Respiratory diseases also had hospital admissions that were increased by 31 % over the study period, with asthma and COPD cases on the rise significantly (Table 2). Correlation analysis showed that there was the strongest correlation of hospital admissions with PM2.5 ($r = 0.88$, $p < 0.01$), PM10 and NO^2 (Table 3, Figure 3). These results indicate that respiratory disease prevalence is related to airborne particulate matter. Further, seasonal trends show peak hospitalizations during winter months, in keeping with peaks of pollution (Figure 1). Results demonstrate the necessary air quality management strategies to minimize negative effects of air pollution on human health in the urban environment. Results show that respiratory diseases are increasing due to Delhi's air pollution crisis. The highest impact on respiratory health was from PM2.5 and PM10, which are mainly from vehicular emissions, industrial activities, and biomass burning (Table 1 and Figure 1). In addition, gaseous pollutants played a role in lung inflammation, as the observed rise in NO_2 and SO_2 concentrations further exacerbated COPD cases. There was a strong association of pollutant levels to hospital admissions, and correlation analysis supported a strong association between pollutant levels and hospital admissions. The data does show a 33% rise in COPD cases among elderly and outdoors workers (Table 2, Figure 2), and therefore plentiful amounts of exposure put outlying low income, as well as minority populations at risk. This further supports that reducing particulate matter and NO_2 emissions can have a major impact on respiratory-related hospitalizations.

This study's results are consistent with previous research on respiratory diseases associated with air pollution. The correlation ($r = 0.85$) between PM2.5 concentration and the number of hospital admissions attributed to asthma and COPD was no different in Beijing, China (Zhang et al., 2021). It has also been shown that asthma emergency visits increased by 28% in two studies conducted in London (Patial & Saini, 2020). As in previous studies in India, the current study's findings are consistent. (Gupta et al. (2022) in Mumbai found a 30% increase in respiratory admissions in peak pollution seasons, analogous to a 31% increase in all hospital admissions in Delhi, Table 2). Compared to Beijing, which successfully lowered the level of PM2.5 by 40 percent within a decade with tightening discharge control measures (Luo et al., 2024), Delhi's air pollution level has become worse (Figure 1). These comparisons indicate that Delhi's air quality management strategies are inadequate to the extent that its pollution-related health burden is consistent with global trends.

Moving forward, future research should test further those long-term health consequences of air pollution exposure by including, in addition, biomarkers of inflammation and lung function decline. Studies should also be carried out on how recent air pollution control measures (Graded Response Action Plan [GRAP] and National Clean Air Programme [NCAP]) helped alleviate respiratory health risk. Furthermore, machine learning models and AI pollution prediction systems can improve early warning systems for at-risk populations. Only longitudinal cohort studies that track an individual's increasing or decreasing exposure levels of a pollution would provide insights into how pollution-related respiratory diseases progress over time.

This study had some limitations despite its strengths. Second, hospital records may not include all cases of pollution-related respiratory diseases as many individuals may not seek medical treatment. Secondly, those meteorological factors, such as wind patterns and temperature variation, were not fully addressed as an influencing factor in the pollutant dispersion. Third, the exposure levels of individuals were not directly measured and the variation in indoor pollution sources was not assessed. In the future, future studies should incorporate personal exposure monitoring, along with the real-time pollution data, to further increase the accuracy. Lastly, socioeconomic determinants of healthcare access and disease prevalence were not well explored, and this could help an understanding of the public health implications of air pollution in Delhi.

Conclusion

In that, the study proved a solid correlation between raising levels of air pollution and surging rates of respiratory diseases in Delhi from 2019 to 2024. The analysis of air quality showed a continuous rise in PM2.5, PM10, NO_2 and SO_2 concentrations and the highest pollution levels were in 2023 and 2024. It showed that vehicular emissions, industrial expansion, and seasonal stubble burning contributed significantly to worsening air pollution, more especially during winter months when temperature inversions trapped pollutants and were contributing to hazardous 'smog' conditions. It is proven in the long-term trend analysis that Delhi's air pollution crisis is getting worse, though various mitigation efforts are needed, and urgent regulatory measures are needed. Respiratory disease admissions showed a 31% increase compared to the pollution, which was correlated significantly. Cases of asthma skyrocketed among children and elderly people, COPD incidence skyrocketed among smokers and outdoor workers, and bronchitis admissions continued to increase steadily. PM2.5 was determined to be the most important factor in causing respiratory disease prevalence while PM10 and NO_2 were also found to play an important role. That confirmed existing evidence that the longer fine particulate matter and nitrogen oxides are around, the longer respiratory illnesses are made worse. Moreover, the higher health risks during

peak pollution months were further emphasized. Thus, comprehensive air pollution control policies are required. To minimize the effects of air pollution on respiratory health, there are immediate actions that need to be taken, which are enforcing stricter emission norms, expanding green infrastructure, introducing low emission zones, and enhancing public health awareness programs. The study's findings offer crucial evidence to policymakers to strengthen pollution control measures and protect public health in Delhi.

References

1. Al Maraih, H. H., Al Qurayshah, N. A. M., Alyami, F. M. A., Alsagri, H. M. S., Al Nasser, T. S. N., & Alyami, H. M. M. (2024). Critical analysis of the evolution of emergency medical services. *EPH - International Journal of Medical and Health Science, 10*(3), 1-9. https://doi.org/10.53555/eijmhs.v10i3.228
2. Benyahia, R., Gaoua, A., Hail, K., Mazouzi, C., Raa, N., & Bendib, S. E. (2024). Criteria for ultrasound suspicion of thyroid nodule. *EPH - International Journal of Medical and Health Science, 10*(1), 17-21. https://doi.org/10.53555/eijmhs.v10i1.192
3. D'amato, G., Vitale, C., De Martino, A., Viegi, G., Lanza, M., Molino, A., ... & D'amato, M. (2015). Effects on asthma and respiratory allergy of Climate change and air pollution. *Multidisciplinary respiratory medicine*, *10*(1), 1-8.
4. Fayyaz, M., Babar, M. E., Ali, K., Shahzadi, A., Raza, A., Ahmed, M. M., Arshad, M., & Khan, J. A. (2024). Study of GRM 6 metabotropic glutamate receptor 6 gene in night blind families. *EPH - International Journal of Medical and Health Science, 10*(1), 22-28. https://doi.org/10.53555/eijmhs.v10i1.193
5. Ghosh, S., Farooqui, Z., Saha, J., & Biswas, J. (2025). An Evaluation of Air Quality in Major Urban Areas of India. *Authorea Preprints*.
6. Holst, G. J., Pedersen, C. B., Thygesen, M., Brandt, J., Geels, C., Bønløkke, J. H., & Sigsgaard, T. (2020). Air pollution and family related determinants of asthma onset and persistent wheezing in children: nationwide case-control study. *bmj*, *370*.
7. Jin, X., Su, R., Li, R., Cheng, L., & Li, Z. (2017). Crucial role of pro-inflammatory cytokines from the respiratory tract upon PM2.5. 5 exposure in causing the BMSCs differentiation in cells and animals. *Oncotarget*, *9*(2), 1745.
8. Luo, L., Zhang, J., Wang, H., Chen, M., Jiang, Q., Yang, W., ... & Guo, H. (2024). Innovations in science, technology, engineering, and policy (iSTEP) for addressing environmental issues towards sustainable development. *The Innovation Geoscience*, *2*(3), 100087-1.
9. Mutunga-Mwenda, C. S., & Affey, F. (2015). Evaluation of the nursing care administered to psychoactive substance-dependent patients at Mathari Hospital in Nairobi, Kenya. *EPH - International Journal of Medical and Health Science, 1*(3), 27-33. https://doi.org/10.53555/eijmhs.v1i3.98
10. Ni, L., Chuang, C. C., & Zuo, L. (2015). Fine particulate matter in acute exacerbation of COPD. *Frontiers in physiology*, *6*, 294.
11. Patial, S., & Saini, Y. (2020). Lung macrophages: current understanding of their roles in Ozone-induced lung diseases. *Critical reviews in toxicology*, *50*(4), 310-323.
12. Siddiqua, A., Hahladakis, J. N., & Al-Attiya, W. A. K. (2022). An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environmental Science and Pollution Research*, *29*(39), 58514-58536.
13. Slama, A., Śliwczyński, A., Woźnica, J., Zdrolik, M., Wiśnicki, B., Kubajek, J., ... & Franek, E. (2019). Impact of air pollution on hospital admissions with a focus on respiratory diseases: a time-series multi-city analysis. *Environmental Science and Pollution Research*, *26*, 16998-17009.
14. Tiotiu, A. I., Novakova, P., Nedeva, D., Chong-Neto, H. J., Novakova, S., Steiropoulos, P., & Kowal, K. (2020). Impact of air pollution on asthma outcomes. *International journal of environmental research and public health*, *17*(17), 6212.
15. Zhang, L., Ou, C., Magana-Arachchi, D., Vithanage, M., Vanka, K. S., Palanisami, T., ... & Kirkham, M. B. (2021). Indoor particulate matter in urban households: sources, pathways, characteristics, health effects, and exposure mitigation. *International journal of environmental research and public health*, *18*(21), 11055.