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Urban Air Pollution Multivariate Analysis and Effect on Respiratory Morbidity in Industrial Regions

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Abstract: The purpose of the research was to evaluate the effects of urban air pollution on respiratory morbidity in the industrial district of Kirkuk city, which has high industrial activity. The study population consisted of 150 participants, with an age range of 18-65 years, and the majority were male (80%). Data were gathered in the form of environmental measurements of air pollutants, and health questionnaires, medical record reviews and pulmonary function tests. The findings revealed that the concentration of air pollutants was significantly high, with PM2.5 and PM10 levels exceeding the recommended limit, indicating a high environmental exposure. Respiratory diseases were also high in the study, with 48% having chronic respiratory symptoms, 38% had dyspnea, 29.3% had chronic bronchitis, and 25.3% had asthma.The statistical test showed that there is a significant correlation between high exposure to particulate matter and high risk of asthma ($p < 0.01$). Pulmonary function tests showed that there was a significant decline in FEV1 and FVC in those people who were subjected to high pollution levels. The multivariate logistic regression analysis established that PM2.5 exposure, smoking and industrial work are independent risk factors for high respiratory morbidity. The research concludes that respiratory health is under a severe threat from air pollution in industrial zones, and the environmental and health situation will need immediate intervention to minimize exposure and alleviate the disease burden caused by it.

Keywords: Air Pollution, Industrial Regions, Respiratory Morbidity, Kirkuk City

Introduction

One of the most important environmental indicators for people's health is air quality. Air quality refers to the condition of the air in a specific area, particularly regarding the presence and concentration of pollutants. These contaminants, including gases and small suspended particles, directly impact the functions of respiratory organs and affect the whole population of a state or country [1]. The problem of air contamination meaning harmful substances present in the air is especially relevant to industrial regions. Factories, traffic, and other types of combustion-related emissions expose people to a constant, dense cloud of gases and small suspended particles [2].

It has been established through global research that chronic exposure to these pollutants is linked to higher incidences of chronic respiratory illnesses, including asthma, chronic bronchitis, and dyspnea and a steady decline in the state of lung functioning, which creates severe health and economic liabilities to the population [3].

Prematurely formed fine particles of PM2.5 and PM10 can go through the upper respiratory tract and into the alveoli, leading to chronic inflammation and tissue destruction. Also, the interaction between environmental pollutants and behavioural issues like smoking is a compounding factor which predisposes the risk of respiratory diseases [4,5]. Thus, research on the correlation between respiratory morbidity and exposure to air pollution in the industrial areas is essential to determine the extent of risk and make preventive recommendations on how to reduce exposure and promote health among the population [5,6,7]. This paper will concentrate on the industrial district of Kirkuk city because the region has a high concentration of industrial activities and traffic and is thus an apt model to study the impacts of urban and industrial pollution on respiratory health. The research seeks to estimate the level of air pollution, the prevalence of respiratory illness in the residents, and the connection that exists between exposure and respiratory complications through descriptive, bivariate, and multivariate designs that will give a complete picture of how air pollution affects the health of people living in the industrial cities.

Research Methods

Study Population and Sample Size

The participants in this study were 150 people living in the industrial district of Kirkuk city, an urban region, and one with high pollution levels as a result of industrial operations and heavy traffic. The participants were aged between 18 and 65, and both genders and various occupational groups were represented, such as industrial and non-industrial workers.

Random sampling was used to select the participants to make sure that they represented various population groups and minimised selection bias. To make sure that the connection between air pollution exposure and health status is considered correctly, the inclusion criteria were that one should have lived long enough in the area, and people with severe non-respiratory chronic illness were not allowed to participate in the study to prevent the development of acute respiratory illnesses.

Data Collection

A multi-source approach was chosen as the method of data collection to gain the correct and full information about environmental exposure and health of the participants.

Environmental measurements: The air quality monitoring devices were used to determine the levels of air pollutants in the research area. The levels of particulate matter (PM2.5 and PM10) and gaseous compounds like nitrogen dioxide (NO 2) and sulfur dioxide (SO2) were measured in several locations throughout the industrial district at various times to achieve a reasonable reflection of environmental differences [8].

Health data: Health data was gathered by use of the structured questionnaires, which contained demographic and behavioural data, and measurement of respiratory symptoms, including cough and dyspnea. Clinical diagnoses were checked by referencing the medical records. Spirometry was used to carry out pulmonary function tests to quantify indicators like the FEV1 and FVC, which offer an objective assessment of respiratory efficiency [9].

Examination Procedures

All the environmental measurements and the clinical measurements were carried out according to standardised procedures to ensure the accuracy, reliability and reproducibility of the measurements.

In terms of environmental monitoring, the air pollutant concentrations were determined by the air monitoring devices that were pre-calibrated as per the specifications of the manufacturer. Measurements were made at various pre-determined points in the industrial area where the devices were set at a height of about 1.5-2 meters off ground level, and it was necessary because it is the human breathing zone [10]. The data were collected at various times of the day (morning and evening) as well as on various days to ensure that temporal variation in the level of pollutants was taken care of. The parameters measured were particulate matter with aerodynamic diameter of ≤2.5 μm (PM2.5) and ≤10 μm (PM10), and gaseous pollutants, namely nitrogen dioxide (NO2) and sulfur dioxide (SO_2). The concentrations were measured in micrograms per cubic meter (μg/m3) [11].

Health evaluation was done in two consecutive stages. The collection of health data was based on structured interviews with the help of standardised questions specially designed to gather data on the problem in the first stage, under direct observation of the researchers to avoid biases and guarantee the completeness of the data. Basic physiological parameters such as respiratory rate and heart rate were also checked in accordance with the usual clinical practices.

The second phase involved testing pulmonary functioning with the help of spirometry according to international standards. The participants were advised to make a deep inhalation and a quick and vigorous expiration into the apparatus. Important parameters such as forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) were measured [12]. Every test was to be repeated at least 3 times by the participant, and the best possible reading was to be chosen with reference to the quality criteria.

Independent Variables

Environmental and demographic variables that were believed to determine respiratory health were considered independent variables. Such variables were concentrations of air pollutants, including PM2.5, PM10, NO2, and SO2, which were considered the main indicators of environmental exposure [13].

The demographic and behavioral variables were age, gender, marital condition, education level, economic status and smoking status (current, former, or non-smoker). Occupation, particularly occupational exposure to pollutants in the industrial environment, was also taken into account.

Dependent Variables

Dependent variables encompassed health indicators of the respiratory system that were applied to determine the effects of air pollution. Among them were the occurrence of respiratory illnesses like asthma and chronic bronchitis, and the persistent cough, dyspnea, and wheezing, which were the chronic respiratory symptoms.

Dependent variables provided were pulmonary function test results (FEV1 and FVC), which are significant variables to indicate the efficiency of the respiratory system and to identify any functional defects of the lungs in the participants.

Statistical Analysis

The data were analyzed with the help of descriptive statistics that provided the characteristics of the samples, chi-square tests, t-tests, and ANOVA that were used to investigate the differences between variables. The data were analyzed using multivariate logistic regression to ascertain the association between air pollution and respiratory diseases, and control confounding variables, odds ratios and 95% interval confidence were determined, and the significance level was set at $p < 0.05$.

Results

General Characteristics of the Study Sample

The demographic particularities of the study sample were presented in the form of descriptive results following redistribution. The number of males (120 participants) and females (30 participants) also mirrored the ratio between males and females working in industrial regions (80 % and 20 %, respectively). The distribution of ages was fairly equal, and the prevalence of smokers was significantly high, especially amongst men and workers in factories. These features play a significant role in the interpretation of the correlation between exposure to air pollution and respiratory morbidity (Table 1, Figure 1).

Table 1. Demographic Characteristics of Participants (n=150)

Variable	Number	Percentage (%)
Gender		
Male	120	80.0
Female	30	20.0
Age Group		
18–30	34	22.7
31–45	52	34.7
46–65	64	42.6
Smoking		
Smoker	80	53.3
Non-smoker	50	33.3
Former smoker	20	13.4

Occupation		
Industrial worker	85	56.7
Non-industrial	65	43.3

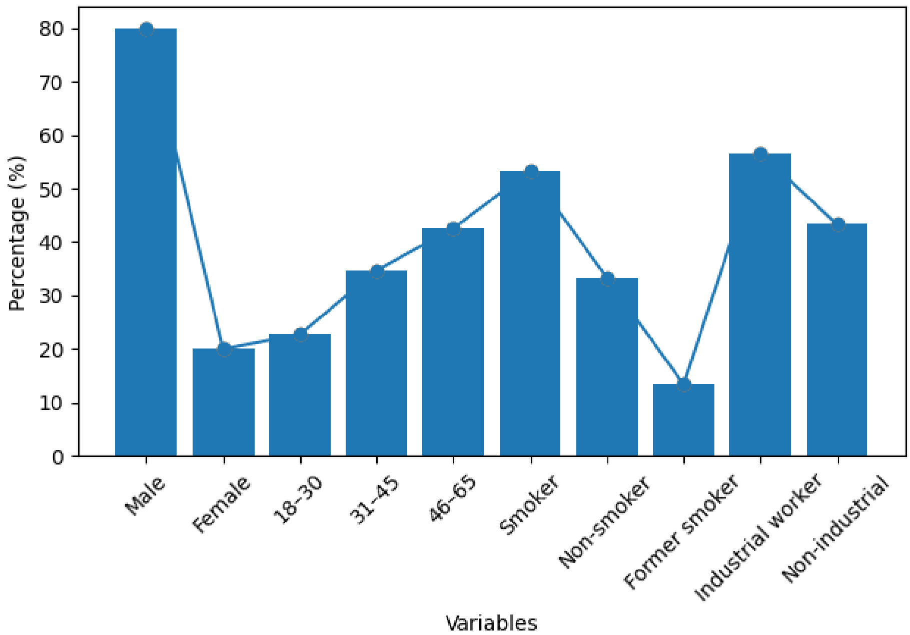

Figure 1. Integrated Visualization of Study Population Characteristics

Air Pollution Levels in the Industrial District

The studies on the environment showed that the level of air pollutants in the research location was visibly higher than the global allowable levels, particularly that of particulate matter, which is regarded as one of the most dangerous pollutants to the respiratory system. These findings reveal that there is a high environmental exposure of the residents, which supports the study hypothesis with reference to the effects of pollution on the respiratory health (Table 2, Figure 2).

Table 2. Mean Air Pollutant Concentrations

Pollutant	Mean ± SD	Permissible Limit
PM2.5 (µg/m³)	68.4 ± 15.2	25
PM10 (µg/m³)	132.7 ± 28.6	50
NO_2 (ppb)	41.5 ± 10.3	40
SO_2 (ppb)	29.8 ± 8.7	20

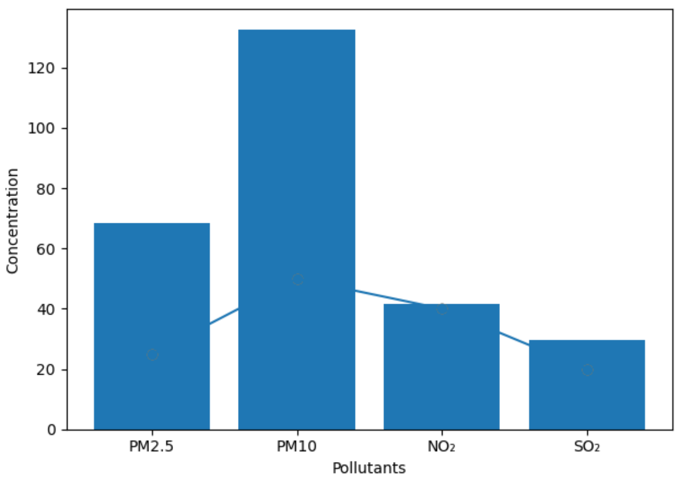

Figure 2. Combined Visualization of Air Pollutant Concentrations and Permissible Limits

Prevalence of Respiratory Diseases

The findings showed that respiratory diseases were very prevalent among the study participants, and the most prevalent was chronic respiratory symptoms, followed by dyspnea and chronic bronchitis. This trend indicates the possibility of the effects of constant exposure to the air pollutants in the industrial district (Table 3, Figure 3).

Table 3. Prevalence of Respiratory Diseases

Disease	Number	Percentage (%)
Asthma	38	25.3
Chronic bronchitis	44	29.3
Dyspnea	57	38.0
Chronic respiratory symptoms	72	48.0

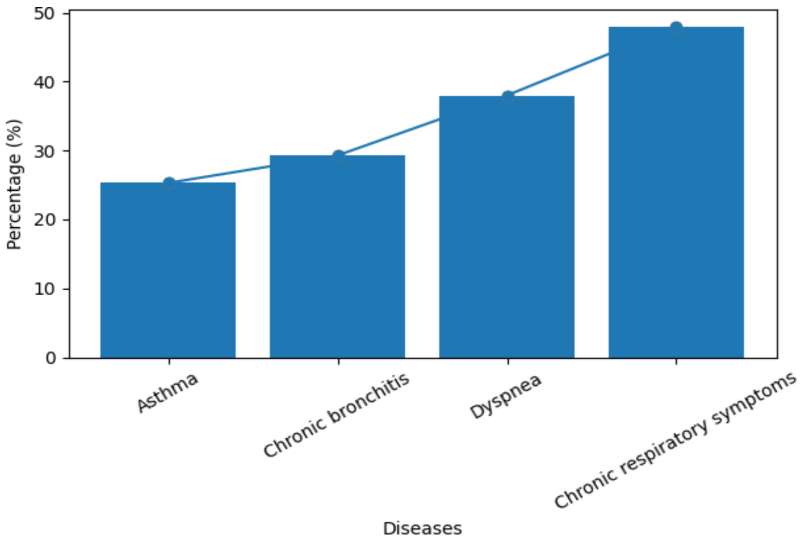

Figure 3. Combined Visualization of Respiratory Disease Prevalence among the Study Population

Relationship Between Pollution and Respiratory Diseases (Bivariate Analysis)

According to the bivariate analysis, there was a strong correlation between high exposure to PM2.5 and high chances of asthma, which pointed to the direct impact of the mentioned pollutants on respiratory health. Findings also showed that there was significant association between smoking and chronic bronchitis, as the interaction between the environmental and behavioral factors (Table 4, Figure 4).

Table 4. PM2.5 Exposure and Asthma

PM2.5 Level	Asthma Cases	Non-Asthma	p-value
Low	8	32	
High	30	80	<0.01

Pulmonary Function Test Results

The tests of pulmonary function revealed that respiratory performance indicators were significantly lower in people exposed to high rates of pollution than in those people who were exposed to lower levels which pointed to influence of chronic exposure to pollution on the performance of the lungs (Table 5, Figure 5).

Table 5. Pulmonary Function by Exposure Level

Variable	Low Exposure	High Exposure	p-value
FEV1	3.1 ± 0.5	2.4 ± 0.6	<0.01

FVC	3.8 ± 0.7	3.0 ± 0.8	<0.01
FEV1/FVC	81%	74%	<0.01

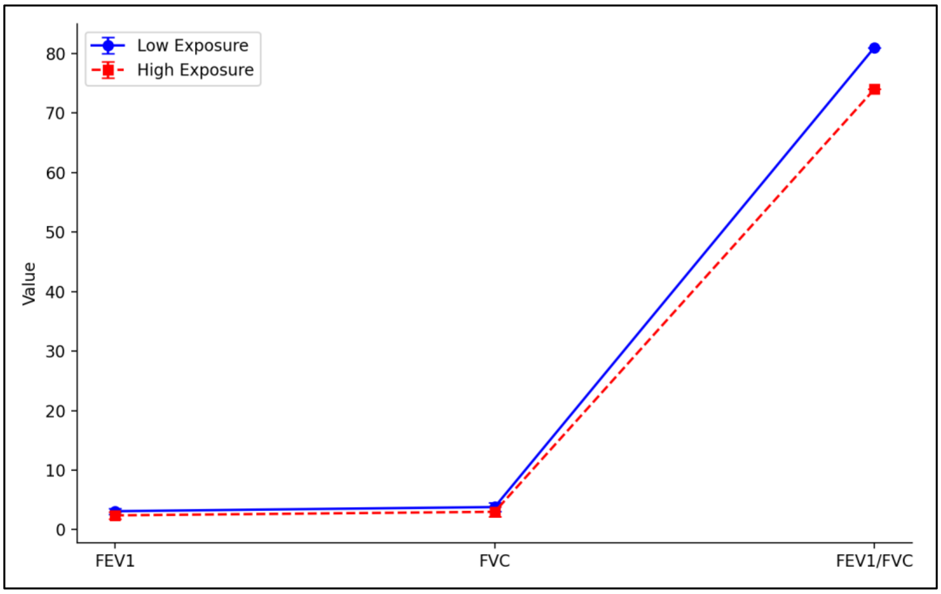

Figure 4. Combined Visualization of Pulmonary Function Parameters by Exposure Level

Multivariate Logistic Regression Analysis

The multivariate logistic regression analysis showed that air pollutant exposure, in particular, PM2.5 exposure is a confounder-adjusted independent factor that enhances the risk of respiratory illness. The strongest risk factors were smoking and industrial work, which represented the accumulated impact of environmental and behavioral factors (Table 6, Figure 6).

Table 6. Multivariate Risk Factors

Variable	OR	95% CI	p-value
High PM2.5	2.8	1.6 – 4.9	<0.01
High PM10	2.1	1.2 – 3.7	0.02
Smoking	3.4	1.9 – 6.1	<0.001
Industrial work	2.6	1.5 – 4.5	<0.01
Age (>45)	1.9	1.1 – 3.3	0.03

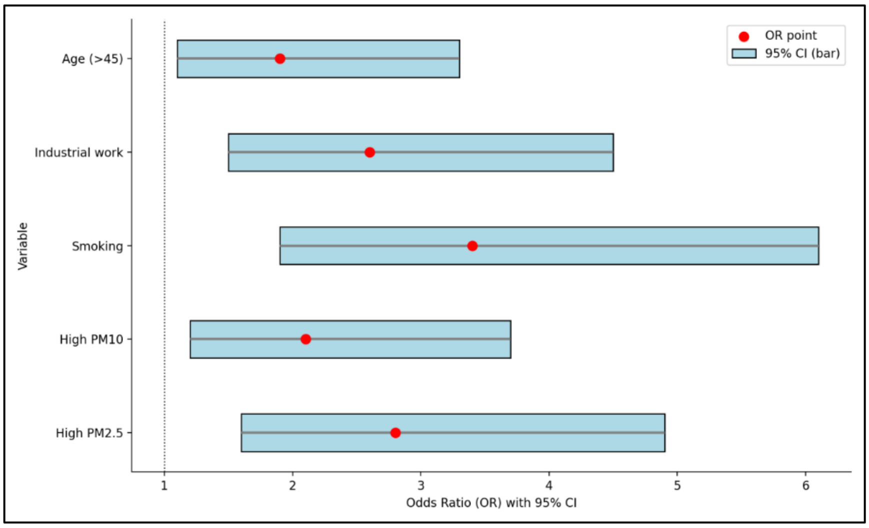

Figure 4. Risk Factors Associated with Elevated Odds Ratios (OR) with 95% Confidence Intervals

Discussion

According to the research findings, there is a distinct and statistically significant exposure to the urban air pollution in the industrial district, in determining the rate of respiratory morbidity, which is in line with the study hypothesis [14]. High levels of air pollutants, especially PM2.5 and PM10, were above the recommended limits across the world, and this is indicative of a polluted environment being chronic [15]. The fact that these fine particles can reach the respiratory system and enter alveoli is especially dangerous, as it leads to chronic inflammation and destruction of the lung's functioning in the long run [16].

The sample was mainly male (80%), which is a representation of the labour force in the industrial regions where physical and industrial work is dominated by the male population. The smoking was also found to be at a high level, and this is important since smoking enhances the impact of air pollution [17]. The association between the environmental exposure (pollution) and behavioural factors (smoking) predisposes the occurrence of respiratory diseases, and it is hard to differentiate the effect of every factor without the use of multivariate analysis, which was used in this study [18].

There was an evident increase in respiratory disease prevalence, and the prevalence of chronic respiratory symptoms was 48%, and dyspnea followed by chronic bronchitis, 29.3% and 38% respectively, which indicates a high burden of health[19]. The exposure to air contaminants may be attributed to the continuous exposure to these contaminants, which can be explained by the lack of strong environmental control measures or personal protective gear. Pollution concentration in the respiratory system results in chronic and not acute symptoms [20].

The bivariate analysis showed a significant relationship between high exposures of PM2.5 and a strong likelihood of asthma, as it has been observed in the literature that the cause-and-effect relationship between fine particles and respiratory inflammation and bronchial hyperreactivity is direct [21]. Chronic bronchitis was highly likely to be associated with smoking, which demonstrated the contribution of environmental pollutants and behavioral factors in the occurrence of respiratory damage [22].

The findings were supported by the results of pulmonary function tests, which indicated a substantial reduction in FEV1 and FVC in people who were exposed to high levels of pollution, which evidenced that high levels of pollution had a functional effect on respiratory efficiency [23]. The low FEV1/FVC ratio is a potential indication of airway obstruction, which is in line with the higher prevalence of asthma and chronic bronchitis. This is to show that the outcome of pollution goes beyond the clinical symptoms to the physiological lung functioning [24].

Multivariate analysis revealed that at the high level of PM2.5 exposure, the risk of respiratory diseases is exposed to an increased risk (2.8 times) even after the confounder is taken into consideration [25]. Smoking was found to be the highest risk factor (OR=3.4), which was followed by industrial work, which confirmed the fact that environmental and behavioral risk factors jointly work to augment the risk of diseases [26]. These findings show that air pollution is not only a companion factor but an independent risk factor [27].

It is comparable to the world literature that confirms that the long-term exposure to fine particulate matter is related to the ultimate rate of respiratory diseases and reduced lung capacity [28]. These results are also consistent with epidemiological models that indicate that industrial zones are at risk areas as far as environmental health is concerned [29].

In spite of such important results, the study is characterised by certain limitations, such as a cross-sectional design, which restricts the possibility of causal inference, and the possible bias of self-reported questionnaires [30]. The small percentage of females could also influence the ability to generalise the findings to the whole population [31].

On the whole, this research proves that the problem of air pollution in the industrial sector is an actual threat to respiratory health, and the nature of the environmental policy, in regulating industrial emissions, combined with health awareness campaigns, especially smoking risks and wearing protective equipment in polluted workplaces[32].

Conclusions

This research supports a substantial relationship to indicate that respiratory morbidity is associated with exposure to urban air pollution in industrial regions. An increase in the number of respiratory diseases and poor lung functioning was associated with high concentrations of PM2.5 and PM10. Air pollution, smoking, and industrial work were the independent risk factors according to multivariate analysis. Altogether, air pollution is an acute human health concern, which needs immediate environmental regulation and medical efforts to minimise its consequences.

REFERENCES

[1] H. A. Shahriyari, Y. Nikmanesh, S. Jalali, N. Tahery, A. Zhiani Fard, N. Hatamzadeh, *et al*., “Air pollution and human health risks: mechanisms and clinical manifestations of cardiovascular and respiratory diseases,” *Toxin Reviews*, vol. 41, no. 2, pp. 606–617, 2022.

[2] C. K. Swain, “Environmental pollution indices: a review on concentration of heavy metals in air, water, and soil near industrialization and urbanisation,” *Discover Environment*, vol. 2, no. 1, p. 5, 2024.

[3] P. Marchetti, J. Miotti, F. Locatelli, L. Antonicelli, S. Baldacci, S. Battaglia, *et al*., “Long-term residential exposure to air pollution and risk of chronic respiratory diseases in Italy: The BIGEPI study,” *Science of the Total Environment*, vol. 884, p. 163802, 2023.

[4] Ł. Zaręba, K. Piszczatowska, K. Dżaman, K. Soroczynska, P. Motamedi, M. J. Szczepański, and N. Ludwig, “The relationship between fine particle matter (PM2.5) exposure and upper respiratory tract diseases,” *Journal of Personalized Medicine*, vol. 14, no. 1, p. 98, 2024.

[5] H. A. Shahriyari, Y. Nikmanesh, S. Jalali, N. Tahery, A. Zhiani Fard, N. Hatamzadeh, *et al*., “Air pollution and human health risks: mechanisms and clinical manifestations of cardiovascular and respiratory diseases,” *Toxin Reviews*, vol. 41, no. 2, pp. 606–617, 2022.

[6] A. A. J. Alqdori, “Spatial modeling for predicting and identifying levels of climate-related disease hazards in Iraq using (GIS) Kirkuk as a model,” in *E3S Web of Conferences*, vol. 633, p. 05002, 2025.

[7] S. T. Wafula, A. Nalugya, H. Mendoza, W. K. Kansiime, T. Ssekamatte, A. W. Walekhwa, *et al*., “Indoor air pollutants and respiratory symptoms among residents of an informal urban settlement in Uganda: A cross-sectional study,” *PLoS One*, vol. 18, no. 8, p. e0290170, 2023.

[8] B. N. Aljafen, N. Shaikh, J. M. AlKhalifah, and S. A. Meo, “Effect of environmental pollutants particulate matter (PM2.5, PM10), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO) and ground level ozone (O3) on epilepsy,” *BMC Neurology*, vol. 25, no. 1, p. 133, 2025.

[9] S. Kakavas, O. S. Kotsiou, F. Perlikos, M. Mermiri, G. Mavrovounis, K. Gourgoulianis, and I. Pantazopoulos, “Pulmonary function testing in COPD: looking beyond the curtain of FEV1,” *NPJ Primary Care Respiratory Medicine*, vol. 31, no. 1, p. 23, 2021.

[10] Z. Jia, Z. Ai, and G. Bekö, “The use of respiratory protective equipment redefines breathing zone and increases inhalation exposure of self-exhaled pollutants,” *Building and Environment*, vol. 247, p. 111035, 2024.

[11] S. A. Meo, M. A. Salih, J. M. Alkhalifah, A. H. Alsomali, and A. A. Almushawah, “Environmental pollutants particulate matter (PM2.5, PM10), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and ozone (O3) impact on lung functions,” *Journal of King Saud University-Science*, vol. 36, no. 7, p. 103280, 2024.

[12] P. Devmurari, P. Rathod, C. Patel, and K. Parmar, “Design and testing of breathing retraining device: a multiphasic exploratory study in healthy subjects,” 2025.

[13] S. A. Meo, M. A. Salih, J. M. Alkhalifah, A. H. Alsomali, and A. A. Almushawah, “Environmental pollutants particulate matter (PM2.5, PM10), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and ozone (O3) impact on lung functions,” *Journal of King Saud University-Science*, vol. 36, no. 7, p. 103280, 2024.

[14] A. Gou, X. Zhu, X. Ding, J. Wang, C. Gou, Q. Tan, and X. Lv, "Spatial association between chronic respiratory disease mortality rates and industrial manufacturing enterprises: A case study of Chongqing, China," *Sustainable Cities and Society*, vol. 113, p. 105720, 2024.

[15] G. Polezer, S. Potgieter-Vermaak, A. Oliveira, L. D. Martins, J. C. Santos-Silva, C. A. Moreira, *et al*., "The new WHO air quality guidelines for PM2.5: predicament for small/medium cities," *Environmental Geochemistry and Health*, vol. 45, no. 5, pp. 1841–1860, 2023.

[16] R. Sharma, O. P. Kurmi, P. Hariprasad, and S. K. Tyagi, "Health implications due to exposure to fine and ultra-fine particulate matters: A short review," *International Journal of Ambient Energy*, vol. 45, no. 1, p. 2314256, 2024.

[17] B. A. Kansake, G. B. Sakyi-Addo, and N. K. Dumakor-Dupey, "Creating a gender-inclusive mining industry: Uncovering the challenges of female mining stakeholders," *Resources Policy*, vol. 70, p. 101962, 2021.

[18] H. Su and H. Xie, "Associations between lifestyle habits, environmental factors and respiratory diseases: a cross-sectional study from southwest China," *Frontiers in Public Health*, vol. 13, p. 1513926, 2025.

[19] G. Tomisa, "Exploring the prevalence and influence of risk factors and comorbidities on clinical outcomes in the asthma patient population," Ph.D. dissertation, 2025.

[20] R. J. Laumbach and K. R. Cromar, "Personal interventions to reduce exposure to outdoor air pollution," *Annual Review of Public Health*, vol. 43, no. 1, pp. 293–309, 2022.

[21] Y. Tang, L. Li, W. Hao, H. Xu, and X. Deng, "Screening and identification of key serum biomarkers between PM2.5-induced asthma onset," *Frontiers in Public Health*, vol. 13, p. 1693575, 2025.

[22] G. Shaykhova, I. Sapaev, E. Bekmirzayev, N. A. Khamitdkhanovich, K. Hakimov, and D. Pulatova, "Assessing the impact of environmental factors on animals and their role in causing chronic respiratory diseases including asthma and bronchitis," *Journal of Animal Environment*, vol. 17, no. 2, pp. 218–230, 2025.

[23] L. O. Okeleji, A. F. Ajayi, G. Adebayo-Gege, V. O. Aremu, O. I. Adebayo, and E. T. Adebayo, "Epidemiologic evidence linking oxidative stress and pulmonary function in healthy populations," *Chronic Diseases and Translational Medicine*, vol. 7, no. 2, pp. 88–99, 2021.

[24] S. Beigh, "Elucidating the molecular pathophysiology and mechanistic insights of chronic obstructive pulmonary disease," in *Environmental Toxicants and Lifestyle Diseases*, Singapore: Springer Nature, pp. 315–335, 2025.

[25] T. Chen, F. E. Chen, K. Wang, X. Ma, X. Wei, W. Wang, *et al*., "Acute respiratory response to individual particle exposure (PM1.0, PM2.5 and PM10) in the elderly with and without chronic respiratory diseases," *Environmental Pollution*, vol. 271, p. 116329, 2021.

[26] E. Y. Lee, F. Akhtari, J. S. House, R. J. Simpson Jr., C. P. Schmitt, D. C. Fargo, *et al*., "Questionnaire-based exposome-wide association studies (ExWAS) reveal expected and novel risk factors associated with cardiovascular outcomes in the Personalized Environment and Genes Study," *Environmental Research*, vol. 212, p. 113463, 2022.

[27] Z. Fu, Q. Liu, J. Liang, Z. Weng, W. Li, J. Xu, *et al*., "Air pollution, genetic factors and the risk of depression," *Science of the Total Environment*, vol. 850, p. 158001, 2022.

[28] G. C. Goobie, C. Carlsten, K. A. Johannson, N. Khalil, V. Marcoux, D. Assayag, *et al*., "Association of particulate matter exposure with lung function and mortality among patients with fibrotic interstitial lung disease," *JAMA Internal Medicine*, vol. 182, no. 12, pp. 1248–1259, 2022.

[29] M. Rajesh, R. G. Babu, U. Moorthy, and S. V. Easwaramoorthy, "Machine learning-driven framework for realtime air quality assessment and predictive environmental health risk mapping," *Scientific Reports*, vol. 15, no. 1, p. 28801, 2025.

[30] S. E. Baumeister, T. Kocher, P. N. Papapanou, B. Holtfreter, and R. T. Demmer, "Cross-sectional studies: strengths, limitations, and methodological considerations," *Journal of Periodontal Research*, 2026.

[31] I. Degtiar and S. Rose, “A review of generalizability and transportability,” *Annual Review of Statistics and Its Application*, vol. 10, no. 1, pp. 501–524, 2023.

[32] C. M. Obianyo, V. Ezeamii, O. C. Ekwebene, O. A. Eyeghre, A. Egbuchiem, and L. Okwuonu, “Global air quality trends and their implications for public health: a comparative analysis of industrial and developing nations,” *European Journal Pharmaceutical and Medical Research*, 2025.