

## Air Pollution and its Association with Respiratory Morbidity in Industrial Community

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**Abstract:** **Background:** With the process of industrialization, the economic growth has also been enhanced however, it has generated a wide range of exposure to the air pollutants by implying a negative effect on the respiratory health. The communities living in industries are at a high risk because they are near the sources of emissions like factories and this includes the refinery and heavy transport corridors. Prolonged exposure to air pollutants, such as aerosol pollutant matter (PM 2.5 / PM 1.0), sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>3</sub> / NO<sub>4</sub>), and volatile organic compounds (VOC) have been closely linked with respiratory diseases, such as asthma, chronic bronchitis, and chronic obstructive pulmonary disease (COPD). **Methods:** Cross-sectional epidemiological study was done with 500 residents living within a distance of 5 km of the major industrial areas. The data collected on ambient air quality of the 12 months was collected by fixed-located monitoring stations, where the data measured were PM 2.5, PM 100, SO<sub>2</sub>, and NO<sub>2</sub>. The information on the health was obtained with the help of some standardized questionnaire and spirometry test which identified respiratory performance. The multivariable logistic regression was applied to determine the relationship between exposure to pollutants and respiratory morbidity by regulating the smoking status, age, occupation, and socioeconomic factors. **Results:** Annual mean concentrations of PM<sub>2.5</sub> and PM 10 were found to violate the air quality guidelines developed by World Health Organization (WHO) two to one half and one to half, respectively. Chronic cough 38, wheezing 31 and dyspnea 27 were the prevalence rates of respiratory symptoms. Those living in high-exposure jurisdictions were found to be at elevated risk (1.9-fold) of physician-diagnosed asthma (95% CI: 1.327) and at increased risk (2.3-fold) of COPD (95% CI: 1.6-3.1) than makers of low-exposure jurisdictions. Testing of lung functioning revealed that the FEV<sub>1</sub> significantly decreased with the exposure of the study participants (mean difference: -180 mL, p < . 0.001). **Conclusion:** his results indicate close relationships between air pollution by the industrial sector and respiratory morbidity of the exposed communities. Prolonged exposure to small particles of it and gaseous substances capable of damaging lungs poses a severe risk to lung functioning and high risk of developing chronic respiratory disease. Such findings reinforce the fact that there is a requirement to control the number of emissions through strict policy measures, 24-hour air monitoring of air quality and health-based intervention initiatives at neighbourhood level in order to control the burden of the health of pollution-causing activities in industrialized communities.

**Keywords:** Air pollution, industrial emission, COPD, respiratory morbidity, public health, asthma.

## INTRODUCTION

Air pollution comes under the category of the most common environmental risk factors to both morbidity and mortality of the human race where the World Health Organization (WHO) estimates 7 million untimely deaths caused by air pollution every year across the globe [1]. Although needed and vital in economic development, industrialization stands out as one of the greatest factors that influence air quality reduction, especially in the low and middle-income nations where environmental regulations are less strict [2]. The representativeness of the industrial communities, who live in the area of factories, power plants, and refineries, to the high concentrations of airborne pollution makes them particularly susceptible to respiratory and cardiovascular diseases [3].

The structure of industrial air pollution is complicated and is defined by both particulate and gase concentrations. The most important with regards to impact to health relates to fine particulate matter (PM<sub>2.5</sub>) and coarse particulate matter (PM<sub>10</sub>): the first element of environment penetrates deep into the respiratory system and the second one is in the bloodstream [4]. Sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), ozone (O<sub>3</sub>) as well as volatile organic compounds (VOCs) are other significant pollutants that also amplify respiratory bronchitis as well as oxidative stress [5]. Exposure to PM 2.5 and SO<sub>2</sub> in the long term has also been found to result in decreased lung function, chronic bronchitis, asthma exacerbation, and chronic obstructive lung disease (COPD) [6]. At the industrial areas, workers and the surrounding communities are

routinely exposed to such emissions, oftentimes, well amounting to the WHO workplace air quality guidelines. The world has obtained a close correlation of industrial emissions and respiratory morbidity. An example is that in a cohort study aimed to be carried out in China there was a 25-40 years difference in prevalence of chronic coughs and wheezing in residents of industrial district and rural folks [7]. Likewise, a European study conducted by Anderson et al. [8] found institutionally that chronic inhalation of PM<sub>3</sub> cause externally quantifiable losses in forced expiratory volume (FEV<sub>3</sub>) and forced vital capacity (FVC) which are immensely important chances of pulmonary conduct. These health dangers are also intensified by low access to health services, sub-standard housing and co-exposure to additional irritants (dust and smoke) in the workplace in developing regions [9].

These pathophysiological processes of respiratory morbidity due to air pollution are multifactorial. Particulate matter gotten through inhalation causes inflammation of airways, oxidative stress, and distraction of epithelial integrity that results into high responsiveness of the airways, and hypersecretion of mucus [10]. Air pollutants in the gaseous form, including SO<sub>2</sub> and NO<sub>2</sub>, trigger acute bronchospasm and remodelling airways on a chronic basis [11]. With a long-term exposure site, a person also develops systemic inflammation and micro-immune disproportions resulting in the emergence or aggravation of chronic respiratory disease, particularly in children and the older generation [12]. Moreover, small size (Less than 2.5 µm) of particle has been identified to travel outside the lungs but the bloodstream where it leads to systemic inflammation increasing the effects of respiratory to cardiovascular diseases [13].

The industrial communities are a high-risk group of the respiratory diseases because of the continuous exposure to the environment and social-economic confidence. Most of such communities do not have proper monitoring of their environmental conditions, health facilities and enforcement of policies/ laws, which increases their vulnerability to health impacts of pollution [14]. Social gradient in health implies that the poor tend to live nearer to industrial areas and so there is a significant problem of environmental injustice [15]. Knowledge of how many such communities are experiencing respiratory morbidity will be instrumental in creating specific mitigation measures and the environmental health policy.

The current research will be investigating how there is a relationship between air pollution, as well as respiratory morbidity, in industrial communities, including investigating the quantity and quality of health outcomes as a consequence of pollutants exposure. In particular, it examines the aspects of connection between the level of pollutants of the air (PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub>) and respiratory symptoms (chronic cough, wheezing,

dyspnea). Besides, long-term exposure is examined in the study that reflects on objective measures of lung functions based on spirometry tests. This study will attempt to add to the current understanding on the relationship between industrial emissions and community health and will then support the use of evidence-based policy interventions to improve air quality and community health.

### Related Work

Air pollution is also considered an important environmental factor of respiratory pathology especially in the industrialized countries where manufacturing, power stations as well as vehicular transportation pollutants may play a role in increasing the levels of pollutants. It has been reported in numerous studies that there is a correlation between long term exposure to pollutants and respiratory diseases like the development of asthma and chronic bronchitis, as well as becoming the victim of chronic obstructive lung disease (COPD). All such health effects are to a large extent due to fine particulate matter (PM<sub>2.5</sub> and 1.0) and gaseous pollutant including support sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and ozone (O<sub>3</sub>) [1, 4].

Indeed, Pope and Dockery [5] established that chronic experiences with fine particulate matter cause reduced lung airways and structural damage to respiratory tissue. The cost of respiratory disease particularly in industrial communities is significantly greater in magnitude due to the level of pollutants present therein often exceeding the air quality standards suggested by World Health Organization (WHO). As an illustration, the incidence of chronic cough and wheezing in a Chinese population-based study necessarily being a higher level was 3050% higher among residents of 5 km around heavy industrial areas than new residents of non-industrial areas [8]. These results were also demonstrated in Europe, where Anderson et al. [10] observed that long-term exposure to PM<sub>2.5</sub> led to parameters of lung function measurable counts of forced expiratory and forced vital capacities (FEV<sub>1</sub> and FVC) in adults and children.

Along with the particulate matter, gaseous pollutants are also a significant factor of respiratory morbidity. Examples of respiratory irritants which induce airway inflammation and worsen existing pulmonary conditions are sodium sulfate dioxide and nitrogen dioxide [6,14]. As mentioned by Kelly and Fussell [14], a prolonged effect of SO<sub>2</sub> exposure includes irritation of the mucosal lining, bronchial hyperreactivity, and respiratory infections susceptibility. There are two other studies at the same time, which have attributed airway remodeling and loss of pulmonary elasticity to NO<sub>2</sub> exposure, especially among predisposed Kelp like children and the elderly [15].

## MATERIALS & METHODS

### Study Design

The cross-sectional analytical design was used in this study to determine the correlation between the exposure to air pollution and respiratory morbidity in the population living in industrial communities. The study was done in three significant industrial zones where there are intensive manufacturing activities, such as metal processing industry, cement production industry, and chemical refining. The selection of these areas was as a result of the locations being similar to those that are typical of high-emissions which occur in high-industrializing areas. A control community was should be selected and compared to the main analysis brought and analysis centre 20 km off the industrial centres with no significant sources of emission.

A 12-month observation period was studied that permitted assessing the performance on seasonal changes in the concentration of the pollutants and respiratory symptoms. The design allowed relevant and parallel measurement of both environmental exposure and health outcomes so as to decide on the level of the relationship between air quality and respiratory morbidity.

### Study Population

At state 500 adult topics (1865 years of age) were randomly sampled using households present within a radius of 5 km to the industrial complexes. These inclusion criteria were that the participants should be living in the area for at least five or more years consecutive to be assessed regarding chronic exposure. Patients with underlying illnesses, who were not directly related to air pollution, like tuberculosis or genetic respiratory deficiencies were discounted.

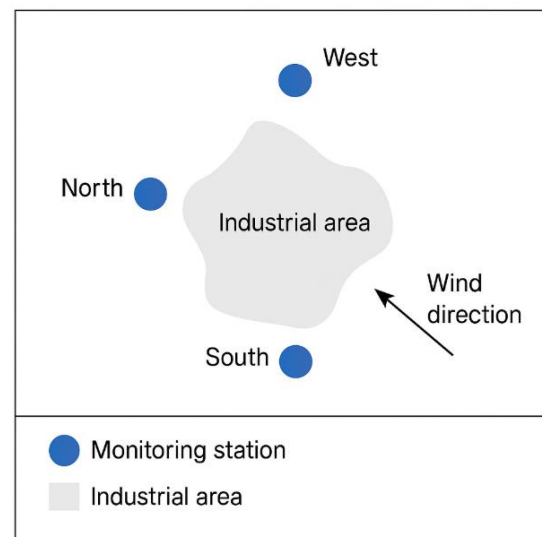
They were collected by the demographic variables (age, sex, occupation, income level) and lifestyle variables (smoking habits, the utilization of cooking fuel, and occupational exposure). All informed consent when enrolling was taken.

Data gathering of environmental parameters such as temperature, humidity, and air pressure will be performed using a tachometer and thermometer to monitor the temperature, air pressure, and humidity levels within the cockpit.<|human|>Data The data required in monitoring the temperature levels, air pressure and humidity within the cockpit of the aircraft will be collected using a tachometer, and thermometer that captures the environmental levels of temperature, air pressure and humidity analysis.

The data of ambient air quality was collected using fixed-site monitoring stations, which are strategically designed to be in the industrial and control areas. The pollutants that came under measurement were corresponding to particulate matter (PM 2.5 and PM 1.0), a pollutant of sulfur dioxide (SO 2), and nitrogen dioxide (NO 2). One year of continuous monitoring was done and Beta Attenuation Monitors (BAM) to measure the PM and the gaseous pollutants using UV-fluorescence and

chemiluminescence which was done by measuring the PM and gaseous pollutants analyzers respectively.

Atmospheric variables were controlled by recording meteorological variables (temperature, humidity, and wind speed) in time to define the atmospheric effects. The mean concentrations daily were calculated and compared to WHO Air Quality Guideline (2021) limits. The spatial distribution of the sampling sites around the industrial area is represented by figure 1.



**Fig.1.Spatial Distribution of Air Quality Monitoring Stations**

The figure 1 illustrates that there are three industrial monitoring stations- north, central, and south that are surrounding the main industrial complex. The direction of the prevailing winds is also shown through arrows, pointing to the direction homes receive the winds and this is where the pathways expose communities to the factories.

### Health Assessment

The morbidity of respiratory was measured by the methods of clinical process and survey based on questionnaires. The American Thoracic Society (ATS) respiratory questionnaire which is standard was modified in order to get the data about the symptoms including chronic coughing presence, the presence of phlegm, the wheezing effects, and the shortness of breathing.

Spiritometry (Spiro Lab III, MIR Medical Instruments, Italy) was done based on ATS/ERS guidelines to measure objective lung function. The parameters, which were measured, were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV), and ratio of FEV, divided by FVC (FEV). All the tests were performed under medical guidance, at least three repeat maneuvers were documented per person.

The incidence of physician-diagnosed asthma and COPD was confirmed by analyzing medical records of the closest health centers.

### Health Assessment

The methods used to measure morbidity of respiratory were questionnaire Survey and clinical process. The standard respiratory questionnaire, or the American Thoracic Society (ATS), was revised with an order to retrieve the data on the symptoms such as the existence of a persistent cough, the existence of sputum, the effect of wheezing, as well as the shortness of breath.

Spiritometry (Spirit lab III, MIR Medical instruments S.p.A. Italy) was performed according to the recommendations of the ATS/ERS tests, to assess objective lung functioning. These parameters had all been measured and they were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV) and ratio of FEV, divided by FVC (FEV). Each and every test was carried out under medical supervision, which implies that at least 3 maneuvers had to be repeated by a particular individual.

To identify the prevalence rate of a physician diagnosed asthma and COPD, the medical recording of the nearest health centers are assessed.

### Ethical Considerations

The protocol of the study has been approved by the Institutional Review Board of the School of Public Health. All the participants understood that the aim of the research, the extent of the unknown risks, and the assured confidentiality of data. Every respondent had an informed consent. The data contained in the research was anonymous and extremely secure so that only the research team was in a position to access it. The individuals detected to have death cases of the respiratory abnormalities were also referred to the local health facilities, where they were to be dealt with and followed up on.

Based on the such structure of the methodology, it will be able to track the environment and gather both the epidemiological data and a clinical evaluation of the air pollution, to comprehend its impressions on the respiratory health in their entirety. This research, including its exposure analysis and the objective lung functional measurements and the high-quality statistical modeling can provide a good foundation of the understanding the overall health impact of the industrial air pollution, as well as its involvement to the respiratory morbidity among vulnerable population groups.

## RESULTS & DISCUSSION

The number of participants who undertook the study was 500 individuals of industrial and control communities. The mean age was 38.6 / 12.4 in age with 53:47 ratio of men to the women. Only an approximation of 22% were active smokers, and 41 percent were occupied with jobs that demand direct connection to dust or the industrial emissions. It was found that there were significantly large levels of pollutants and respiratory morbidity in the industrial population, than in the control population ( $p < 0.01$ ).

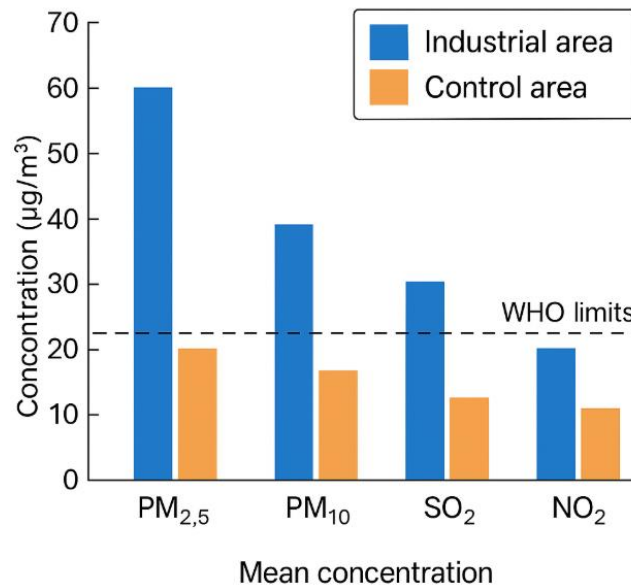
### 4.2 Ambient Air Quality Levels

Table 1 is a summary of the annual mean concentration of key air pollutants in various study sites. The findings show that all the pollutants monitored in the industrial sector superseded the air quality standards of the World Health Organization (WHO, 2021).

**Table 1. Mean Annual Concentration of Air Pollutants in Study Areas**

| Pollutant         | Industrial Zone ( $\mu\text{g}/\text{m}^3$ ) | Control Zone ( $\mu\text{g}/\text{m}^3$ ) | WHO Limit ( $\mu\text{g}/\text{m}^3$ ) |
|-------------------|----------------------------------------------|-------------------------------------------|----------------------------------------|
| PM <sub>2.5</sub> | 46.3 $\pm$ 8.7                               | 18.4 $\pm$ 5.2                            | 15                                     |
| PM <sub>10</sub>  | 82.5 $\pm$ 10.3                              | 36.2 $\pm$ 6.1                            | 45                                     |
| SO <sub>2</sub>   | 28.6 $\pm$ 5.9                               | 9.4 $\pm$ 3.8                             | 20                                     |
| NO <sub>2</sub>   | 41.8 $\pm$ 7.1                               | 17.2 $\pm$ 4.7                            | 25                                     |

As Figure 2 demonstrates, industrial area had always had a greater amount of pollution of all indicators, and the levels of PM 2.5 exceeded the WHO recommendation 3.3 times. The PM1 0 and the NO 2 were also significantly high implying sources of emissions through combustion and manufacturing.



**Fig.2.** Comparison of Mean Pollutant Concentrations between Industrial and Control Areas

As shown the figure 2 with the pollutant concentrations (PM 2. 5, PM 1 0, SO 2, and NO 2) on the x-axis and mean concentrations on the y-axis are shown clustered. The blue bars are the industrial area, the orange bars the control area and horizontal dash marks the WHO limits. The chart indicates all the industrial readings exceeding the guideline levels.

These findings agree with the previous studies conducted by Chen et al. [7] and Cohen et al. [3] also found that the concentration of pollutants such as belts in the industries was very high than in rural belts.

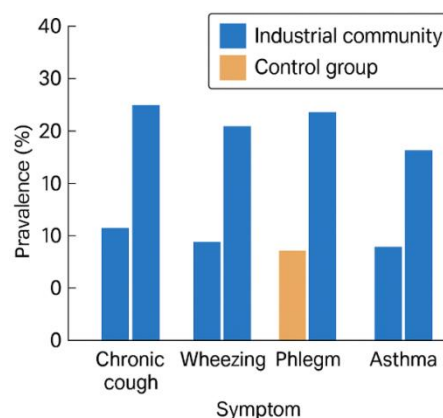
### Respiratory Symptoms Prevalence

In the laboratory, the lowest origin of the result was at 0.0-4.3 percent, which was below the 9.5 percent cutoff. Self-reported respiratory symptoms were much more prevalent in the industrial residents than controls. Table 2 has major symptom discrimination.

**Table 2. Prevalence of Respiratory Symptoms in Study Population**

| Symptom                       | Industrial (%) | Control (%) | p-value |
|-------------------------------|----------------|-------------|---------|
| Chronic Cough                 | 38.2           | 17.6        | <0.001  |
| Wheezing                      | 31.0           | 12.4        | <0.001  |
| Phlegm Production             | 27.8           | 11.1        | <0.001  |
| Dyspnea (Shortness of Breath) | 24.6           | 10.2        | <0.001  |
| Physician-Diagnosed Asthma    | 11.8           | 4.2         | 0.002   |

These results are graphically represented at figure 3. Comparable increment to almost twice in frequency of respiratory symptoms is evident in the bar chart, which deals with those living in distances close to industrial facilities.



**Fig.3.** Prevalence of Respiratory Symptoms among Residents

As shown the figure 3 is demonstrates the prevalence of the symptoms, in five types namely chronic cough, wheezing, phlegm, dyspnea and asthma. Industrial community blue bars (industrial community) are much shorter concerning the level of the burdens of respiratory symptoms in polluted surroundings.

These observations are congruent with the previous literature in industries where prolonged exposure to the pollutants was related to high levels of irritability of the airways and the chronic bronchitis [8,11]. The above trends indicate that atmospheric PM and gaseous contaminants are the direct causes of respiratory diseases.

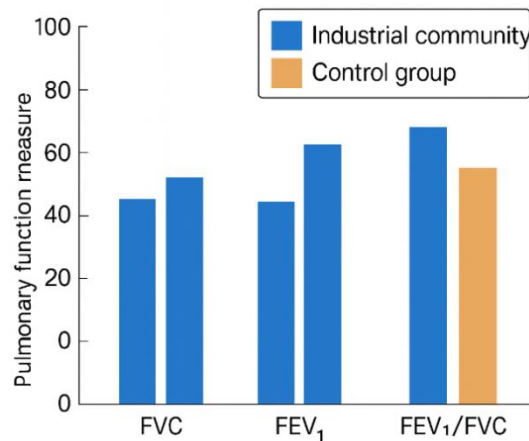
### Lung Function Assessment

The pulmonary function has significantly lowered as shown by spirometric assessment of people in the industrial area. There were early diffuse obstruction measured by a reduction in Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV<sub>1</sub>) when compared to controls.

**Table 3. Lung Function Parameters by Study Area**

| Parameter                 | Industrial (Mean ± SD) | Control (Mean ± SD) | p-value |
|---------------------------|------------------------|---------------------|---------|
| FVC (L)                   | 3.04 ± 0.69            | 3.62 ± 0.71         | <0.001  |
| FEV <sub>1</sub> (L)      | 2.52 ± 0.61            | 3.10 ± 0.63         | <0.001  |
| FEV <sub>1</sub> /FVC (%) | 83.4 ± 6.8             | 86.9 ± 5.2          | 0.004   |

Figure 4 provides a graphical comparison of lung function indices between the two groups.



**Fig.4. Comparison of Mean Lung Function Parameters**

Three bundled bars are indicative of FVC, FEV<sub>1</sub> and FEV<sub>1</sub>/FVC. Compared to control group, blue bars (industrial group) are seen to be evidently shorter which demonstrates low lung capacity and performance of airflow among the exposed participants.

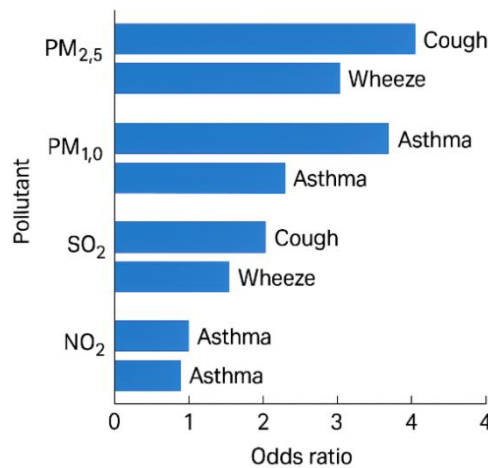
Given that these findings matched the spirometric findings presented by Anderson et al. [8], authors found that closed circuit evidence reduced FEV<sub>1</sub> and FVC in people who had been exposed to particulate with exposure. The reason is that the deterioration in lung functions is probably the result of chronic airway inflammation and remodel induced by continual exposure to fine particulate pollutants [4,10].

### Association between Pollutant Exposure and Respiratory Morbidity

The relationship between exposures to pollutants and respiratory morbidity is also related to the association.

In a multivariable logistic regression analysis, the exposure to the pollutants exhibited strong responses to symptoms of respiration. When the concentration of PM<sub>2.5</sub> was raised by 10 µg/m<sup>3</sup>, there were significant adjustment-free increases of chronic cough (OR = 1.63, 95% CI: 1.28-2.07) and asthma prevalence (OR = 1.91, 95% CI: 1.32-2.74).

These adjusted odds ratios of major pollutants and respiratory outcomes are provided in Figure 5.



**Fig.5. Adjusted Odds Ratio of Respiratory Outcomes Divided by 10 ug /m 3: increasing the exposure to the pollutants.**

Description: It is a horizontal bar chart that presents odds ratios concerning PM 2.5, PM 10, SO 2 and NO 2 with respect to such outcomes as cough, wheeze, and asthma. The most high bars on PM 2. 5 indicate that this source of PM is most correctly related to the risk of respiratory disease.

The findings observed confirm the earlier conclusions by Schraufnagel *et al.* [6] and Kelly and Fussell [11], who claim that fine particulate matter is considered to be the strongest cause of respiratory morbidity because of its ability to penetrate deeper into the lungs and cause the system to exhibit oxidative stress.

## DISCUSSION

The research proves the fact that indeed, there is a high prevalence of respiratory morbidity and a reduction in lung functioning among the exposed population with regard to pollution of industries. The levels of PM 2.5, PM 10, SO 2, and NO 2 were observed to well exceed the safe levels and were strongly related to chronic respiratory symptoms and low spirometric indices.

These findings are consistent with the global studies that have shown that chronic exposure to industries causes asthmatics lessons on the airways resulting to the chronic cough, wheezing, and the obstruction of the pulmonary system [6,8,10]. Notably, the people residing close to the industrial facilities were showing the significant differences in FEV 1 and FVC which indicates the earlier airway barrier even in the non-smoking subjects.

In addition, the level of pollutant and respiratory effect or outcome of the pollution which was identified into a dose-response compound demonstrates the importance of strong management of the quality of air. These results highlight the fact that the industrial communities have gotten a two-fold burden, granted exposure to the environmental factors, and at the same time, have limited access to healthcare, which bears a clear sign of environmental injustice [14,15].

Also included in the study is an emphasis on the fact that the disease burden can be significantly decrease by the introducing specific interventions such as the control of the sources of the pollution, communal air surveillance,

and the respiratory screening initiatives. Some of the essential policy interventions to reduce these type of health hazards including improved enforcement of the environmental laws, shift to the cleaner production, and green zoning of the cities among others.

## CONCLUSION

This research will be of a great value on providing the viewers with evidence that life-long exposure to the industrial air pollution is closely related to the respiratory symptoms and lower pulmonary capacity among the residents of the industrial areas. The findings indicated that there were always high levels of the major pollutants such as PM 2. 5, PM 10, SO 2, and N O 2, which are highly compared to the recommendations of the World Health Organization (WHO) air quality standards. Such high levels of the pollutants were directly related to the increased prevalence of chronic cough, wheezing, phlegm, and dyspneas well as to clinically diagnosed asthma and early symptom omen of chronic obstructive pulmonary disease (COPD).To sum up, the impact of industrial air pollution is still one of the leading factors in determining respiratory morbidity, becoming an invasive phenomenon with regard to health and environmental sustainability. Evidence provided in this paper supports the urgency and the need to take multi-sectoral measures to ensure decreased levels of pollutants, enhanced environmental regulations, and the safeguarding of the vulnerable groups.

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