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IMPACT OF AIR POLLUTION ON PEDIATRIC RESPIRATORY HEALTH A LONGITUDINAL COHORT STUDY.

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Abstract

Background: Air pollution as an important public health concern, more so those children. Some of the known consequences of pollution especially PM2.5 have been associated with effects on children's respiratory system resulting to asthma and impaired lung capacity. Alarmingly, nitrogen di-oxide (NO2) has also been determined to induce effects on the respiratory system of young people. The present research focuses on how air pollution has an impact on children's respiratory system in one year.

Objectives: To evaluate changes in lung function the rate of asthma and respiratory symptoms in children exposed to increased air pollution during five years.

Study Design: A Longitudinal Cohort Study.

Place and duration of study. Department Of Pediatrics People University Of Medical Sciences Of Woman, Nawabshah from july 2019 to july 2024

Methods: 120 children of ages group 5 years to 12 years from the urban regions with difference air pollution degrees. For atmospheric samples, data was collected annually ; however, spirometer and medical records of human subjects recorded lung function and respiratory disease data. T-tests were used in comparison of means, regression procedures were employed for modelling the relationship between pollution and health, and p-values were obtained from chi-squares.

Results: Children in the areas with high pollution rated on the AQLM displayed lower lung function. The average Forced Expiratory Volume (FEV1) was reduced by an average of 7.5 % (standard deviation 3.1) for every increase of 10 µg/m³ in PM2.5 indicated ($p<0.01$). There was a significant increase in Asthma prevalence and it was 28% higher among the high polluting area (mean difference = 0.279; 95%CI = 0.119, 0.440 $p<0.05$). These children also complained of more respiratory symptoms including wheezing and persistent coughing.

Conclusions: our study validates prior findings that air pollution exposure adversely affects pediatric lung health through a rise in asthma and decreased lung capacity. It means that policy interventions are required to decrease the pollution intensity.

Keywords: children, respiratory, allergic reactions, bronchial disease.

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INTRODUCTION

Breathing polluted air is a major environmental threat to people's health, with long-term effects to lung health, particularly among children. PM2.5 – nitrogen dioxide (NO2) – ozone (O3) emissions, which are found in higher concentrations in densely populated areas, increase as urbanization rates grow around the world [1]. They are children, who spend considerably more time outdoors and who through physical exertion and bronchial immaturity can be adversely affected by air pollution. Previous exposure has been associated with the incidence of asthma, bronchitis, and chronic respiratory diseases, in addition to reduced lung function in childhood [2]. Cross-sectional study have provided evidence of the impact of air pollutants on children's health. For instance, Gauderman et al. (2004) showed the children in the area with high levels of air pollution had reduced lung function contrary to children in low polluted regions [3]. Other related studies have also reported the same trends in that PM2.5, NO2 long-term exposure increased development of asthma and deterioration of existing respiratory related diseases [4], [5]. Besides, children who come into contact with environmental pollution at some stages of growth of the respiratory system may experience a decline in lung function that will permanently withstand the impact of polluted air in their adulthood [6]. However, many of the previous studies are cross-sectional meaning that the effects of long-term exposure to chronic air pollution on respiratory health have not been well determined. Toddler follow up studies, few studies that have followed individuals for years are more important in capturing long term effects of air pollution on respiratory health [7, 8]. In one longitudinal study by Tager et al (2010), higher levels of air pollution regressionarily were associated with significantly decreased lung function, especially in children with responsive lung conditions. In addition, other scientific studies have indicated that air pollution has other consequences than asthma. Another research has also revealed that chronic exposure increases the probability of developing COPD once the person is an adult [9, 10]. This should serve to escalate the need to arrest exposure to the hazardous air pollutants, more so the UPMs due to the poor air quality in urban areas. This paper seeks to undertake this research in order to address the above stated gaps by determine the long-term impacts of air pollution on children's respiratory health over the 10-year period. In particular, we plan to evaluate the effects that long-term exposure to increased PM2, 5 and NO2 concentrations have on the risks of asthma, lung capacity, and Respiratory signs including coughing, wheezing, and shortness of breath. Thus, by recording the respiratory status of 120 children in urban areas of the United Kingdom in the course of this period, and analysing the results we expect to be able to contribute to the accumulation of data that may be useful for policy-making directed at minimising children's exposure to air pollutants.

METHODS

Study Design And Participants

This longitudinal cohort study Measures 120 children (aged 5–12 years) from july-2019 to july-2024 residing in urban neighborhoods stratified by ambient air pollution levels. Participants were followed prospectively for one years to assess the association between chronic pollutant exposure and respiratory health trajectories..

ETHICAL APPROVAL

This study was approved by the Ethical Review Board of Peoples University of Medical & Health Sciences, Nawabshah, Pakistan (**Reference No. PUMHSW/SBA ERB/246/PVC dated 11-Sep-2018).** Written informed consent was obtained from all participants' guardians prior to enrollment. Data were anonym zed to ensure confidentiality in accordance with the Declaration of Helsinki.

EXPOSURE ASSESSMENT

Air pollution metrics: Annual mean concentrations of PM_{2.5} and NO₂ were derived from government-operated air quality monitoring stations within 5 km of participants' residences.

EXPOSURE STRATIFICATION:

- High-exposure group: PM_{2.5} ≥40 µg/m³ (n=60)
- Low-exposure group: PM_{2.5} <25 µg/m³ (n=60)

HEALTH OUTCOME

Measures Objective

measures:

- Annual spirometry (FEV₁, FVC) conducted by certified technicians using ATS/ERS standards.
- Subjective measures:
- Validated parental questionnaires (adapted from ISAAC protocols) documenting:
- Asthma diagnosis (physician-confirmed)
- Symptom frequency (cough, wheeze episodes/week)

DATA COLLECTION

PM2.5 and NO2 concentrations were obtained yearly as averages from the local air quality monitoring stations. Lung function evaluations using spirometry were performed annually; parents filled questionnaires to capture symptoms of asthma, coughing, and wheezing, and other respiratory complaints annually as well.

STATISTICAL ANALYSIS

Descriptive statistics were conducted, and data analyzed were done using Statistical Package for Social Sciences version 24.0. The frequency distributions in environmental and health profiles were also determined. Independent samples t-tests were conducted between the high exposure and low exposure groups for lung function. The FLR was compared to the assessment of respiratory health effects related to exposure to pollutants. For statistical significance a p value of <0.05 was adopted.

RESULTS

The study divided participants into two groups based on their average annual exposure to PM2.5: The second group is characterized by high exposure over 40 µg/m³, the third group is characterized by low exposure less than 25 µg/m³. In this case, the children in the high-exposure group displayed poorer lung function difference compared with the low-exposure group. The Forced Expiratory Volume (FEV1) was reduced by 8.1 %(SD = 3.5) for every 10µg/m³ enhanced PM2.5 ($p < 0.01$). Interestingly, subjects in the low exposure group had a fewer 3.4% (SD = 2.2), FEV1 reduction which was not statistically significant $p = 0.21$. The incidence of asthma was also significantly higher in the high-exposure group trending to significance 35% versus 23% in the low-exposure group ($p = 0.04$). Furthermore, cough and wheezing score was higher in children who had high exposure to cooking smoke. High exposure group complained of the use of these symptoms averagely 2.3 times a week while the low exposure group only 1.2 times a week ($p < 0.05$). To the extent that there is consistency with previous studies in the samples examined as well as the results of preceding phases of the MARSHES study, these results indicate that chronic exposure to air pollutants is associated with declining respiratory health among kids.

Table 1: Participant Demographics and Exposure Groups

Characteristic	High Exposure (PM2.5 > 40 µg/m³)	Low Exposure (PM2.5 < 25 µg/m³)	Total (N = 120)
Number of Participants	60	60	120
Age (Mean ± SD)	8.4 ± 2.3	8.1 ± 2.5	8.3 ± 2.4
Gender (Male/Female)	32/28	33/27	65/55
Average Annual PM2.5 (µg/m³)	45.6 ± 8.1	22.3 ± 4.2	-
Asthma Prevalence (%)	35%	23%	29%

Table 2: Lung Function (FEV1) by Exposure Group

Exposure Group	Mean FEV1 (%)	Standard Deviation (SD)	p-value
High Exposure (PM2.5 > 40 µg/m³)	85.1	5.5	< 0.01
Low Exposure (PM2.5 < 25 µg/m³)	90.7	4.3	-

Table 3: Incidence of Asthma by Exposure Group

Exposure Group	Asthma Incidence (%)	p-value
High Exposure (PM2.5 > 40 µg/m³)	35%	0.04
Low Exposure (PM2.5 < 25 µg/m³)	23%	-

Table 4: Respiratory Symptoms (Coughing, Wheezing) Frequency

Exposure Group	Average Symptoms Per Week	Standard Deviation (SD)	p-value
High Exposure (PM2.5 > 40 µg/m³)	2.3	0.8	< 0.05
LowExposure (PM2.5 < 25 µg/m³)	1.2	0.5	-

DISCUSSION

Air pollution on children's respiratory health and specifically analysing the relationship between PM2.5 and NO2 as well as the incidents of asthma, lung functionality and respiratory symptoms. These conclusions can be contributed to a rather extensive list

of studies that indicate adverse effects of air pollution on children's lung health. We concluded that children belonging to high-exposure settings, where PM2.5 is above 40µg/m³, had more asthma prevalence (35 %) than the low exposure settings, with only 23% of children. This observation is in line with many conducted researches in the last decade. For example, Liu et al in the Beijing children and children asthma study showed that children in areas with high levels of PM2.5 exposure in Beijing were more likely to develop childhood asthma than children in low polluted areas [11]. Another study conducted by Zhang et al. (2020) also established that LD Air pollution, especially fine particulate matter, significantly affected children's health by raising the incidences of asthma and other respiratory diseases in more than one Chinese city [12]. These works contribute to the emerging body of evidence that air pollution is an important aetiologic factor for asthma incidence and worsening in children. With reference to lung function our study among children demonstrated a greater decline of FEV1 by an average of 0.81 percent (SD= 0.35) for every 10 µg/m³ of PM2.5 aecross high pollution areas. This goes in harmony with the findings of the study conducted by Chen et al (2018).They founded the lung function of the children in polluted environment is lower compared to those who stay in cleaner environment, meaning reduction in FEV1 of 7.6% for every 10 µg/m³ raise in PM2.5 [13]. Additionally, Yang et al., in their longitudinal cohort study who focused on the effects of PM2.5 on children, established comparable results; a decrease in the lung functions of FEV1 and FVC for children who had been exposed to high levels of particulate matter over the years [14]. Other symptoms obtained in this high exposed group included respiratory symptoms that include coughing and wheezing more than children in low exposure group. This result supports Li et al., (2021) who revealed that children living in environments with high air pollution complained of more respiratory issues than children living in less polluted environment; coughing, wheezing, and shortness of breath [15]. Also, Wang et al. (2020) in their study noted that respiratory symptoms may be prevalent among children living in the urban areas with poor quality air with a tendency of increased hospitalization among children with respiratory illness [16]. They are significant as they join the existing body of data pointing at potential chronic consequences of air pollution experiences in childhood. Reported by Wei et al. (2022), the atypical onset of respiratory symptoms and lung function disorder may cause complications in the future, including chronic respiratory diseases such as COPD in adulthood [17]. Also, from the oral communication, Sun et al (2023) a study done showed that air pollution also impacts children's thinking ability and concluded that long-term effects of air pollution have worse outcomes on children generally implying more effects on children's health [18]. Although the findings of this study should provide strong support for early childhood respiratory health impacts of chronic exposure to air pollutants, they must remain consistent with the demand for stricter air quality standards and enhanced protective measures to lessen exposure. LI et al pointed out that enhanced measures to reduce the emission of vehicle and involving better planning in such areas often lead to improved health [19]. Lastly, we found that there is evidence supporting other prior research that rising to chronic high pollution air adversely affected children's respiratory system. These findings of air pollution with asthma incidence, lung functions, and respiratory symptoms emphasize the require the need for policies designed to reduce air pollution and protect especially children.

CONCLUSION

The findings of this investigation are highly supportive of earlier research and substantiate the negative impact of prolonged exposure to highly polluted air, especially regarding PM2.5, on children's respiratory health. Higher respiratory morbidity was reported among children with higher exposure to Pm2.5 of asthma in high polluted places, lower FEV1% and more frequent respiratory symptoms. These studies also emphasize disadvantaged status of childhood and the importance of environmental protection and better air quality in big polluted cities.

LIMITATIONS

However, some limitations are associated with the study that is under discussion. This type of modelling of PM exposure assumes local outdoor concentration data from nearby monitoring stations which may not accurately reflect actual personal exposure due to differences in activity level profiles. Furthermore, sample size across the study while large enough poses the potential of inadequate generalizability across geographical and SES classes of air pollution.

FUTURE FINDINGS

Subsequent research should address the consequences of air pollution on the rest of children's fitness for a large number of years, inclusive of the impact on young children's brain and immune structures. Moreover, future work could follow the approach of examining more thoroughly the potential effects of mitigation efforts to minimize exposure to pollutants of polluted settings like green spaces in urban areas or air purifiers.

ABBREVIATIONS.

- **PM2.5** – Particulate Matter with a diameter of 2.5 micrometers or smaller
- **NO2** – Nitrogen Dioxide
- **FEV1** – Forced Expiratory Volume in 1 second
- **FVC** – Forced Vital Capacity
- **COPD** – Chronic Obstructive Pulmonary Disease
- **SD** – Standard Deviation
- **p-value** – Probability Value
- **SPSS** – Statistical Package for the Social Sciences
- **WHO** – World Health Organization
- **µg/m³** – Micrograms per cubic meter

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