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ORIGINAL ARTICLE

THE EFFECTS OF PARTICULATE MATTER ON RESPIRATORY TRACT DISEASES IN RESIDENTS OF PESHAWAR CITY

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ABSTRACT

Background: Air pollution, a global concern with an annual emission of 600 million tons of pollutants, poses a significant health threat, particularly in cities like Peshawar. Our objectives were to study the nature and distribution of particulate matter (PMs) in the air of fourteen sites in Peshawar city and assess its association with respiratory symptoms and peak flow.

Materials & Methods: This study selected 14 sites in Peshawar for air sampling. Air quality was assessed for PM 1-10, Cadmium, and lead in milligrams/m^3 of the air through a device called High volume Air sampling system (PM 10-4200 AFC, HI-Q Environmental Health Services, San Diego, California USA). By systematic random sampling, one hundred and eighteen individuals were questioned on these 14 sites for their demographic details and respiratory symptoms through a structured questionnaire. The researchers measured the peak flow through a portable Mini-Wright peak flow meter. SPSS version 20 conducted the statistical analysis. The chi-square test and Pearson's correlation test were applied. The criterion standard for the p-value was less than 0.05.

Results: In a study involving 118 individuals from diverse professions in Peshawar, evaluated air pollutant levels, particularly PM1-10, lead, and Cadmium, exceeded WHO recommendations. The active cough was the predominant symptom in 55% (n=66) of the study sample. In contrast, 54% exhibited lower-than-predicted peak flow values, clinical symptoms like cough, impaired exercise tolerance, and exposure to pets correlated with reduced peak flow. Positive correlations were found between peak flow and age and inverse correlations with symptom duration.

Conclusion: Particulate matter in the air of Peshawar city is higher than the upper limits recommended by the WHO. This bad air quality in Peshawar affects its residents through active coughing and low peak flow readings, amongst many other respiratory problems.

KEY WORDS: Particulate matter; Cadmium; lead; Peak flow; Respiration; Breathing; Cough.

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INTRODUCTION

Clean air, which is necessary for the well-being of the human population, is at risk due to widespread air pollution, resulting in a multitude of health hazards that vary from trivial eye itching, infections of the upper airways, and chronic lung and cardiac diseases to cancers, leading to possible hospitalization and even death.[1] Airborne particulate matters (PM) like PM10, PM2.5, and ultrafine particles, with diameters <10 micrometers, are significant contributors.[2] Current data reports a staggering annual emission of 600 million tons of air pollutants worldwide.[2] This tremendous number of pollutants causes a rising trend in hospitalization, clinician appointments, academic absenteeism, and life-threatening respiratory crises worldwide.[3]

Understanding the direct link between pulmonary disorders and air pollution is challenging. Studies highlight the increasing significance of outdoor air pollution, particularly traffic-related, in developed and underdeveloped areas.[4] Recent studies identify substandard air quality as a significant contributor to morbidity and mortality, surpassing obesity, passive

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smoking, and road traffic accidents.[5] International studies, including a 2015 meta-analysis in Beijing, underscore the significant impact of pollutants like PM10, carbon monoxide, and nitrogen dioxide on daily respiratory mortality.[6] European estimates attribute approximately 400,000 premature deaths to air pollution.[7]

In 2017, air pollution ranked as Pakistan's top environmental factor for deaths and disabilities by the Institute for Health Metrics and Evaluation and the fifth-highest factor overall.[8] The specific mortality from respiratory diseases lacks clarity, with a 2006 report from Pakistan EPA/World Bank estimating 22,000 adults and 700 children's annual deaths from PM exposure, incurring a health cost of 62-65 billion Pakistani rupees, about 1% of the GDP.[9]

Living in highly polluted cities, Peshawar residents are vulnerable to respiratory disorders. A study is needed due to scarce data on air pollution and its impact. The study will analyze air pollutants and respiratory diseases, filling the gap in existing knowledge and providing directions for future work. Our objectives were to study the nature and distribution of particulate matter (PMs) in the air of fourteen sites in Peshawar city and assess its association with respiratory symptoms and peak flow.

MATERIALS AND METHODS

This quantitative descriptive study, conducted from 20-3-2022 to 30-9-2022, employed systematic random sampling to select every fifth eligible participant, resulting in a sample size of 118, calculated with http://OpenEpi.com with a prevalence of 15% and a confidence limit of 95% utilizing the reference of Sanaullah.[10] The study included individuals residing or working in the designated population for at least five months, irrespective of age or gender. Exclusions comprised those failing to meet the criterion and unwilling short-term visitors. Ethical approval was obtained from the Ethical Board (BLINDED FOR REVIEW) (148/DME/BLINDED; dated 17-3-2022), with informed consent from participants.

A specially designed questionnaire covered demographic data, smoking habits, air pollutant exposure, occupational and medical history, respiratory symptoms, and medications. Lynn criteria were utilized for validation with a threshold of 0.80 by six subject experts.[11]

Air samples were collected from 14 significant traffic stops in Peshawar (Figure 1), based on heavy traffic load, high population density, commercial/industrial hubs, and elevated air pollution levels as per the record of the University of Peshawar, accessed on 15-8-2022.[12] For each site, a single specimen was organized for 8 hours per working day (excluding Sundays and gazetted holidays). These sampling sites were: Karkhano Bazaar stop, Board Bazaar stop, Peshawar University stop, Abdara Road stop, Tahkal stop, Saddar stop, Dabgari Garden stop, Kohat Road stop, Pishtakhara stop, Hazar Khwani stop, Haji Camp stop, Gulbahar stop, Firdous stop and Charsadda Road stop.

Air samples for Pb and Cd analysis underwent meticulous procedures. Collected in polythene bags, they were labeled and stored at room temperature. Toxic metals were extracted using standard procedures, and concentrations were quantified by atomic absorption spectrophotometry. Laboratory apparatus underwent thorough cleaning with Nitric acid, tap water, and distilled water before being dried and stored. Filter paper, digesting with Nitric and Hydrochloric acid before undergoing boiling and cooling, and the digests were filtered, diluted to 1000 ml, and analyzed for elements of interest using an Atomic Absorption Spectrophotometer (AAS-700, Perkin Elmer USA) at PCSIR. PMs of sizes 1 and 10 micrometers were calculated using a high-volume air sampling system (PM 10-4200 AFC, HI-Q Environmental Health Services). Participant respiratory diseases were assessed via spirometry tests using a Mini-Wright Standard Peak Flow meter (Clement Clarke Ltd, Harlow, UK).[13]

Data collected were evaluated utilizing the Windows version of IBM SPSS Statistics 20 (IBM Corporation, Armonk, NY; IBM Corp., 2018 release). Data were presented as tables, graphs, and charts. Low peak flow values were stratified amongst different clinical symptoms, and associations were determined using the Chi-squared test. Pearson's correlation test was utilized to assess any association between the peak flow readings of study participants and the quantity of particulate matter in the air. A *p*-value of less than 0.05 was considered the criterion standard.

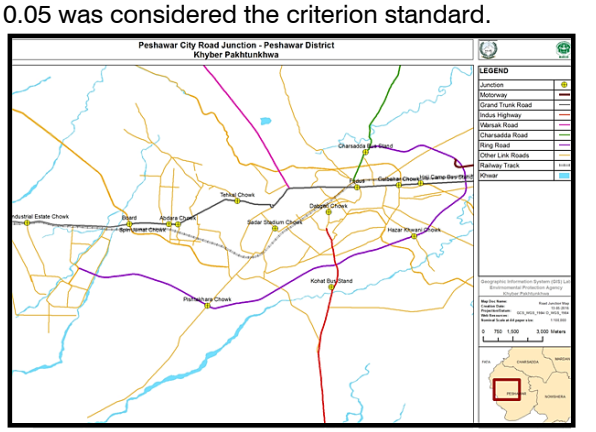

Figure # 1. Selected 14 Sites for Air Sampling in Peshawar

RESULTS

One hundred eighteen individuals were interviewed at 14 different locations of district Peshawar. The mean age (years) was 33.22 ± 9.64. Most participants belonged to professions with maximum dust exposure (Table 1). Eighty-nine subjects (75%) in the study reported exposure to dust almost always daily.

However, 25% (n=29) of the participants had intermittent or occasional exposure to dust and dirty air.

The mean peak flow (L/min) was 406 ±123. Sixty-four (54%) study participants had lower than predicated peak flow values, while fifty-four (46%) had peak flow values within the normal range. Low peak flow values were stratified amongst different clinical symptoms, and the association was determined using the Chi-squared test (Table 2).

Notably, all the air pollutants under the current study (PM 1-10, lead, and Cadmium) had values higher than the upper reference range recommended by WHO (Table 1). The concentrations of PM1-10, Cadmium, and Lead at different locations are given in Table 3.

Table 1: Descriptive statistics of participant-related continuous data

Variables	Mean	SD	Occupation (n)	Comorbidities (n)
Age	33.22	9.64		
Duration of chest symptoms (months)	4.16	4.73	Engineer (4)	Infective chest diseases (12)
Peak flow meter (L/min)	405.89	123.31	Labourer (35)	Airway diseases (12)
All particulate matter (mg/m^3)	8.93	1.86	Mechanic (7)	Others (5)
Cadmium(mg/m^3)	0.79	0.36	Driver (38)	
Lead(mg/m^3)	31.64	4.76	Shopkeeper (14)	
			Others (20)	
			Total (118)	

Table 2: Stratification of low peak flow reading concerning different clinical characteristics by using the Chi-squared test

Symptom	Yes (%)	No (%)	P value
Active cough	70	30	<0.001
Hemoptysis	30	70	0.01
Sputum Production	58	42	0.46
Dyspnea	56	44	0.79
Exercise tolerance	41	59	0.02
Smoking	65	35	0.04
Contact with pets (last year)	69	31	0.04
Contact with TB patients (Last year)	45	55	0.36

Table 3: Quantities of different types of particulate matter (PM) in the air samples of 14 study sites

SITES	PM10 (mg/m^3)	PM2.5 (mg/m^3)	PM1 (mg/m^3)	PM1-PM10 (mg/m^3)
Saddar stop	3.58	5.18	3.38	12.14
Board bazaar stop	2.69	2.35	2.54	7.58
Karkhano bazaar stop	2.91	2.64	1.78	7.33
Charsadda road stop	4.38	4.30	3.69	12.37
Kohat Road stop	4.20	3.32	3.18	10.7
Dabgari Garden stop	3.07	3.38	3.06	9.51
Pishtakhara stop	1.73	1.76	1.81	5.3
Tahkal stop	3.15	2.81	2.89	8.85
Hazar khwani stop	2.86	2.83	2.69	8.38
Haji camp stop	3.43	2.86	2.49	8.78
Firdous stop	3.06	3.13	2.95	9.14
Abdara Road stop	3.19	2.74	2.30	7.96
University stop	2.79	2.68	2.52	7.99
Gulbahar stop	2.87	3.24	2.90	9.01

Table 4: Pearson's correlation of peak flow readings (L/min) with different parametric variables

		PM 1-10	Cadmium	Lead	Age	Duration of symptoms
Peak flow	r value	-0.20	0.32	-0.25	0.22	-0.22
	P value	>0.05	>0.05	>0.05	0.02	0.01

Pearson's correlation test was used to assess any association between peak flow readings and the quantity of particulate matter in the air. Peak flow had a positive relationship with the age of the participants ($p = 0.02$). In contrast, the duration of chest symptoms (months) had a statistically significant inverse correlation with the peak flow of the study subjects ($p = 0.01$) (Table 4).

DISCUSSION

Our study's mean peak flow (L/min) was on the lowest normal side, with 54% (n=64) having absolute low peak flow readings. The number of air pollutants, participant age, and symptoms influenced peak flow. Active cough, inability to exercise, hemoptysis, smoking, and contact with pets showed statistically significant associations with peak flow values.

In our study, particulate matter was negatively correlated with peak flow readings, though statistically insignificant. Comparable findings were noted in studies by Tanzina Akhtar and Shatabdi Roy, indicating the harmful effect of particulate matter on lung functions.[14,15] A study conducted on older patients in Taiwan illustrates exposure to PM2.5 causes a decrease in the vital capacity of lung function, while PM 2.5-10 negatively affects conductive airway function.[16]

All PMs (PM 1-10, Cadmium, and lead) had mean values higher than WHO recommendations, with the highest concentrations on Kohat Road. Our study aligns with Bahadar Zeb, stating that PM2.5 and PM10 values in Peshawar are 11-13 times higher than WHO recommendations.[17] Our findings also correspond with Hussain Majid, reporting higher PM10 and lead concentrations than EPA Pakistan's recommended values.[18] However, our study noted values lesser than Alam K, possibly due to differences in study duration and sampling sites.[19] A study conducted by Afifa Aslam et al. in Faisalabad city of Pakistan, also documents the values of PM2.5, PM10, and CO higher than recommended by US-EPA and NEQs.[20]

Our study findings are almost comparable with a study conducted by Mohammad Ali Awan, who determined the concentration of particulate and heavy metals in ambient air of the four main cities of Pakistan, namely Islamabad, Gujranwala, Faisalabad, and Bahawalnagar.[21] However, our findings are much higher than those reported by Colbek I, which measured only PM10 in Peshawar during 2004.[22] Higher values of PMs are documented in various national studies conducted in different cities of Pakistan.[23]

It is noteworthy that asthma and COPD (Chronic obstructive pulmonary disease) were the most likely leading diagnoses in the participants of this study. However, the researcher failed to detect any direct relationship between air pollutants and asthma and COPD, although smoking is documented in nearly half of the study participants.

Utilizing a portable peak flow meter may not be as reliable as laboratory measurements. The Miller RM protocol was followed to minimize this confounder bias for these devices' calibration and validation.[24]

Limitations: This study lacks a control group, and the possibility of confounding factors. It does not account for factors such as the participants' socioeconomic background, which could influence their access to healthcare or exposure to indoor air pollutants. This research is a cross-sectional work, so it failed to document any relationship between PMs and malignancies of the lung and PMs and ILDs (Interstitial lung diseases). Longitudinal and meta-analytical studies will be required to find out this relationship. Future studies should focus on large prospective cohorts with randomization and robust statistical tools, including subgroup analysis and regression analysis, for better comprehension of statistical correlation, validation, and generalization of study findings.

Recommendations: Considering air pollution's significant impact, urgent measures are required. Individuals with respiratory issues should consider changing occupations to mitigate continuous exposure. Governments must enact stringent air quality legislation, offer financial incentives for low-emission products, enhance vehicle emission monitoring, enforce existing legislation, and educate the public on health and environmental consequences. Heightened taxation on air-polluting activities, traffic limitations, and stricter monitoring of industrial emissions are imperative.

CONCLUSION

Particulate matter in the air of Peshawar city is higher than the upper limits recommended by the WHO. This bad air quality in Peshawar city is affecting its

residents through active cough and low peak flow readings, amongst many other respiratory problems.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	SS, IH
Acquisition, Analysis or Interpretation of Data:	SS, IH, MO, UN
Manuscript Writing & Approval:	SS, IH, MO, UN

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.