

Original Research Article

Comparative assessment of Industrial air pollutant exposure on pulmonary function and respiratory symptoms among primary school children, Kala Amb, Sirmour, Himachal Pradesh, India

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ABSTRACT

Background: Outdoor air quality has been connected with the prevalence of allergic respiratory infections in children. The impact of industrial pollution on respiratory health during early years of life in school children is a major concern. Pulmonary function tests can be used to assess the impact of air pollution and the degree of airway reactivity.

Methods: A cross sectional comparative study was conducted between Primary school children aged 6 to 10 years in the industrial area and non-industrial area. Structured questionnaire based data was recorded from the students regarding respiratory symptoms. Spirometric parameters recorded were Forced Vital Capacity (FVC), Forced Expiratory Volume at one second (FEV1), Maximal Midexpiratory flow (FEF 25-75%) and Peak Expiratory Flow Rate (PEFR).

Results: Data from 102 students from each of the two primary schools revealed mean forced expiratory volume in 1 second (FEV1) as 1.01 ± 0.31 L/sec in industrial area and 1.12 ± 0.34 L/sec in non-industrial area ($p=0.01$). Four or more episodes of allergic rhinitis in the last year were present in 24/84 (28.5%) children in the industrial area as compared to 8/90 (8.8%) in the non-industrial area ($p=0.002$). Point prevalence of allergic rhinitis was 36 (35.3%) students in industrial area and 22 (21.6%) students in non-industrial area ($p=0.03$).

Conclusions: Industrial air pollution has impact on the lung function tests of school children in the age group of 6 to 10 years with significant difference in spirometric parameters of FEV1, frequency of episodes of allergic rhinitis and point prevalence of allergic rhinitis.

Keywords: Lung function, Respiratory symptoms, Spirometry

INTRODUCTION

Respiratory diseases are a major cause of poor health in children. In developing countries they are the most important cause of childhood morbidity and mortality resulting in an extensive use of drugs and medical services.¹ Poor outdoor air quality, exposure to indoor allergens have been connected with the prevalence of asthma and allergic rhino conjunctivitis in children.² Children are in general more exposed to outdoor air

pollution because of greater time spent outdoors and also enhanced physical activity as compared to adults. Respiratory tract symptoms are particularly prevalent in young children as compared to adults.³ The lack of a fully developed pulmonary metabolic capacity in children make them more susceptible to air pollutants compared with adults.⁴ Pulmonary function tests can be used to assess the impact of environmental factors (e.g. air pollution) and the degree of airway reactivity by using spirometer. These parameters are influenced by weight,

height, age, sex, ethnicity, patient cooperation, effort and technical factors. Epidemiological studies have found a significant positive correlation between environmental pollution and decreased pulmonary functions.⁵

Passive smoking is increasingly recognized as an independent risk factor for its detrimental effect on respiratory health of children. Research conducted now a days mainly focus on the association of respiratory health and emissions from traffic, smog, indoor air pollution etc. However, the impact of industrial pollution on respiratory health during early years of life of school children is less often explored.⁶⁻⁹

The impact of localised air pollution from industry on health of school going children is a major concern. Hence, the present study was planned to compare the Industrial air pollutant exposure on pulmonary function and respiratory symptoms between primary school children, North India.

METHODS

A cross sectional comparative study was conducted among Primary school children in the age group of 6-10 years in industrial area, Kala Amb, Distict Sirmour, Himachal Pradesh, India.

Ethical committee approval from the Institutional Ethical Committee and permission from deputy director elementary education of the respective district was sought prior to initiation of the study. Two government schools were randomly selected from study area with one each from industrial (exposed group) and non-industrial area (Comparative) group.

Location of the school was recorded in Epicollect 5 and then google mapping was done. The aerial distance between the two school sites was 8 km (Figure 1).

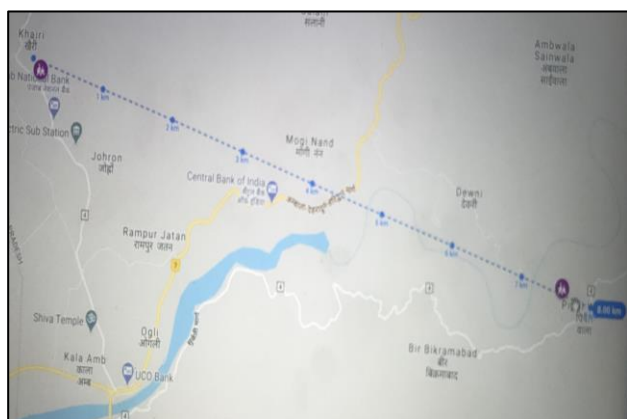


Figure 1: Location of the study sites.

Enrollment of the students was based on their presence in the school on the day of visit and who had valid informed consent from the parents.

Children were medically examined by a doctor in the school. Children excluded from the study were those children with history and clinical findings suggestive of cardiac illness, chronic respiratory disease like pulmonary tuberculosis, structural deformity of thoracic cage, cleft lip/ cleft palate and non-cooperative children. Structured questionnaire based data was recorded from the students regarding respiratory symptoms. Pulmonary function tests were measured by the investigator as per standard guidelines by using Spirotech+CMSP-20 spirometer (manufactured by Clarity Medical Pvt. Ltd.) with flow range of -8 L/sec to +12 L/sec, maximum volume range of 5L with measurement accuracy of $\pm 1\%$.

Measurement was done with flow integrated mouthpiece and transducer with bidirectional turbine cartridge. It was operated through laptop mode with feature of autointerpretation, storage and transfer of reports in pdf and excel format. Each test was explained thoroughly to a group consisting of five students. The test was performed in sitting position using a noseclip. Spirometric parameters recorded were Forced Vital Capacity (FVC), Forced Expiratory Volume at one second (FEV₁), Maximal Midexpiratory flow (FEF_{25-75%}) and Peak Expiratory Flow Rate (PEFR). Age was taken from the date of birth recorded in the school register. Trained health educators from the department of community medicine measured height and weight of the students.

Height was measured to nearest 0.5 cm by using stadiometer. The students were asked to stand straight with closed heels, buttocks and occiput touching against the wall, looking straight ahead with aligning tragus of the ear and inferior margin of the orbit parallel to the ground. Weight was recorded as kilograms to nearest 0.5 kg in an electronic weighing scale. Machine was kept in smooth flat hard surface. Correction of the zero error followed by recording of weight without shoes was done.

Analysis was done using percentage, range, mean, standard deviation. Chi square test and multivariate regression analysis was used for interpretation of various spirometric parameters. p value <0.05 was considered statistically significant. SPSS 23 version was used for data entry and analysis.

RESULTS

A total of 204 students in the age group of 6 to 10 years were enrolled in the study with 102 students from each of the two primary schools. Mean age of the students enrolled in the industrial area was 8.13 ± 1.51 years and in non-Industrial area was 8.35 ± 1.57 years ($p=0.32$). There was significant difference in Body Mass Indices between groups with value of 17.69 ± 2.23 in industrial area and 16.20 ± 2.56 in non-industrial area ($p<0.001$).

Mean Forced Expiratory Volume in 1 second (FEV₁) was 1.01 ± 0.31 in industrial area 1.12 ± 0.34 in non industrial area ($p=0.01$). There was no significant difference in

other values of pulmonary function tests between groups (Table 1). Positive correlation was depicted between BMI and pulmonary functions FVC, FEV1, PEFR, FEF (25%-75%) (Figure 2). The significant predictors for correlation of pulmonary function tests with BMI by forward regression analysis were FEV1 ($r^2 < 0.001$), FEV1, FVC

($r^2 < 0.011$), FEV1, FVC, PEFR ($r^2 < 0.047$). Median value comparative data for values in the 1st and 2nd quartile revealed values for FVC, FEV1, PEFR, FEF as 1.27, 1.01, 2.38, 1.44 for industrial area and 1.31, 1.16, 2.22, 1.42 for non industrial area (Figure 3).

Table 1: Comparison of physical parameters and pulmonary functions between the primary school children in industrial and non-industrial area.

Parameter	Industrial area	Non industrial area	p value
Age (Mean±SD)	8.13±1.51	8.35±1.57	0.32
Height (Mean±SD)	121.73±9.70	122.61±11.296	0.55
Weight (Mean±SD)	22.99±5.15	21.37±5.55	0.32
BMI (Mean±SD)	17.69±2.23	16.20±2.56	0.00
FVC (Mean±SD)	1.27±0.36	1.30±0.43	0.70
FEV1 (Mean±SD)	1.01±0.31	1.12±0.34	0.01
PEFR (Mean±SD)	2.34±0.65	2.23±0.70	0.26
FEF (Mean±SD)	1.52±0.43	1.42±0.35	0.06

School children in Industrial and non-Industrial area.

Table 2: Comparison of physical parameters and pulmonary functions between male and female primary school children industrial and non-industrial area.

Parameter	Industrial area		p value	Non industrial area		p value
	Male	Female		Male	Female	
Age Mean±SD	8.20±1.38	8.07±1.63	1.67	8.47±1.61	8.22±1.53	0.43
Height Mean±SD	121.16±9.08	122.26±10.29	0.57	124.22±11.15	120.87±11.30	0.13
Weight Mean±SD	22.85±5.06	23.11±5.29	0.80	22.35±5.27	20.30±5.70	0.06
BMI Mean±SD	17.77±2.18	17.63±2.47	0.75	16.67±2.34	15.70±2.70	0.05
FVC Mean±SD	1.28±0.39	1.26±0.34	0.75	1.37±0.41	1.22±0.43	0.07
FEV1 Mean±SD	1.02±0.31	1.00±0.28	0.79	1.21±0.31	1.01±0.34	0.003
PEFR Mean±SD	2.27±0.67	2.40±0.63	0.34	2.49±0.66	1.95±0.65	0.00
FEF Mean±SD	1.62±0.45	1.43±0.40	0.02	1.49±0.31	1.34±0.38	0.03

Table 3: Comparison of respiratory health characteristics between primary school children in industrial and non-industrial area.

Parameter	Industrial area	Non-industrial area	p value
History of allergic rhinitis in the previous year	84 (82.4%)	90 (88.2%)	0.36
Four or more episodes of allergic rhinitis in the last year	24 (28.5%)	8 (8.8%)	0.002
Presence of allergic rhinitis on the day of examination	36 (35.3%)	22 (21.6%)	0.03
History of passive smoking	33 (32.3%)	25 (24.5%)	0.29

No difference in pulmonary function tests between males and females was present in the industrial area except FEF (25%-75%) with values in males as 1.62±0.45 and in females as 1.43±0.40 ($p=0.02$). However in the non-Industrial area, the differences in parameters such as FEV1, PEFR and FEF (25%-75%) was significant (p values =0.00,0.00,0.03) between males and females with lower values in females (Table 2).

Among the children belonging to the industrial area, history of allergic rhinitis was present in 84 (82.4%) of

students and the frequency varied from one to seven times for last 1 year. Out of these, 60 (71.4%) students had one to three episodes of allergic rhinitis during the last year. Eighteen (21.4%) students had 4 episodes of allergic rhinitis and 5 (5.9%) had six such episodes in the previous year.

History of seven episodes of allergic rhinitis were present in one child. Overall, history of wheezing was present in 2 (2%) of students. Thirty nine (38.2%) had allergic rhinitis episodes during the winter season. Five (4.9%)

students responded as symptoms for most of the time during the year. Allergic rhinitis on the day of survey was present in 36 (35.3%) students. Out of these 30 (83.3%) students had symptoms less than three days. However history of any allergic respiratory infection was denied in 18 (17.6%).

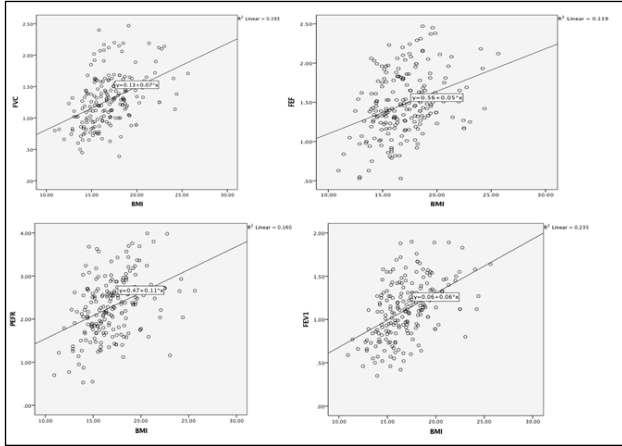


Figure 2: Correlation between pulmonary function tests and body mass index (n=204).

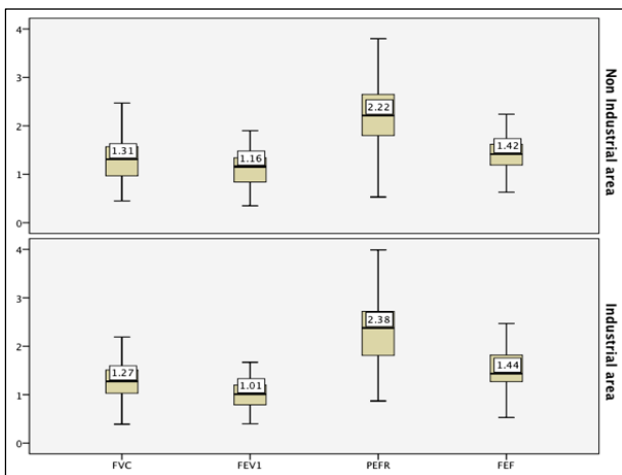


Figure 3: Comparison of median values of pulmonary function tests between groups.

Comparative data of the children belonging to the non-industrial area revealed episodes of allergic rhinitis for last one year in 90 (88.2%). Frequency of episodes for last one year ranged from once to seven times with majority 44 (48.8%) having one episode. Four or more episodes of allergic rhinitis in the past 1 year were present in 8 (8.8%).

Overall, wheezing was present in 2 (2%) students. Hospitalization secondary to severe respiratory illness was present in 1 (1%). Symptoms during winter season were present in 78 (76.5%). Three (2.9%) reported the presence of symptoms most of the time. Allergic rhinitis on the day of survey was present in 22 (21.6%) students.

Out of these 21 (95.4%) had symptoms for less than 3 days.

The difference in the presence of allergic rhinitis on the day of survey between the comparative groups was statistically significant ($p=0.03$). History of passive smoking was present in 33 (32.4%) students in industrial area and 25 (24.5%) in non-industrial area ($p=0.29$) Table 3.

DISCUSSION

Comparison of pulmonary function tests showed the significant difference in Mean Forced Expiratory Volume in 1 second (FEV1) as 1.01 ± 0.31 litres in industrial area and 1.12 ± 0.34 litres in non-industrial area ($p=0.01$). There was no significant difference in other values of pulmonary function tests between groups. However, the mean FVC was lower in children belonging to industrial area as compared to non-industrial area.

A cross-sectional study in Argentina children (aged 6 to 12 years) living near petrochemical industry also showed lower lung function (13% FEV1 percent predicted).¹⁰ In Italy a cross-sectional study among children (aged 6 to 14 years) living in the vicinity of petrochemical industry showed a lower lung function 10.3% FEV1 and an increase in wheezing symptoms (adjusted prevalence ratio of 1.70) compared to children in a reference area.¹¹ This study showed positive correlation between BMI and pulmonary function tests.

The significant predictors for correlation of pulmonary function tests with BMI by forward regression analysis were FEV1 ($r^2 < 0.001$), FEV1, FVC ($r^2 < 0.011$), FEV1, FVC, PEFR ($r^2 < 0.047$). Study by Fung et al, also noted increased spirometric flows correlating to increased BMI in a population of chinese schoolchildren.¹²

Bhattacharya and Banerjee in Jaipur also observed that vital capacity increases with increase in BMI in both the sexes.¹³ The higher values for PEFR and FEF among children in industrial could be because of significant difference of BMI between children of industrial area and non-industrial area. However FEV1 was significantly lower despite BMI ($p=0.01$).

No difference in pulmonary function tests between males and females was present in the industrial area except FEF ($p=0.02$) with values in males as 1.62 ± 0.45 and 1.43 ± 0.40 in females.

However, in the non-Industrial area, the differences in parameters such as FEV1, PEFR and FEF was significant (p values = 0.00, 0.00, 0.03) between males and females with lower values in females.

This study did not reveal any difference between mean FVC values among male and female students. However, study by Sharma et al, in Delhi observed that FVC values

were significantly ($p < 0.05$) greater for boys than girls.¹⁴ Vijayan et al, found that in south Indian children, the mean FVC values were significantly high in boys. Bhattacharya and Banerjee interpreted that females have lower vital capacities than males.¹⁵

History of allergic rhinitis on the day of examination was present among 36 (35.3%) children in industrial area and 22 (21.6%) children in non-industrial area.

The difference in the presence of symptoms pertaining to allergic rhinitis on the day of examination was statistically significant between groups ($p = 0.03$).

Study among Korean school children depicted lower prevalence of allergic rhinitis in metropolitan area (46.6%) as compared to that in rural area (35.5%). It was significantly different ($p < 0.001$).¹⁶

Four or more episodes of allergic rhinitis in the last year were present in 24/84 (28.5%) children in the industrial area as compared to 8/90 (8.8%) in the non-industrial area ($p = 0.002$). A Georgian study revealed that 2.3% of children had respiratory infections 7-8 times per year, and 19.9% children had frequency of respiratory infections as 3-5 times per year.¹⁷

The difference between the frequency of allergic respiratory infection in rural and urban area was statistically significant ($p < 0.001$). Insignificant difference was observed in the history of passive smoking between the two comparative areas ($p = 0.29$).

CONCLUSION

Industrial air pollution has impact on the pulmonary function tests of school children in the age group of 6 to 10 years with significant difference in spirometric parameters of FEV1, frequency of episodes of allergic rhinitis for last one year and point prevalence of allergic rhinitis.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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