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Public Health Concerns of Ambient Air Pollution in an Industrial Town of Punjab, India

Revised Article

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Article Information

Received: 03-01-2023;
Accepted: 02-03-2023;
Published: 08-03-2023.

Abstract

Introduction: Mandi Gobindgarh is an iron industry town of Punjab in India. In this town more than 50% laborer are migrated from Uttar Pradesh and Bihar.

Material and Methods: A follow up for 20 years (2001-2021) of follow up was conducted in Mandi Gobindgarh an "Industrial Town" of Punjab, India.

Results: Trends shows that air pollution level was extremely higher in Mandi Gobindgarh an industrial town during the period of 20 years as compared to permissible limit. Adjusted Odds Ratio for, Chronic Obstructive Pulmonary Disease (COPD) in year 2021 was (OR=4.01, 95% CI 1.72-5.92 P=0.01) as compared to year 2001 i.e. (OR=2.23, 95% CI 1.10-4.53 P=0.03) were found significantly higher after a follow up of 20 years in the residents of Industrial Town. After this follow up study it is observed that due to deterioration of air quality in 20 years and its continuous exposure cause significantly more chronic respiratory morbidity in 2021 as compared to year 2001 among Adult population of Industrial Town.

Conclusion: It is concluded that continuous exposure to high concentration of PM10 and TSP in the ambient air for 20 years leads to poor respiratory health in migrated adults of Industrial town.

Key Words: Air Pollution, Public Health, Industrial Town, Hazards

Introduction

Air Pollution and health are increasingly recognized as a global public health priority. Incorporating mixed flows of economic, forced, and irregular migration, migration has increased in extent and complexity. Globally, it is estimated that there are 244 million international migrants and significantly more internal migrants – people moving within their country of birth. The Ministry of Environment, Forest and climate change, Government of India has identified Mandi Gobindgarh as one of the critically polluted area in the country. In Mandi Gobindgarh more than 50% of laborers working in Iron industries are migrated from neighboring state like Uttar Pradesh and Bihar2.

To assess risk aspects due to air pollution at the general population levels, several factors have to be considered, i.e., exposure dose, biological effect and proportion of the Industrial Town population. The results of these studies are difficult to interpret because of a variety of limitations mostly regarding exposure assessment and handling of co-factors3.

Chronic obstructive pulmonary disease (COPD) is one of the leading causes of morbidity and mortality both in the industrialized and the developing countries. The burden of this respiratory disease worldwide is expected to increase and have an impact on the individual and the society33. The disease contribute an immense in this country as well.21, 37

An attempt has been made in the past to estimate the gross burden of chronic obstructive pulmonary disease (COPD) in India.21 The median values of prevalence rates from published studies were 5.0 percent in male and 2.7 percent in female population21. These results also substantiated by a multi-centric epidemiological study from India.35 But the role of air pollutants has not been clearely studied from India.

This is a follow up study aimed to evaluate the effects of air pollutants on respiratory morbidity among adults in representative samples of two populations one each in industrial town of Punjab.

Material and Methods

Study Area

Industrial Town Mandi Gobindgarh is located at a latitude of 30.66oN and a longitude of 76.31o E, having an area of 32 Km2 and population of 55,400 as per the census report for the year 2001. the year 2001 and 2021. According to cluster sampling scheme, two colonies were selected from industrial town. Interview was carried out based on a structured questionnaire. The questionnaire on respiratory symptoms was tailored on the questions listed by the British Medical Research Council, UK12, American Thoracic Society2, and International Study of Asthma and Allergies in Childhood (ISAAC) schedules3. The questionnaire pertained to the questions on socio-economic characteristics,

Citation: Kumar M. Public Health Concerns of Ambient Air Pollution in an Industrial Town of Punjab, India. Medp Public Health Epidemiol. 2023; 2(1): mpphe–202301004.

household environment, respiratory symptoms, smoking history, residence and occupational history. To assess the socio-economic status, modified Kuppuswami scale25 was used. Data collection was collected for a follow up in the year 2001 and 2021. It consisted of interview and physical examination of the individual and the air sampling in industrial towns.

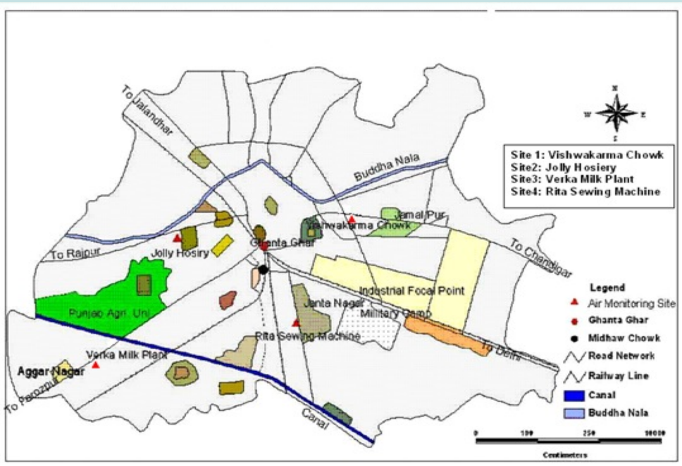


Figure 1: Site of Air Quality Monitors in Ludhiana, India

Interview and Physical Examination

The individuals were interviewed by using an interview schedule. After completion of the interview, the physical examination was carried out and measurements were made for, height and weight.

Air quality monitoring

Air quality monitoring was done by the High Volume Air Sampler (HVS) (Envirotech APM 460), every week, for particulate matter less than ten micron size (PM10), TSP, NOx, SOx and O3. Weekly sampling by the Organic Vapour Sampler (OVS) (Envirotech APM 850) was done for CO and data was collected from other sources like State Pollution Control Board and compared between year 2001 and 2021.

Statistical Analysis

Suitable statistical test like Chi-square test was used to test significant difference, in the categorical and t-test for quantitave variables. T-test was used to compare means values of years of residence, smoking duration and smoking index. Odds ratio and 95% confidential intervals for residence in industrial town were estimated using binary logistic regression analysis in SPSS programme.

Results

Level of Air Pollution

Level of PM10 was 110.2 mg/m3 in year 2001 and 122.8 mg/m3 in year 2021 in study town. Levels of all the pollutants were higher in year 2021 as compared to 2001 after the follow up of 20 years.

Daily and yearly variations of all the parameters were under permissible limit except PM10 and total suspended particulate matter (TSP) between 2001 and 2021. Levels of all the pollutants were higher in Industrial Town during this period.

Table 1: Air pollutants with permissible limits in 2001 and 2021

Ambient air pollutants	Industrial Town		Permissible Value		
			CPCB	WHO	USEPA
	2001	2021			
PM_{10} (µg/m^3)	110.2	122.8	77	83-127	150
TSP (µg/m^3)	890.3	946.4	500	-	75-260
NOx (µg/m^3)	27.4	30.4	120	200	100
SOx (µg/m^3)	29.6	32.8	120	125	365
O_3 (ppm)	0.05	0.23	-	0.10	0.12
CO (µg/m^3)	962.9	1042.1	5000	10,000	10,000

Study Population Characteristics

For the household survey, 1003 subjects were selected from the Industrial Town in 2001 and 1001 subjects in year 2021. There was equal distribution of men and women in the two sample groups, only than having age more than 20 years were sampled.

The level of higher socio-economic status, current smoking, passive smoking, biomass fuel use, household environment such as inadequate light, inadequate ventilation and dampness, moderate to severe dust exposure, immigrants and factory workers were higher in the year 2021. Therefore, prevalence of respiratory morbidities was compared according to socio-economic status, smoking, biomass fuel use, dust exposure, immigrants and factory workers in both the towns.

Increase in chronic respiratory morbidities

It was found that prevalence of cough and phlegm in Industrial Town was 30.9% and 27.2% respectively in total population, which were significantly in 2021.

It was found that prevalence of breathlessness and wheezing in Industrial Town were 33.3% and 16.7% in total population, which were significantly higher in 2021.

Prevalence of COPD and asthma was significantly higher in total population of Industrial Town (22.3% and 8.8% respectively) in 2021 as compared to 2001.

The population characteristics in Industrial Town were not similar in 2001 and 2021 with respect to socio-economic status, smoking, use of biomass fuel, ethnically, and length of residence in the town. Some of these characteristics particularly smoking, use of biomass fuel and occupation have been shown to be associated with chronic respiratory morbidities. Therefore, prevalence of respiratory morbidity was compared in stratified analysis in smokers and non smokers users of biomass fuel and non users of biomass fuel and among occupational socio-economic, migrant and resident groups. The prevalence of respiratory morbidities was significantly higher in Industrial Town even in non-smokers, non-biomass fuel users, among those having higher socio-economic status, in 2021 as compared to 2001. Confounding in

Table 2: Prevalence of Cough and Phlegm in 2001 and 2021

Respiratory Symptoms	Industrial Town	
	Year 2001 Total (N=1003) No. (%)	Year 2021 Total (N=1001) No. (%)
Cough	201(20.0)*	309(30.9)*
Cough during the day or at night in winter.	197(19.6)*	218(21.8)*
As much as three months each year.	173(17.3)	189(18.9)
Phlegm	194(19.3)	272(27.2)
Twice or more times in winter during the day or night.	182(18.2)	199(19.9)
Three months or more in a year.	33(3.3)	64(6.4)
Two or more periods in past three year.	41(4.1)	72(7.2)

*Between towns P<0.05

Table 4: Incidence of Respiratory Diseases in 2001 and 2021

Respiratory Diseases	Industrial Town	
	Total (N=1003) Year 2001	Total (N=1001) Year 2021
Chronic Bronchitis	146(14.6)*	221(22.3)*
Asthma	36(3.6)*	88(8.8)*
Tuberculosis	22(2.2)	34(3.4)

*Between towns P<0.05

*Based on symptoms of cough with expectoration for more than three months in a year for two consecutive years.

**Self-reported

these variables was evaluated in multivariate analysis.

After controlling the effect of age, sex, socioeconomic status, smoking, biomass fuel use, inadequate lighting, inadequate ventilation, dampness, residence duration, dust exposure,

Table 3: Prevalence of Breathlessness and Wheezing in 2001 and 2021

Respiratory Symptoms	Industrial Town	
	Year 2001 (N=1003) No. (%)	Year 2021 (N=1001) No. (%)
Breathlessness		
On hurrying on level ground or walking up a slight hill.	272(27.1)	333(33.3)
On walking with other compared to people of your age on level ground.	260(25.9)	284(28.4)
On walking of your own pace on level ground.	159(15.9)	198(19.8)
On washing or Dressing etc.	95(9.5)	122(12.2)
Wheezing	105(10.5)*	167(16.7)*
Constant	54(5.4)	93(9.3)
Intermittent	52(5.2)	81(8.1)
Wheezing on provocation.	68(6.8)*	73(7.3)*
Worse at day	19(1.9)	70(7.0)
Worse at night	51(5.1)*	60(6.0)*
No change	35(3.5)	43(4.3)

- P<0.05 between towns

factory workers and migrant population by using binary logistic regression models on individual symptoms Adjusted Odds Ratio for, Chronic Obstructive Pulmonary Disease (COPD) in year 2021 was (OR=4.01, 95% CI 1.72-5.92 P=0.01) as compared to year 2001 i.e. (OR=2.23, 95% CI 1.10-4.53 P=0.03) were found significantly higher after a follow up of 20 years in the residents of Industrial Town. Symptoms for cough, phlegm, dyspnoea, wheeze, asthma and COPD were significant associated with poor ambient air quality exposure for long term. Whereas tuberculosis were not significant in the area of poor ambient air quality in 2021 as compared to 2001. Smoking, biomass fuel, duration of residence and migration were independently associated with respiratory morbidity. The ambient air quality was poorer in due to high PM10 and TSP and could be responsible for high prevalence of cough, phlegm, dysponea, wheeze and COPD was also observed in Industrial Town between 2001 and 2021. Similarly association of poor air quality with chronic respiratory morbidity has observed in other studies.

Discussion

The acute effects of air pollution have stimulated the interest of epidemiologists and clinicians, and several studies were published focusing on the associations between adverse respiratory symptoms and concentrations of air pollutants on long

Table 5: Distribution of population characteristics in 2001 and 2021

Variables	Industrial Town in 2001 (N=1003)	Industrial Town in 2021 (N=1001)
Higher socio-economic status	28(2.8)*	42(4.2)*
Current Smoking	318(31.8)*	219(21.9)*
Passive Smoking	361(36.0)*	361(36.0)*
Biomass fuel use	705(70.3)*	705(70.3)*
Inadequate lighting	177(17.6)*	177(17.6)*
Inadequate ventilation	264(26.3)*	264(26.3)*
Dampness in house	124(12.4)*	124(12.4)*
Mattress use	813(81.1)	813(81.1)
Carpet use	547(54.5)	547(54.5)
Presence of insects	963(96.0)	963(96.0)
Overcrowding	697(69.5)	697(69.5)
Moderate to severe dust exposure	407(40.7)*	407(40.7)*
Immigrants	507(50.5)*	507(50.5)*
Factory workers	200(19.9)*	200(19.9)*

*Between towns P<0.05

Table 6: Association of residence in poor air quality town with chronic respiratory morbidities

Variables	Odds Ratio	95% Confidence Interval		Significance P-Value
		Lower	Upper	
Cough	1.59	1.21	2.21	0.001
Phlegm	1.56	1.17	2.07	0.003
Dysponea	1.41	1.09	1.78	<0.01
Wheeze	1.52	1.05	2.19	0.03
Chronic bronchitis	3.13	2.11	4.64	<0.001
Asthma	2.27	1.12	4.59	0.03
Obstructive defects	1.89	1.45	2.45	<0.001
Restrictive defects	1.66	0.98	1.66	0.07
Tuberculosis	1.33	0.56	3.16	0.5

Logistic regression model include age, sex, socio-economic status, smoking, use of biomass fuel, inadequate ventilation and lighting, dampness in house, mattress or carpet use and overcrowding.

term exposure. Time series studies have shown that air pollution is associated with increased hospital admissions and mortality due to cardiorespiratory diseases as pre-existing conditions aggravate with rise in air pollution. However, long term effects of ambient air pollution in causing chronic respiratory problems such as COPD and asthma, have been less clear.

Air quality was monitored in the study area for PM10, TSP, NOx, SOx, CO and O3 by using standard methods prescribed by Bureau of Indian Standards (BIS)15,16,17,18,19. Concentrations of air pollutants are compared with the standards of ambient air quality that have been set for Indian climate by CPCB, World Health Organisation (WHO) and United State of Environment Protection Agency (USEPA). Level of PM10, TSP, NOx, SOx, CO and O3 were significantly higher in 2021 as compared to 2001. Only the level of SPM was more than the permissible limits of CPCB and USEPA in Industrial Town.

Only the level of Total Suspended Particulate matter (TSP) was observed more than permissible limit in Industrial Town. Level of monthly means of Total Suspended Particulate matter (TSP) in year 2001 was 890.3 mg/m3 while in 2021 it is 946.4 mg/m3. Levels of all the pollutants were higher in Industrial Town than in Non-Industrial Town. (Table 1)

Level of TSP is increased alarming stage between 2001 and 2021. PM10 is considered to be more sensitive parameter than TSP. Concentration of PM10 in Industrial Town was mostly more than the permissible limit of CPCB. Level of monthly mean of PM10 was 110.2 mg/m3 in year 2001 and 122.8 mg/m3 in year 2021. The level of air pollutants in study area during year 2001 was less as compared to year 2021. Reason for increase in the level of TSP in 2021 could be due to the increase in the number of vehicles, construction work, population and industries.

The prevalence of cough, phlegm, breathlessness and wheezing in year 2021 were 30.9%, 27.2%, 33.3% and 16.7% in total population. Kamet et al., (1987) has reported the prevalence of chronic cough in the range of 1.7% to 5.1% and dyspnoea range from 3.2% to 7.2% in Mumbai. Chronic cough was 12% and 11.2% in Parel and Lava whereas dyspnoea was 53% and 13% respectively.

Jindal S.K. et al., (2001) have reported asthma prevalence of 3.9% in urban males, 3.9% in rural males, and 1.3% in both urban and rural females from north India21. Gupta D. et al., (2001) have reported asthma in 3.3% children who were not Industrial Town to environmental tobacco smoke13. According to ISSAC study (1998) asthma prevalence was 2.8% among children in Chandigarh.

In this study COPD prevalence was 22.3% among total population in Industrial Town in year 2021. Jindal S. K. et al. (2001) reviewed 14 studies, to estimate the gross burden of chronic obstructive pulmonary disease (COPD)21. The median values of different prevalence rates were 5 % in male and 2.7 % in female population. In three urban areas of Mumbai prevalence of COPDranged from 2.3% to 4.5% (Kamet et al., 1987). Bakke et al., (1991) has reported chronic bronchitis4 in 5.4%.

Prevalence of self reported tuberculosis among total population was 2.4% in year 2021. The prevalence of tuberculosis was reported as 0.4% in India. In a study spirometer standards developed by Jindal S.K. and Wahi P.L., (1990) for north India population were used20.

Chhabra S.K. et al. (2001) also found that subjects those who were Industrial Town to poor ambient air quality due to high level of SPM had poor lung function tests in Delhi8. Similarly studies by Detels R. et. al.11 (1981) and Pope C.A. et al. 31 (1991) have also reported association of poor air quality and higher respiratory morbidity in USA. Kamat et al22. (1987) showed a higher morbidity with raised levels of air pollution in 3 urban and a rural community of Mumbai. In the respective 4 areas standardised prevalence were: for dyspnoea 7.3%, 6%, 3.2% and 5.5%; for chronic cough 5.1%, 2.7%, 1.7% and 3.3%; for COPD4.5%, 4.5%, 2.3% and 5.0%.

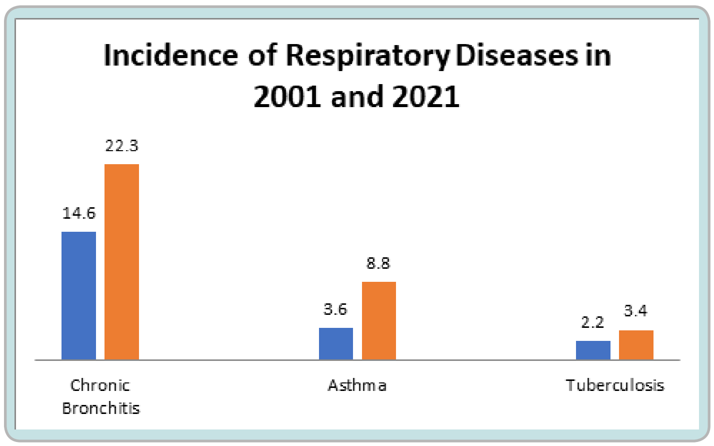
In present study association between poor ambient air quality was found with adjusted Odds Ratio for, Chronic Obstructive Pulmonary Disease (COPD) in year 2021 was (OR=4.01, 95% CI 1.72-5.92 P=0.01) as compared to year 2001 i.e. (OR=2.23, 95% CI 1.10-4.53 P=0.03). This is supported by study of Wong C.M. et al., (1989), which shows a significant effects of air pollution on morning cough (OR=1.65, 95%CI: 1.03–2.64), phlegm in morning (OR=1.40, 95%CI: 1.03–1.92), phlegm day or night (OR=1.63, 95%CI: 1.10–2.42) and phlegm for three months (OR=1.70, 95%CI: 1.13 – 2.56) in nonsmoking women in high polluted area. The odds ratio (OR) for the distinct effect was 1.55, which is consistent with Dockery's statements that the health effects of air pollution observed in the cites of the United States would usually be weak, with a relative risk of less than 2 and often less than 1.5 for typical exposure34.

In this study subjects Industrial Town to poor ambient air quality significantly associated with Chronic Obstructive Pulmonary Disease (COPD) in year 2021 was (OR=4.01, 95% CI 1.72-5.92 P=0.01. These results are in accordance to study done by Karita K. et al., (2001) who reported an increase in prevalence of obstructive changes in the peripheral airways among traffic police in Bangkok23. Ostro B. D. et al. (1991) found that air borne H+ was significantly associated with several indicators of asthma status, including moderate or severe cough and shortness of breath26.

Zemp E. et al. (1999), in a cross-sectional study in random population samples of adults at eight study sites in Switzerland reported independent, positive association between annual mean concentrations of NO2, total suspended particulates, and particulates of less than 10mm in aerodynamic diameter (PM10) with prevalence of chronic phlegm production, chronic cough or phlegm production, breathlessness at rest during the day, breathlessness during the day or at night, and dysponea on exertion. They found no associations with wheezing without cold, current asthma, chest tightness, or chronic cough. Among never-smokers, the odds ratio (95% CI) for a 10 mm/m3 increase in the annual mean concentrations of PM10 was 1.35 (1.11 to 1.65) for chronic phlegm production, 1.27 (1.08 to 1.50) for chronic cough or phlegm production, 1.48 (1.23 to 1.78) for breathless during the day, 1.33 (1.14 to 1.55) for breathlessness during the day or night, and 1.32 (1.18 to 1.46) for dyspnoea on exertion. Similar associations were also found for former and current smokers, except for chronic phlegm production. The observed associations remained stable when further control was applied for environmental tobacco smoke exposure, past and current occupational exposures, atopy, and early childhood respiratory infections when restricting the analysis to long-term residents and to non alpine areas, and when excluding subjects with physician-diagnosed asthma35.

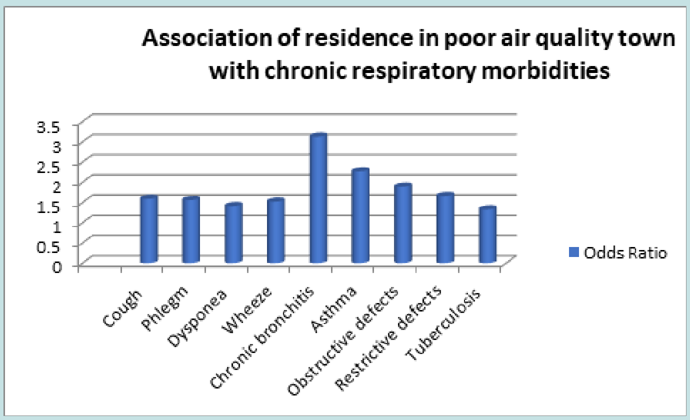
Peter J.M. et al. (1999) conducted a ten year prospective cohort study of Southern California children, with a study design focused on four pollutants; ozone, particulate matter, acids, and nitrogen dioxide (NO2). Wheeze prevalence was positively associated with levels of both acid (OR = 1.45; 95%Cl, 1.14.83), and NO2 (OR = 1.54; 95%Cl, 1.08-2.19) in boys. In the present study dyspnoea (OR=1.41, 95%CI 1.09-1.78, P=0.01) and asthma (OR=2.27, 95%CI 1.12-4.59, P=0.03) was significantly associated with poor ambient air quality30. Chhabra S.K. et al. (1999), studied the magnitude of the problem of childhood asthma in India and the factors influencing its occurrence. Multiple logistic regression analysis showed that male sex, a positive family history of atopic disorders, and the presence of smokers in the family were significant factors influencing the development of asthma whereas socio-economic class, air pollution (total suspended particulates), and type of domestic kitchen fuel were not associated with asthma8.

Chhabra S.K. et al. (2001) compared nonsmoking residents of lower- and higher-pollution zones in Delhi stratified according to socioeconomic levels and sex. Chronic cough, chronic phlegm, and dyspnoea (but not wheezing) were significantly more common in the higher-pollution zone in only some of the strata. Lung functions of asymptomatic nonsmokers were consistently and significantly better among both male and female residents of the lower-pollution zone[9].



Several times series studies have shown correlation of air pollution with hospital admission and cardiorespiratory mortality. A study by Pande J N et al., (2002) on outdoor air pollution and emergency room visits at All India Institute of Medical Sciences (AIIMS) in Delhi has show that emergency room visits for asthma, chronic obstructive airway disease (COAD) and acute coronary events increased by 21.30%, 24.90% and 24.30% respectively on account of higher than acceptable levels of pollutants29. The study of Sunyer J et. al., in 1993 showed that sulphur dioxide and black smoke concentrations in the urban air of Barcelona were associated with the number of COPD emergency room admissions in both winter and summer32. Burnett R.T. et al. (1995), studied6 the association of daily cardiac and respiratory admissions of 168 cases to acute care hospital in Ontario, Canada, with daily levels of particulate sulphates examined over the six year period 1983-1988. A 13 mg/m3 increase in sulphates recorded on the day prior to admission (the 95th percentile) was associated with a 3.7% (p<0.0001) increase in respiratory admissions and a 2.8% (P<0.0001) increase in cardiac admission. After adjusting for ambient temperature and ozone, similar increased respiratory admissions were observed in the period from April to September (3.2%) and in the period from October to March (2.8%). Results of study conducted by Chew E.T. et. al., (1999), shows that ambient air pollutant levels, in particular, those of SO2, TSP and NO2 were consistently associated with emergency room visits for asthma in children7. Damia A.D.D. et al. (1999) showed that air pollutants (black smog and SO2) correlate significantly with emergency room admissions for asthma (SO2 [r=0.32], black smoke [r=0.35]); however, multiple regression analysis showed that black smoke was the only significantly predicator of weekly visits10.

A cross-sectional study was carried out by Kumar R et al. (2004), to estimate the prevalence of chronic respiratory symptoms (cough, phlegm, breathlessness or wheezing) i.e. 27.9 and 20.3 % and obstructive ventilatory defect i.e. 24.9 and 11.8 %, in the study and Non-Industrial Town towns, respectively. Logistic regression analysis showed that residence in the study town was independently associated with chronic respiratory symptoms (odds ratio [OR]=1.5; 95% confidence interval [CI]=1.2,1.8; p<0.001) and spirometric ventillatory defects (OR=2.4; 95% CI=2.0,2.9; p<0.001) after controlling for other demographic effects 24.



This study shows that poor ambient air quality at Industrial Town was associated with high incidence of cough, phlegm, dysponea, wheeze, chronic bronchitis and asthma but not with tuberculosis. This study provides further evidence that long-term exposure to air pollution of rather high levels of TSP is associated with higher prevalence of respiratory symptoms in adults.

Finally, the association between chronic respiratory morbidities with air pollution found in this follow up seems to be causal in nature. Of the pollutants studied, level of total suspended particulate matter (TSP) was higher between 2001 and 2021 in Industrial Town and it is an important contributor in causation of respiratory morbidity and abnormal lung functions. Level of PM10, NOx, SOx, O3 and CO were also more in 2021 as compared to 2001 but were below the permissible limit. Air pollutants cause damage to respiratory endothelium Pande J.N. (2002) found that people living in areas with high air pollution have increased levels of soluble intercellular adhesion molecule-1, a marker for endothelial activation. Chronic respiratory morbidities such as COPD occur after a prolonged exposure. Most study subjects are permanent residents of the town or are long time migrants to Industrial Town. They are Industrial Town to air pollution since industrialization started in this town about 60-70 years ago. The air pollution levels are alarmingly high in Indian metropolitan towns.34 The World Health Organization (1998) estimated 3 million premature deaths per year, mainly in acute and chronic respiratory infections, attributed to exposure to air pollution on a worldwide basis.

Acknowledgments

We thank the participants of this study.

Funding: Ministry of Environment, Forest and Climate Change, Government of India

Conflict of interest: None declared

Ethical considerations and Ethical approval: The subjects were informed about the purpose of the study. They were assured that all personal information would be kept confidential and used only for research and study purpose. The study was approved by the Institutional Ethics Committee.

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Citation: Kumar M. Public Health Concerns of Ambient Air Pollution in an Industrial Town of Punjab, India. Medp Public Health Epidemiol. 2023; 2(1): mpphe–202301004.